Web Scraping science papers from site:
PubMed on the topic - "Electroactive Polymers".

Electroactive hemoglobin-surfactant-polymer biomembrane-like films.

https://www.ncbi.nlm.nih.gov/pubmed/10619442

Polyions complex 2C12N+ PSS- was prepared by reacting poly(sodium styrenesulfonate) (Na+ PSS-) with didodecyldimethylammonium bromide (2Cl2N+ Br-). Stable thin films made from 2C12N+ PSS- with incorporated redox protein hemoglobin (Hb) on pyrolytic graphite (PG) electrodes were then characterized by electrochemistry and other techniques. Cyclic voltammetry (CV) of Hb-2C12N+ PSS- films showed a pair of well-defined and nearly reversible peaks for HbFe(III)/Fe(II) couple at about -0.17 V vs. saturated calomel electrode (SCE) in pH 5.5 buffers. The electron transfer rate between Hb and PG electrode was greatly facilitated in microenvironment of 2C12N+ PSS- films. Positions of Soret absorption band suggest that Hb keeps its secondary structure similar to its native state in 2C12N+ PSS- films at the medium pH. The results of X-ray diffraction and differential scanning calorimetry (DSC) suggest synthesized lipid 2C12N+ PSS- films have an ordered bilayer structure intercalated between PSS- polyion layers, and the incorporated Hb expands the layer spacing of the films. HbFe(I), a highly reduced form of Hb, might also be produced in these films at about -1.09 V, and could be used to catalytically reduce organohalide pollutants.

An all-organic composite actuator material with a high dielectric constant.

https://www.ncbi.nlm.nih.gov/pubmed/12239563

Electroactive polymers (EAPs) can behave as actuators, changing their shape in response to electrical stimulation. EAPs that are controlled by external electric fields--referred to here as field-type EAPs--include ferroelectric polymers, electrostrictive polymers, dielectric elastomers and liquid crystal polymers. Field-type EAPs can exhibit fast response speeds, low hysteresis and strain levels far above those of traditional piezoelectric materials, with elastic energy densities even higher than those of piezoceramics. However, these polymers also require a high field (>70 V micro m(-1)) to generate such high elastic energy densities (>0.1 J cm(-3); refs 4, 5, 9, 10). Here we report a new class of all-organic field-type EAP composites, which can exhibit high elastic energy densities induced by an electric field of only 13 V micro m(-1). The composites are fabricated from an organic filler material possessing very high dielectric constant dispersed in an electrostrictive polymer matrix. The composites can exhibit high net dielectric constants while retaining the flexibility of the matrix. These all-organic actuators could find applications as artificial muscles, 'smart skins' for drag

reduction, and in microfluidic systems for drug delivery.

Study of DNA hybridization on polypyrrole grafted with oligonucleotides by photocurrent spectroscopy.

https://www.ncbi.nlm.nih.gov/pubmed/11390217

Recognition of DNA sequences by biochemical sensor is generally performed by analysis after completion of hybridization. Using a technique able to directly translate the biological event into an electrical signal allows the in situ monitoring of the hybridization kinetics. In this aim, the photoelectrochemical behavior of one electroactive polymeric sensor based on a copolymer of polypyrrole and polypyrrole-oligonucleotide has been investigated in aqueous solution. This sensor has been studied as such (i) and in two other situations: (ii) when the copolymer is in presence of non-complementary oligonucleotides; and (iii) when the copolymer is in presence of complementary oligonucleotides. From the photocurrent spectra obtained at -0.6 V/SCE versus incident energy the allowed direct and indirect transitions for each polymer have been evidenced. The photocurrent evolution during hybridization and adsorption processes has been recorded in real time and the hybridization kinetics has revealed to be comparable with mass variations obtained by quartz crystal microbalance under the same experimental conditions.

The non-specific inhibition of enzymes by environmental pollutants: a study of a model system towards the development of electrochemical biosensor arrays.

https://www.ncbi.nlm.nih.gov/pubmed/11679267

Previous research has shown that lactate dehydrogenase (LDH) was competitively inhibited by pentachlorophenol (PCP) and a modified assay produced a detection limit of 1 microM (270 microg l(-1)). This work used spectrophotometric rate-determination but in order to move towards biosensor development the selected detection method was electrochemical. The linkage of LDH to lactate oxidase (LOD) provided the electroactive species, hydrogen peroxide. This could be monitored using a screen-printed carbon electrode (SPCE) incorporating the mediator, cobalt phthalocyanine, at a potential of +300 mV (vs. Ag/AgCl). A linked LDH/LOD system was optimised with respect to inhibition by PCP. It was found that the SPCE support material, PVC, acted to reduce inhibition, possibly by combining with PCP. A cellulose acetate membrane removed this effect. Inhibition of the system was greatest at enzyme activities of 5 U ml(-1) LDH and 0.8 U ml(-1) LOD in reactions containing 246 microM pyruvate and 7.5 microM NADPH. PCP detection limits were an EC(10) of

800 nM (213 microg l(-1)) and a minimum inhibition detectable (MID) limit of 650 nM (173 microg l(-1)). The inclusion of a third enzyme, glucose dehydrogenase (GDH), provided cofactor recycling to enable low concentrations of NADPH to be incorporated within the assay. NADPH was reduced from 7.5 to 2 microM. PCP detection limits were obtained for an assay containing 5 U ml(-1) LDH, 0.8 U ml(-1) LOD and 0.1 U ml(-1) GDH with 246 microM pyruvate, 400 mM glucose and 2 microM NADPH. The EC(10) limit was 150 nM (39.9 microg l(-1)) and the MID was 100 nM (26.6 microg l(-1)). The design of the inhibition assays discussed has significance as a model for other enzymes and moves forward the possibility of an electrochemical biosensor array for pollution monitoring.

Poly(vinyl chloride) ion-selective electrodes for piribedil determination.

https://www.ncbi.nlm.nih.gov/pubmed/10933543

Piribedil (PD) ion-selective electrodes have been constructed from poly(vinyl chloride) matrix membrane containing piribedil-tetraphenylborate (PD-TPB) as the electroactive component with dibutylphthalate or dioctylphthalate as the plasticizing solvent mediator. The electrodes displayed a linear response over the concentration range 2.0 x 10(-5) to 10(-2) M PD. The working pH ranges of the electrodes were 3.5-6.4 and 3.0-6.0, and the isothermal coefficients of the cells were 0.00129 and 0.00096 V/degrees C respectively. The electrodes were used for the determination of the diprotonated PD species, the most successful being that based on dioctylphthalate solvent mediator. The electrodes show a linear response over the concentration range of 8.0 x 10(-6) to 10(-2) M PD, with Nernstain slope 30 mV/PD concentration decade when preconditioned by soaking in distilled water for 30 min. The electrodes exhibit good selectivity for the PD with respect to a large number of inorganic cations and organic substances of biological fluids. Piribedil is determined successfully in pure solutions and in tablets or in biological fluids using the standard additions and potentiometric titration methods. The membrane withstood soaking in distilled water for more than 5 months.

PVC matrix membrane sensor for potentiometric determination of metoclopramide hydrochloride in some pharmaceutical formulations.

https://www.ncbi.nlm.nih.gov/pubmed/12615239

The construction and characteristic performance of metoclopramide (MCP)-polyvinyl chloride (PVC) membrane sensor are described. The sensor is based on the use of MCP-tetraiodomercurate ion pair as electroactive material in PVC matrix in presence of dioctylphthalate (DOP) as solvent

mediator. MCP membrane sensor shows a stable, near Nernstian response over the concentration range 1 x 10(-2)-6 x 10(-5) M of MCP at 25 degrees C in the pH range 3-7 with cationic slope of 53.0+/-0.5. The detection limit of 4 x 10(-5) M and the response time of 30-60 s have been attained. Selectivity coefficient data for some common ions show negligible intereferences. Direct potentiometric determination of 15-3540 microg/ml MCP show an average recovery of 98.5% and a mean relative standard deviation (R.S.D.) of 1.6% at 100.0 microg/ml. The determination of MCP in Primperan tablets, injection, and syrup gave results that compare favorably with those obtained by the British pharmacopoeia method. Precipitation titrations involving MCP as titrant are monitored with the MCP sensor for some potentiometric precipitation reaction, e.g. sodium tetraphenylborate (STPB) and phosphomolybdic acid (PMA).

Enhanced analysis of purine and pyrimidine bases by the use of double-strand polyaniline coatings in micellar electrokinetic capillary chromatography.

https://www.ncbi.nlm.nih.gov/pubmed/12116134

A double-strand polymeric complex, which suppresses electroosmotic flow relative to fused-silica, is described. The polymeric complex contains a strand polyaniline (PAN) with the second strand containing polyacrylic acid (PAA) and methacrylate (MA) groups. The complex is referred to as PAN:P(AAMA). This polymeric complex has pH-controlled electroactive and hydrophobic characteristics and can be easily coated onto fused-silica. Enhanced separations of theophylline, theobromine, caffeine and adenine, thymine, uracil and cytosine were obtained by the use of the coated capillary in the micellar electrokinetic capillary electrophoresis (MEKC) system. The purine and pyrimdine bases were separated on the coated capillary with a 20 mM, pH 7 phosphate buffer which contains 0.05 M sodium dodecyl sulfate (SDS) as an additive.

Thieno[3,4-b]-1,4-oxathiane: an unsymmetrical sulfur analogue of 3,4-ethylenedioxythiophene (EDOT) as a building block for linear pi-conjugated systems.

https://www.ncbi.nlm.nih.gov/pubmed/11843603

[reaction: see text] An unsymmetrical analogue of 3,4-ethylenedioxythiophene (EDOT) has been synthesized by transetherification of 3,4-dimethoxythiophene. Electropolymerization leads to a stable electroactive polymer with electrochemical and electronic properties intermediate between those of the two symmetrical parent polymers poly(EDOT) and poly(3,4-ethylenedithiathiophene). Experimental work shows that the 2- and 5-positions possess a different reactivity, thus opening the

possibility of synthesizing regioregular oligomers or polymers.

Bio-smart hydrogels: co-joined molecular recognition and signal transduction in biosensor fabrication and drug delivery.

https://www.ncbi.nlm.nih.gov/pubmed/12392946

Two classes of polymers that are currently receiving widespread attention in biosensor development are hydrogels and conducting electroactive polymers. The present study reports on the integration of these two materials to produce electroactive hydrogel composites that physically entrap enzymes within their matrices for biosensor construction and chemically stimulated controlled release. Enhanced biosensing capabilities of these membranes have been demonstrated in the fabrication of glucose, cholesterol and galactose amperometric biosensors. All biosensors displayed extended linear response ranges (10(-5)-10(-2) M), rapid response times (<60 s), retained storage stabilities of up to 1 year, and excellent screening of the physiological interferents ascorbic acid, uric acid, and acetaminophen. When the cross-linked hydrogel components of these composite membranes were prepared with the amine containing dimethylaminoethyl methacrylate monomer the result was polymeric devices that swelled in response to pH changes (neutral to acidic). Entrapment of glucose oxidase within these materials made them glucose-responsive through the formation of gluconic acid. When insulin was co-loaded with glucose oxidase into these "bio-smart" devices, there was a twofold increase in insulin release rate when the devices were immersed in glucose solutions. This demonstrates the potential of such systems to function as a chemically-synthesized artificial pancreas.

Needle-type glucose microbiosensor based on glucose oxidase immobilised in an overoxidised polypyrrole film (an in-vitro study).

https://www.ncbi.nlm.nih.gov/pubmed/11220601

A fast response, needle-type glucose microbiosensor has been fabricated by a one-step electrochemical immobilisation of glucose oxidase in a polypyrrole film. The sensor shows a remarkable rejection of electroactive interferences, especially paracetamol. The maximum bias observed in the worst situation never exceeded the value of 6%. The fabrication procedure delivered very reproducible devices and the sensitivity of a newly prepared biosensor was typically 650 nA mM(-1) cm(-2). The kinetic parameters, obtained from an existing model, permitted to understand the sensor behaviour.

Assembly of electroactive layer-by-layer films of hemoglobin and polycationic poly(diallyldimethylammonium).

https://www.ncbi.nlm.nih.gov/pubmed/11866566

Layer-by-layer (PDDA/Hb)(n) films were assembled by alternate adsorption of positively charged poly(diallyldimethylammonium) (PDDA) and negatively charged hemoglobin (Hb) at pH 9.2 from their aqueous solutions on pyrolytic graphite electrodes and other substrates. The assembly process was monitored and confirmed by quartz crystal microbalance (QCM), UV-vis spectroscopy, and cyclic voltammetry (CV). CVs of (PDDA/Hb)(n) films showed a pair of well-defined, nearly reversible peaks at about -0.34 V vs SCE at pH 7.0, characteristic of Hb heme Fe(III)/Fe(II) redox couple. Positions of Soret absorption band and infrared amide II band of Hb in (PDDA/Hb)(8) films suggest that Hb in the films keeps its secondary structure similar to its native state. The electrochemical parameters of (PDDA/Hb)(8) films were estimated by square wave voltammetry, and the thickness of the PDDA/Hb bilayer was estimated by QCM and scanning electron microscopy. Trichloroacetic acid and nitrite (NO(2)(-)) were catalytically reduced at (PDDA/Hb)(8) film electrodes. The electrochemical catalytic reactions of O(2) and H(2)O(2) on (PDDA/Hb)(8) films were also studied.

Promotion of neural cell adhesion by electrochemically generated and functionalized polymer films.

https://www.ncbi.nlm.nih.gov/pubmed/11640959

New strategies for spatially controllable cell adhesion have been developed for brain cells from embryonic chicken. They are based on electrochemically active phenol and pyrrole derivatives, and can be used for the selective coverage of electroconductive substrates. Besides mimicking standard laminin-related adhesion promoting mechanisms by means of an electroactive monomer-linked 18-peptide segment from laminin (SRARKQAASIKVAVSADR), electrochemically generated thin (6-30 nm) polymer films of 3-hydroxybenzyl-hydrazine (3HBH) and 2-(3-hydroxyphenyl)-ethanol (2(3HP)E) with and without mechanically entrapped or covalently linked D-lysine have proved to promote cell adhesion in serum-free medium on indium-doped tin oxide (ITO) substrates during the first 6 culturing days in vitro. The effectiveness of the peptide was strongly density-dependent. Unexpectedly, laminin itself or a combination of laminin and poly-D-lysine (PDL) did not promote cell adhesion and neuron differentiation in serum-free cultures on ITO. However, they worked perfectly well on regular polystyrene substrates in serum-free medium or on ITO when medium with serum was used. This finding might suggest that the adhesion efficiency of laminin does not depend only

on the kind of medium supplement but also on the type of substrate. In contrast, the adhesion-promoting properties of "artificial" polymeric films seemed to be based on a more direct cell-film interaction, with the film masking the substrate properties.

A versatile approach to affinitychromic polythiophenes.

https://www.ncbi.nlm.nih.gov/pubmed/12381187

The preparation of both postfunctionalizable and chromic poly[3-(N-succinimido-p-phenylcarboxylate(tetraethoxy)oxy)-4-methylthiophene] is reported. The N-hydroxysuccinimide ester side group can easily react with different amine-bearing molecules in the solid state to yield a library of new polythiophene derivatives. The resulting polymers can be dissolved in various solvents, and interactions between the side chains (ligands) and different analytes (targets) can be detected from modifications of both the side-chain and the backbone conformations resulting in important color changes (i.e., affinitychromism). This colorimetric polymeric transducer could therefore lead to highly valuable, versatile, and inexpensive tools for highthroughput screening and drug discovery.

Potentiometric sensor for methylene blue based on methylene blue-silicotungstate ion association and its pharmaceutical applications.

https://www.ncbi.nlm.nih.gov/pubmed/9925330

A methylene blue (MB) poly(vinyl chloride) membrane sensor based on MB-silicotungstate (SLT) ion association as electroactive material was described. The linear response covered the range 1 x 10(-3)-1 x 10(-6) mol x dm(-3) MB solution, with a slope 52.0+/-0.8 mV decade(-1) (pH range 3.0-10.0). The detection limit was 7.65 x 10(-7) mol x dm(-3). The electrode showed stability, good reproducibility and fast response. Interferences from common inorganic cations, some organic base were negligible. These characteristics of the electrode enabled it to be used successfully for the determination of MB in injection. There was a good agreement for the results of MB content in injection between potentiometric method and USP standard procedure.

Biocompatibility of electroactive polymers in tissues.

https://www.ncbi.nlm.nih.gov/pubmed/11007614

The biocompatibility of ethylene-vinyl acetate copolymer (EVAc), polyethylene (PE), and polyaniline

(PANi) films in the emeraldine (EM), nigraniline (NA) and leucoemeraldine (LM) intrinsic oxidation states were assessed through subcutaneous implantation into male Sprague-Dawley rats beneath the dorsal skin, for a period ranging from 19 to 90 weeks. Histological examination, interstitial pressure measurement, and X-ray photoelectron spectroscopy (XPS) were employed to determine the biocompatibility of the polymers. The polymers did not provoke inflammatory responses in the subcutaneous tissues over the entire implantation period. Characteristics features associated with tissue-implant incompatibility were not evident near the implantation. Interstitial pressure was measured to evaluate the development of tissue. Low interstitial pressure readings on the region of implantation confirmed the biocompatibility of these polymer types. The surface composition of the electroactive aniline polymers before and after the implantation was characterized by XPS.

Phosphole-containing pi-conjugated systems: from model molecules to polymer films on electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/11686602

Two series of 2,5-dipyridyl- and 2,5-dithienylphosphole derivatives containing sigma3- or sigma4-P atoms were prepared, and their optical (UV/Vis absorption, fluorescence spectra) and electrochemical properties were systematically evaluated. These physical properties depend mainly on the natures of the 2,5-substituents and of the phosphorus moiety, and they revealed that these compounds contain extended pi-conjugated systems. Structure-property relationships were established on the basis of these experimental data and ab initio calculations on the parent molecules. The limited aromatic character and low-lying LUMO of the phosphole ring appear to be crucial for achieving a highly delocalised pi system. Electrooxidation of 2,5-dithienylphosphole derivatives affords electroactive films with low optical band gaps. As observed for the corresponding monomers, the optical and electrochemical properties of the polymers can be varied over a wide range by modifying the nature of the phosphorus moiety.

Vertically aligned carbon nanotube-sheathed carbon fibers as pristine microelectrodes for selective monitoring of ascorbate in vivo.

https://www.ncbi.nlm.nih.gov/pubmed/24678660

Using as-synthesized vertically aligned carbon nanotube-sheathed carbon fibers (VACNT-CFs) as microelectrodes without any postsynthesis functionalization, we have developed in this study a new method for in vivo monitoring of ascorbate with high selectivity and reproducibility. The VACNT-CFs

are formed via pyrolysis of iron phthalocyanine (FePc) on the carbon fiber support. After electrochemical pretreatment in 1.0 M NaOH solution, the pristine VACNT-CF microelectrodes exhibit typical microelectrode behavior with fast electron transfer kinetics for electrochemical oxidation of ascorbate and are useful for selective ascorbate monitoring even with other electroactive species (e.g., dopamine, uric acid, and 5-hydroxytryptamine) coexisting in rat brain. Pristine VACNT-CFs are further demonstrated to be a reliable and stable microelectrode for in vivo recording of the dynamic increase of ascorbate evoked by intracerebral infusion of glutamate. Use of a pristine VACNT-CF microelectrode can effectively avoid any manual electrode modification and is free from person-to-person and/or electrode-to-electrode deviations intrinsically associated with conventional CF electrode fabrication, which often involves electrode surface modification with randomly distributed CNTs or other pretreatments, and hence allows easy fabrication of highly selective, reproducible, and stable microelectrodes even by nonelectrochemists. Thus, this study offers a new and reliable platform for in vivo monitoring of neurochemicals (e.g., ascorbate) to largely facilitate future studies on the neurochemical processes involved in various physiological events.

Glucose microbiosensor based on alumina sol-gel matrix/electropolymerized composite membrane.

https://www.ncbi.nlm.nih.gov/pubmed/12392950

A procedure is described that provides co-immobilization of enzyme and bovine serum albumin (BSA) within an alumina sol-gel matrix and a polyphenol layer permselective for endogenous electroactive species. BSA has first been employed for the immobilization of glucose oxidase (GOx) on a Pt electrode in a sol-gel to produce a uniform, thin and compact film with enhanced enzyme activity. Electropolymerization of phenol was then employed to form an anti-interference and protective polyphenol film within the enzyme layer. In addition, a stability-reinforcing membrane derived from (3-aminopropyl)-trimethoxysilane was constructed by electrochemically-assisted crosslinking. This hybrid film outside the enzyme layer contributed both to the improved stability and to permselectivity. The resulting glucose sensor was characterized by a short response time (<10 s), high sensitivity (10.4 nA/mM mm(2)), low interference from endogenous electroactive species, and a working lifetime of at least 60 days.

Potentiometric PVC membrane sensor for the determination of scopolamine in some

pharmaceutical formulations.

https://www.ncbi.nlm.nih.gov/pubmed/12502085

A novel PVC membrane electrode for the determination of scopolamine ion based on the formation of an ion-association complex of scopolamine with the phosphotungstate counter anion as an electroactive material dispersed in a PVC matrix is described. The sensor shows a fast, stable, near-Nenstian response for 1 x 10(-2) mol dm(-3) to 1 x 10(-6) mol dm(-3) scopolamine at 25 degrees C over the pH range of 3 - 7 with a cationic slope of 54.5 +/- 0.5 mV/decade. The lower detection limit is 8 x 10(-7) mol dm(-3) and the response time is 15 -45 s. The selectivity coefficients for scopolamine relative to the number of interfering substances were investigated. There was negligible interference from the studied cations, anions, and pharmaceutical excipients. The determination of scopolamine in aqueous solution shows an average recovery of 100.0% and a mean relative standard deviation (RSD) of 1.5% at 500 microg/cm3. The direct determination of scopolamine in some formulations (scopolamine injection and eye drops) gave results that compare favorably with those obtained by the United State of Pharmacopoeia method. Potentiometric titration of scopolamine with sodium tetraphenylborate and phosphotungstic acid as a titrant was monitored with the developed scopolamine electrode as an end point indicator electrode.

In vivo voltammetric detection of rat brain lactate with carbon fiber microelectrodes coated with lactate oxidase.

https://www.ncbi.nlm.nih.gov/pubmed/9666730

To allow rat brain lactate measurement in vivo, a specific sensor based on a carbon fiber (phi = 30 microns) microelectrode coated with lactate oxidase was prepared. Combined with the differential normal pulse voltammetry measurement method, such a sensor, with a sensitivity of 9.15 +/- 0.91 mA.M-1.cm-2, provided a lactate linear response in concentrations ranging from 0.1 to 2.0 mM. The measurements performed appeared to be essentially insensitive to usual interference caused by the electroactive compounds present in the brain (ascorbic acid and peptides). In vivo detection performed in the cortex of the anesthetized rat led to the determination of a lactate concentration of 0.41 +/- 0.02 mM. Moreover, to validate the results obtained in vivo, an ex vivo determination of the lactate level was also performed in samples of brain tissue, plasma, and cerebrospinal fluid, using both voltammetry and a clinical analyzer with colorimetric-based detection. A good correlation was observed between the sets of data established by both methods.

Applications of polyion films containing biomolecules to sensing toxicity.

https://www.ncbi.nlm.nih.gov/pubmed/11197491

This paper describes several applications of polyion-biomolecule films on electrodes related to future development of in vitro chemical toxicity sensors. In the first example, composite films of DNA and ionomers cast onto pyrolytic graphite (PG) electrodes are shown to be useful for detecting DNA damage during incubation with the carcinogen styrene oxide at pH 5.5. Single electrodes can be used to estimate relative damage rates by derivative square wave voltammetry. Films containing the ionomer Nafion gave better reproducibility than another ionomer, Eastman AQ38. In the second example, films containing redox proteins myoglobin (Mb) and cytochrome (cyt) P450cam were constructed in alternate layers with polyions including DNA on rough PG electrodes. Films with reversible protein FeIII/FeII electrochemistry with up to 7 electroactive layers were made. Amounts of electroactive protein on rough PG that were 7 to 17-fold larger than in similar films on smooth gold were achieved because many more layers were electroactive. Films of Mb/DNA also showed oxidation peaks after short incubations with styrene oxide that may be attributable to DNA damage. Results are relevant to the future design of enzyme-DNA films which convert pollutants and drugs to reactive metabolites, followed by electrochemical detection of the resulting DNA damage.

An electroactive biotin-doped polypyrrole substrate that immobilizes and releases EpCAM-positive cancer cells.

https://www.ncbi.nlm.nih.gov/pubmed/24652762

The specific capture and remotely controlled release of the EpCAM-positive cancer cells from biotin-doped polypyrrole (Ppy) films in response to an electrical potential is presented. As Ppy allows the direct incorporation of biotin molecules during the electrochemical process, densely packed biotin molecules can serve as the binding sites for streptavidin-tagged biomolecular complexes. This study demonstrates not only the enhanced capture and enrichment of EpCAM-positive cancer cells but also "on-demand" release of the viable cells from conductive Ppy in an electrical-potential-dependent way. This novel approach is of great importance in a diverse range of applications, and in particular in cancer diagnostics and screening.

Voltammetric determination of imipramine hydrochloride and amitriptyline hydrochloride using a polymer-modified carbon paste electrode.

https://www.ncbi.nlm.nih.gov/pubmed/8951698

In this paper the voltammetric behaviors of imipramine.HCl and amitriptyline. HCl, which are both tricyclic antidepressants, were investigated using a carbon paste electrode, modified by the addition of poly(N-vinylimidazole), in various solutions of different pHs. It was shown that the current density for imipramine increased with modification of the carbon paste electrode and amitriptyline, which was electroinactive with the normal carbon paste electrode, became electroactive on the modified electrode. The optimum conditions for the quantitive determination of imipramine.HCl and amitriptyline.HCl were determined and statistical analysis of the linear relationship between current and concentration is given. The method was applied for the determination of these substances in the pharmaceutical dosage forms.

Electroactive self-doped poly(amic acid) with oligoaniline and sulfonic acid groups: synthesis and electrochemical properties.

https://www.ncbi.nlm.nih.gov/pubmed/24703661

A novel poly(amic acid) with pendant aniline tetramer and sulfonic acid groups (ESPAA) was synthesized by ternary polymerization and characterized by Fourier-transform infrared spectra, ((1))H NMR and gel permeation chromatography. The polymer showed good thermal stability and excellent solubility in the common organic solvents. The electrochemical properties were investigated carefully on a CHI 660A Electrochemical Workstation. The polymer displayed good electroactivity in acid, neutral and even in alkaline solutions (pH=1-10) due to the self-doping effect between aniline tetramer and sulfonic/carboxylic acid groups. It also exhibited satisfactory electrochromic performance with high contrast value, acceptable coloration efficiency and fast switching time in the range of pH=1-9.

Polyelectrolyte multilayers prepared from water-soluble poly(alkoxythiophene) derivatives.

https://www.ncbi.nlm.nih.gov/pubmed/11414842

Electronically conducting polyanion and polycation based on poly(alkoxythiophene) derivatives, poly-3-(3'-thienyloxy)propanesulfonate (P3TOPS) and poly-3-(3'-thienyloxy)propyltriethylammonium (P3TOPA) have been synthesized. Both polymers are water-soluble and exhibit high conjugation length in solution and in the solid state. These polyelectrolytes were used to prepare conducting and electroactive polyelectrolyte multilayers by the sequential layer-by-layer adsorption technique. In aqueous solutions multilayers of P3TOPS with inactive polyelectrolytes (e.g., poly(diallyldimethylammonium chloride), PDADMA) displayed electrochemical and optical behavior

similar to polythiophene films prepared in organic media. Their in-plane conductivity was low (ca. 1.6 x 10(-)(5) S cm(-)(1)). The conductivity could, however, be increased by a factor of ca. 40 in "all-thiophene" films, in which P3TOPA was substituted for the inactive polycation (PDADMA). The interpenetration of layers is of prime importance in films containing conducting components. The interpenetration of P3TOPS was studied by measuring the charge-transfer rate across an insulating polyelectrolyte multilayer between the substrate and the P3TOPS layer with modulated electroreflectance. The extent of interpenetration was 8-9 polyelectrolyte layers, the length scale (7-15 nm) depending on the nature of the insulating layer and, especially, on the ionic strength of the solution used for the adsorption of P3TOPS.

Transducers, sensors, and instrumentation in clinical biomechanics.

https://www.ncbi.nlm.nih.gov/pubmed/2657218

Successful measurements in any field are dependent on the availability of appropriate transducer materials and the associated instrumentation. In recent years there has been a most welcome advance in both these areas. If we consider first the transducer developments that have recently taken place, these have much to do with the discovery and application of new materials such as electroactive polymers, fibre optic devices and many others. Instrumentation has largely benefitted from the microelectronics revolution. Our ability to process and ultimately display data has improved to a remarkable extent. Indeed, the designer of instrumentation is under enormous pressure to convert the data into the digital domain as early as possible simply because the resulting instrument will usually be easier to design and construct, more accurate, more reliable, smaller and possibly more important still, cheaper. This paper reviews some of these developments, gives a number of examples of applications in the clinical biomechanics area and makes some predictions for future developments.

Permselective monolayer membrane based on two-dimensional cross-linked polysiloxane LB films for hydrogen peroxide detecting glucose sensors.

https://www.ncbi.nlm.nih.gov/pubmed/12510264

Novel two-dimensional (2D) cross-linked polysiloxane LB films were prepared and applied for glucose sensing as H2O2-permselective films in order to block other electroactive interferences, such as L-ascorbic acid, L-cysteine, uric acid and acetaminophen; the 2D cross-linked polysiloxane monolayers were remarkably effective in eliminating interfering responses and had a rapid response

for glucose, even though the films were only a monolayer thick.

Enabling variable-stiffness hand rehabilitation orthoses with dielectric elastomer transducers.

https://www.ncbi.nlm.nih.gov/pubmed/24275560

Patients affected by motor disorders of the hand and having residual voluntary movements of fingers or wrist can benefit from self-rehabilitation exercises performed with so-called dynamic hand splints. These systems consist of orthoses equipped with elastic cords or springs, which either provide a sustained stretch or resist voluntary movements of fingers or wrist. These simple systems are limited by the impossibility of modulating the mechanical stiffness. This limitation does not allow for customizations and real-time control of the training exercise, which would improve the rehabilitation efficacy. To overcome this limitation, 'active' orthoses equipped with devices that allow for electrical control of the mechanical stiffness are needed. Here, we report on a solution that relies on compact and light-weight electroactive elastic transducers that replace the passive elastic components. We developed a variable-stiffness transducer made of dielectric elastomers, as the most performing types of electromechanically active polymers. The transducer was manufactured with a silicone film and tested with a purposely-developed stiffness control strategy that allowed for electrical modulations of the force-elongation response. Results showed that the proposed new technology is a promising and viable solution to develop electrically controllable dynamic hand orthoses for hand rehabilitation.

Photophysical properties of sexi(3-methoxythiophene): evidence for energy migration in a conducting oligomer, based on fluorescence quenching.

https://www.ncbi.nlm.nih.gov/pubmed/10888443

The electronic absorption and fluorescence excitation and emission spectra of poly(3-methoxythiophene) (PMOT), a soluble, electroactive oligomer mainly constituted of hexamer, were investigated in dimethylsulfoxide at room temperature. The study of PMOT photophysical properties suggests the existence of important pi-electronic delocalization in the oxidized and reduced form of the oligomer. A significant fluorescence quenching of PMOT takes place in the presence of various quenchers such as dimethylterephthalate, potassium iodide and thallium acetate. Quenching mechanisms implying a quencher-induced intersystem-crossing step are proposed. Modified Stern-Volmer relationships were obtained with large quenching bimolecular rate

constants (2.7 x 10(9)-6.1 x 10(11) l mol(-1) s(-1)), which suggests electronic energy migration throughout the repeat units of the PMOT hexamer.

Reduction of acetaminophen interference in glucose sensors by a composite Nafion membrane: demonstration in rats and man.

https://www.ncbi.nlm.nih.gov/pubmed/7926347

Amperometric glucose sensors typically monitor the production of hydrogen peroxide generated in the course of the enzymatic oxidation of glucose. At the applied potential necessary to oxidize the peroxide produced, other species are also electroactive and contribute to the signal. Interference of ascorbate or urate has been effectively eliminated, but that resulting from the widely used analgesic acetaminophen is not. The aim of this work was to reduce this interference, which was found to be possible by introducing a membrane constructed of Nafion. We compared the in vitro sensitivity to acetaminophen of five Nafion sensors with that of five non-Nafion sensors with identical glucose sensitivity (2.0 +/- 0.4 vs 1.9 +/- 0.1 nA.mmol-1.l-1, NS): sensitivity to acetaminophen was 12.2 +/- 2.7 vs 30.8 +/- 6.3 nA.mmol-1.l-1, respectively (p < 0.05). These sensors were tested in rats by implanting in each animal one Nafion and one non-Nafion sensors. The in vivo sensitivity to glucose was similar (0.33 +/- 0.09 vs 0.30 +/- 0.05 nA.mmol-1.l-1, NS). The current generated by an acetaminophen infusion (plasma acetaminophen plateau = 140 +/- 10 mumol/l) was much decreased in the case of the Nafion sensor: 0.5 +/- 0.3 vs 2.0 +/- 0.7 nA, p < 0.05). Five Nafion sensors were implanted in the subcutaneous tissue of normal human volunteers who were given on oral dose of 500 mg acetaminophen.(ABSTRACT TRUNCATED AT 250 WORDS).

Exoelectrogenic biofilm as a template for sustainable formation of a catalytic mesoporous structure.

https://www.ncbi.nlm.nih.gov/pubmed/24771104

Mesoporous structures can increase catalytic activity by maximizing the ratio of surface area to volume, but current synthesis techniques utilize expensive polymers and toxic chemicals. A Geobacter sulfurreducens biofilm was used as a sustainable template to form mesoporous Pd structures while eliminating the need for synthetic chemicals. The bulk of the biofilm material was removed by thermal treatments after nanoparticle formation, producing a catalytic Pd mesoporous (pore size 9.7â€‰Â±â€‰0.1â€‰nm) structure attached to the graphite electrode with a 1.5-2â€‰Âµm thick backbone composed of nanoparticles (âˆ¼200â€‰nm). A control electrode

electrochemically plated with Pd in the absence of a biofilm exhibited a variable planar Pd base (âˆ¼0.5-3â€‰Âµm thick) with sporadic Pd extrusions (âˆ¼2â€‰Âµm across, 1-5â€‰Âµm tall) from the surface. The biotemplated mesoporous structure produced 15-20% higher stable current densities during H2 oxidation tests than the electrochemically plated control electrode, even though 30% less Pd was present in the biotemplated catalyst. These results indicate that electroactive biofilms can be used as a sustainable base material to produce nanoporous structures without the need for synthetic polymers. Biotechnol. Bioeng. 2014;111: 2349-2354.

Development of choline and acetylcholine Pt microelectrodes.

https://www.ncbi.nlm.nih.gov/pubmed/8297012

Choline (Ch) and acetylcholine (Ach) microenzyme sensors were developed based on the immobilization of choline oxidase (ChO) and acetylcholinesterase (AchE) at the tip of a 25-micron Pt wire sealed in glass. Several immobilization procedures were tested, including code-position of the enzyme/s with an electropolymer and cross-linking with glutaraldehyde. The various electropolymers used were 1,2-diaminobenzene, resorcinol, 4-hydroxybenzenesulfonic acid, and a combination of two polymers, 1,2-diaminobenzene and resorcinol. An inner membrane constructed from cellulose acetate (CA) was deposited prior to immobilization with glutaraldehyde. The analytical characteristics of the microelectrodes, including optimization of immobilization procedures, calibration curves, pH response curves, stability, and selectivity toward possible electroactive compounds found in the brain extracellular fluid, were determined. The best microelectrodes were prepared by cross-linking the enzymes with glutaraldehyde on top of the inner CA membrane. The responses are linear in the concentration range 5.0 x 10(-7)-1.0 x 10(-4) M Ch and 5.0 x 10(-7)-9.3 x 10(-5) M Ach. The time to reach 95% steady-state current was 15-20 s. The CA-coated Ch microelectrodes were useful for measurement of changes in Ch concentration in artificial brain extracellular fluid.

Electrochemical biosensing of non-electroactive targets using ferrocene-labeled magnetic particles and CNT wiring.

https://www.ncbi.nlm.nih.gov/pubmed/24482799

We show that target binding onto ferrocene-modified magnetic microparticles (MP-Fc) promotes physical sheltering of the labels. This can be measured electrochemically by CNT wiring, which enhances ten-fold the signals registered compared to direct detection of the MPs alone. As a proof

of concept, detection of detergents and antibodies is accomplished. In these preliminary experiments, random binding of 0.01% Tween 20 onto MP-Fc was detectable both voltametrically and impedimetrically after a 2 min incubation. Furthermore, affinity capture of 4 Î¼g mL(-1) of biotinylated antibody by streptavidin MP-Fc could be measured in less than 30 min and even in the presence of 1 mg mL(-1) of BSA.

Preparation and unique electrical behaviors of monodispersed hybrid nanorattles of metal nanocores with hairy electroactive polymer shells.

https://www.ncbi.nlm.nih.gov/pubmed/24519851

A versatile template-assisted strategy for the preparation of monodispersed rattle-type hybrid nanospheres, encapsulating a movable Au nanocore in the hollow cavity of a hairy electroactive polymer shell (Au@air@PTEMA-g-P3HT hybrid nanorattles; PTEMA: poly(2-(thiophen-3-yl)ethyl methacrylate; P3HT: poly(3-hexylthiophene), was reported. The Au@silica core-shell nanoparticles, prepared by the modified StÃ¶ber sol-gel process on Au nanoparticle seeds, were used as templates for the synthesis of Au@silica@PTEMA core-double shell nanospheres. Subsequent oxidative graft polymerization of 3-hexylthiophene from the exterior surface of the Au@silica@PTEMA core-double shell nanospheres allowed the tailoring of surface functionality with electroactive P3HT brushes (Au@silica@PTEMA-g-P3HT nanospheres). The Au@air@ PTEMA-g-P3HT hybrid nanorattles were obtained after etching of the silica interlayer by HF. The as-prepared nanorattles were dispersed into an electrically insulating polystyrene matrix and for the first time used to fabricate nonvolatile memory devices. As a result, unique electrical behaviors, including insulator behavior, write-once-read-many-times and rewritable memory effects, and conductor behavior as well, were observed in the Al/Au@air@PTEMA-g-P3HT+PS/ITO (ITO: indium-tin oxide) sandwich thin-film devices.

Rational design and synthesis of new polymeric material.

https://www.ncbi.nlm.nih.gov/pubmed/17817785

Polymers constitute one of the four main areas of materials science. Modern research in polymers focuses on the ways in which tailored macromolecules organize themselves in the solid state and on materials design and synthesis at the interface between polymer science and the fields of ceramics, metals, and electroactive or electrooptical materials.

Determination of desmosine, isodesmosine, and other amino acids by liquid chromatography with electrochemical detection following precolumn derivatization with naphthalenedialdehyde/cyanide.

https://www.ncbi.nlm.nih.gov/pubmed/2729574

Naphthalenedialdehyde (NDA) in the presence of cyanide (CN) reacts with primary amines to produce fluorescent cyano[f]benzoisoindole (CBI) derivatives. These derivatives have been shown to be substantially more stable than the corresponding o-phthalaldehyde derivatives. However, one drawback of this method is that compounds derivatized at more than one site exhibit quenching, precluding the use of fluorescence detection. The CBI derivatives have been found to be electroactive and are oxidized at a modest oxidation potential (+750 mV). Electrochemical detection is especially useful for the analysis of compounds containing more than one primary amine site because the response is not attenuated as it is in fluorescence detection. Desmosine and isodesmosine were of particular interest because of their importance in elastic fiber and the lack of highly sensitive HPLC methods for the determination of these compounds. Both of these compounds react with NDA/CN to produce electrochemically active derivatives. The combination of derivatization with NDA/CN and electrochemical detection was found to be linear over three orders of magnitude. Detection limits for CBI-lysine and CBI-desmosine were 100 fmol at a S/N of 2. Amino acids in elastin were quantitated using this method. The results correlate well with what has been reported previously in the literature. A significant advantage of the use of liquid chromatography with electrochemical detection with precolumn derivatization with NDA/CN for the analysis of desmosine and isodesmosine is that they can be separated and quantitated individually using this method. In addition, the unique voltammetry of multiderivatized CBI-amino acids can be used to verify peak purity.

Determination of diclofenac in pharmaceutical preparations using a novel PVC membrane sensor.

https://www.ncbi.nlm.nih.gov/pubmed/12622249

A novel potentiometric PVC membrane sensor for determination of diclofenac in pharmaceutical preparations has been developed. The sensor is based on the use of the 2,4,6-tri(2-pyridyl)-s-triazine iron(II) diclofenac complex [diclofenac-TPTZ-Fe(II)] as an electroactive material in a plasticized PVC membrane matrix. The sensor exhibits fast, stable and near Nernstian response for diclofenac over the concentration range 10(-2)-10(-6) M and pH 5.5-9.5. Application to

quality control analysis of diclofenac in various dosage forms shows an average recovery of 99% with a mean standard deviation of 0.2%. No significant interferences are caused by inorganic and organic anions and various drug excipients and diluents.

Reactive coupling of poly(ethylene glycol) on electroactive polyaniline films for reduction in protein adsorption and platelet adhesion.

https://www.ncbi.nlm.nih.gov/pubmed/11771698

Poly(ethylene glycol) (PEG)-coupled polyaniline (PANI) film surfaces were prepared by incorporating the chlorinie end-capped methoxy PEG (mPEGCl) of molecular weight of about 2000 onto the emeraldine (EM) base form of PANI via N-alkylation. The microstructure and composition of the mPEG-coupled PANI (mPEG-c-PANI) surfaces were characterized by atomic force microscopy, contact angle measurement and X-ray photoelectron spectroscopy. The concentration of surface-coupled mPEG increased with the increase in concentration of the mPEGCl solution. The mPEG-c-PANI film surfaces exhibited enhanced ability to repel protein adsorption, with only an moderate reduction in their electrical conductivity. The mPEG-c-PANI surface with a high concentration of coupled mPEG also exhibited good resistance towards platelet adhesion.

Direct electrochemistry of hemoglobin in layer-by-layer films with poly(vinyl sulfonate) grown on pyrolytic graphite electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/11339309

Stable layer-by-layer electroactive films were grown on pyrolytic graphite (PG) electrodes by alternate adsorption of layers of polyanionic poly(vinyl sulfonate) (PVS) and positively charged hemoglobin (Hb) from their aqueous solutions. Cyclic voltammetry (CV) of [PVS/Hb]n films showed a pair of well-defined and nearly reversible peaks at about - 0.28 V vs. SCE at pH 5.5, characteristic of Hb heme Fe(III)/Fe(II) redox couple. The process of (PVS/Hb) bilayer growth was monitored and confirmed by CV, X-ray photoelectron spectroscopy (XPS) and UV-Vis spectroscopy. While the amount of Hb adsorbed in each bilayer was the same, the amount of electroactive Hb in each bilayer decreased dramatically with increase of the number of bilayer, and electroactivity was just extended to 8 [PVS/Hb] bilayers. CVs of [PVS/Hb]8 films maintained stable in buffers containing no Hb. Positions of Soret band of Hb in [PVS/Hb]n films grown on transparent glass slides suggest that Hb in the films keeps its secondary structure similar to its native state in a wide pH range. Trichloroacetic acid and nitrite were catalytically reduced by [PVS/Hb]8 films with significant lowering

of the electrode potential required.

3,4-Alkylenedioxypyrroles: functionalized derivatives as monomers for new electron-rich conducting and electroactive polymers.

https://www.ncbi.nlm.nih.gov/pubmed/11597204

New functionalized derivatives of 3,4-ethylenedioxypyrrole (EDOP, 5a) and 3,4-(1,3-propylenedioxy)pyrrole (ProDOP, 5b) as especially electron-rich monomers which yield highly electroactive and stable conducting polymers useful for a diverse set of applications have been synthesized. N-Alkylations of ProDOP were carried out to yield a variety of ProDOP derivatives having alkyl, sulfonatoalkoxy, glyme, and glyme alcohol pendant chains. Iodization of EDOP and ProDOP via iodo-decarboxylation afforded iodo-functionalized derivatives useful for subsequent aryl coupling chemistry. N-Protection and formylation of EDOP, followed by Knoevenagel condensation of the resultant 2-formyl-EDOP with aryl acetonitrile derivatives, led to 1-cyano-2-(2-(3,4-ethylenedioxypyrryl))-1-(2-thienyl)vinylene (23) (Th-CNV-EDOP) and 1-cyano-2-(2-(3,4-ethylenedioxypyrryl))-1-(2-(3,4-ethylenedioxythienyl)vinylene (26) (EDOT-CNV-EDOP). A 14-crown-4-ether 34 based dioxypyrrole was synthesized with a cavity potentially useful for lithium ion coordination and sensing in the resultant electroactive polymer. C-Alkylated ProDOPs (43a, 43b, and 43c) containing octyl, ethylhexyl, and dioctyl substituents appended to the central methylene of the propylene bridge, were prepared as monomers for potentially soluble pi-conjugated polymers.

Copolymerization of electroactive poly(benzyl ether) dendrimer and terthiophene monomer.

https://www.ncbi.nlm.nih.gov/pubmed/24245306

In this study, we report the copolymerization, film properties, and HOMO/LUMO levels of the first generation (G1) poly(benzyl ether) dendrimer functionalized on its periphery with terthiophene and terthiophene monomers. Pure G1 dendrimer (DN1), 1:1 and 1:18 molar ratios of the G1 dendrimer and the monomer (e.g., DNTT11 and DNTT118, respectively) are used to compare film formation and HOMO/LUMO levels. The conjugated polymer network (CPN) film obtained from the highest molar ratio of terthiophene monomers shows smooth film formation. Addition of the terthiophene monomer for electrochemical cross-linking controls the surface morphology and the tunability of energy levels of the CPN films. Furthermore, in situ electrochemical quartz crystal microbalance (EQCM) measurements are performed to characterize frequency change (corresponding to mass

change) per sweep cycle and relative viscoelastic properties through resonant resistance-resonant frequency (R-F) diagram during the formation of each CPN film. The DN1 film has relatively higher eleastic film and mass loading on the QCM surface than the copolymeried DNTT11 and DNTT118 films. Furthermore, the addition of terthiophene monomers increases the viscosity of the film due to the effect of introducing linear species on the CNP film formation in solution. Thus, the copolymerization of eletroactive dendrimers with the same electroactive monomers enables control on surface morphological features and energy bandgap for future optoelectronic device applications and physical properties (i.e., viscoelasticity) of the films.

Operation of a miniature redox hydrogel-based pyruvate sensor in undiluted deoxygenated calf serum.

https://www.ncbi.nlm.nih.gov/pubmed/10905335

An amperometric sensor for the detection of pyruvate in biological fluids was formed by modifying the tip of a 0.25 mm gold wire with a layer of electrically "wired" recombinant pyruvate oxidase (POP). The sensor did not require O2 for its operation. The electroactive area of the tip of the microwire was increased by electrodeposition of platinum black. The POP was adsorbed on the platinum black and then "wired" with the cross-linked, subsequently deposited poly(4-vinylpyridine), part of the pyridine functions of which were complexed with [Os(bpy)2Cl](+/2+) and part quaternized with 2-bromoethylamine. In the resulting thin layer the POP was well "wired". When the electrode was poised at 0.4 V vs Ag/ AgCl, the sensitivity at pH 6 was 0.26 A cm(-2) M(-1) and the current increased linearly with the pyruvate concentration through the 2 x 10(-6) - 6 x 10(-4) M range. Thiamine diphosphate, flavin adenine dinucleotide, and MgCl2 were not required for the assay, but stabilized the stored enzyme electrode. Placement of a dialysis membrane (MWCO 3500) on the electrode alleviated the severe interference of ascorbate. In calf serum, the detection limit was 30 microM, suggesting that the electrode might be used in the continuous monitoring of pyruvate in hypoxic organs.

Imprinted polymer-based sensor system for herbicides using differential-pulse voltammetry on screen-printed electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/10489523

A sensor system for the herbicide 2,4-dichlorophenoxy-acetic acid has been developed based on specific recognition of the analyte by a molecularly imprinted polymer and electrochemical detection

using disposable screen-printed electrodes. The method involves a competitive binding step with a nonrelated electrochemically active probe. For batch binding assays, imprinted polymer particles are incubated in suspension with the analyte and the probe, followed by centrifugation and quantification of the unbound probe in the supernatant. Two different compounds, namely 2,4-dichlorophenol and homogentisic acid, were tested as potential electroactive probes. Both compounds could be conveniently detected by differential-pulse voltammetry on screen-printed, solvent-resistant three-electrode systems having carbon working electrodes. Whereas 2,4-dichlorophenol showed very high nonspecific binding to the polymer, homogentisic acid bound specifically to the imprinted sites and thus allowed calibration curves for the analyte in the micromolar range to be recorded. An integrated sensor was developed by coating the imprinted polymer particles directly onto the working electrode. Following incubation of the modified electrode in a solution containing the analyte and the probe, the bound fraction of the probe is quantified. This system provides a cheap, disposable sensor for rapid determination of environmentally relevant and other analytes.

Synthesis of doubly ethyl-bridged bis(p-sulfonatocalix[4]arene) and its supramolecular polymerization with viologen dimer.

https://www.ncbi.nlm.nih.gov/pubmed/24574110

A water-soluble supramolecular polymer with a high degree of polymerization and viscosity has been constructed based on the strong host-guest interaction between p-sulfonatocalix[4]arenes (SC4As) and viologen. A homoditopic doubly ethyl-bridged bis(p-sulfonatocalix[4]arene) (d-SC4A) was prepared and its binding behavior towards methyl viologen compared with the singly ethyl-bridged bis(p-sulfonatocalix[4]arene) (s-SC4A) by NMR spectroscopy and isothermal titration calorimetry. By employing a viologen dimer (bisMV(4+)) as the homoditopic guest, two linear AA/BB-type supramolecular polymers, d-SC4AâŠƒbisMV(4+) and s-SC4AâŠƒbisMV(4+), were successfully constructed. Compared with s-SC4AâŠƒbisMV(4+), d-SC4AâŠƒbisMV(4+) shows much higher solubility and viscosity, and has also been characterized by viscosity, diffusion-ordered NMR spectroscopy, dynamic light scattering, and atomic force microscopy measurements. Furthermore, the polymer is responsive to electrostimulus as viologen is electroactive, which was studied by cyclic voltammetry. This study represents a proof-of-principle as the polymer can potentially be applied as a self-healing and degradable polymeric material.

Applications of electrochemical immunosensors to environmental monitoring.

https://www.ncbi.nlm.nih.gov/pubmed/8639278

This paper discusses basic electrochemical immunoassay technology. Factors limiting the practical application of antibodies to analytical problems are also presented. It addresses the potential use of immunoassay methods based on electrochemical detection for the analysis of environmental samples. It provides examples for the detection and quantitation of environmental samples using conducting electroactive polymers (CEPs). CEP-based immunosensing systems are compared with conventional environmental immunoassay procedures. The advantages of using these types of sensors for rapid, sensitive, and cost-effective analysis of pesticides and toxic chemicals are analysed and discussed. CEP-based immunosensing technology might eventually be used for continuous monitoring of effluents such as waste streams to determine compliance with regulations. CEP-based sensors are suitable for monitoring ground-water, waste stream effluents, agricultural run-offs and for monitoring the effectiveness of remediation, or for other situations where a real-time monitoring capability is desired.

Cross-linked redox gels containing glucose oxidase for amperometric biosensor applications.

https://www.ncbi.nlm.nih.gov/pubmed/2305956

Oxidoreductases, such as glucose oxidase, can be electrically "wired" to electrodes by electrostatic complexing or by covalent binding of redox polymers so that the electrons flow from the enzyme, through the polymer, to the electrode. We describe two materials for amperometric biosensors based on a cross-linkable poly(vinylpyridine) complex of [Os-(bpy)2Cl]+2+ that communicates electrically with flavin adenine dinucleotide redox centers of enzymes such as glucose oxidase. The uncomplexed pyridines of the poly(vinylpyridine) are quaternized with two types of groups, one promoting hydrophilicity (2-bromoethanol or 3-bromopropionic acid), the other containing an active ester (N-hydroxysuccinimide) that forms amide bonds with both lysines on the enzyme surface and with an added polyamine cross-linking agent (triethylenetetraamine, trien). In the presence of glucose oxidase and trien this polymer forms rugged, cross-linked, electroactive films on the surface of electrodes, thereby eliminating the requirement for a membrane for containing the enzyme and redox couple. The glucose response time of the resulting electrodes is less than 10 s. The glucose response under N2 shows an apparent Michaelis constant, Km' = 7.3 mM, and limiting current densities, jmax, between 100 and 800 microA/cm2. Currents are decreased by 30-50% in air-saturated solutions because of competition between O2 and the Os(III) complex for electrons

from the reduced enzyme. Rotating ring desk experiments in air-saturated solutions containing 10 mM glucose show that about 20% of the active enzyme is electrooxidized via the Os(III) complex, while the rest is oxidized by O2. These results suggest that only part of the active enzyme is in electrical contact with the electrode.

A semiconductive polymer film sensor for glucose.

https://www.ncbi.nlm.nih.gov/pubmed/3435563

The electrical conductivity of organic polymers such as polyacetylene and its derivatives can be varied over twelve orders of magnitude with small amounts (0-3%) of various dopants, such as iodine, bromine, and perchloric acid. Semiconductive polyacetylene film doped with iodine is sensitive to hydrogen peroxide, and can be used as a quantitative hydrogen peroxide sensor. A rapid, quantitative sensor for glucose, using the flavoprotein glucose oxidase, is described and introduces a novel electroactive material, polyacetylene, as the basis for a new biosensor. A significant increase in the sensitivity of this device has been obtained by mediating the doping reaction through lactoperoxidase and potassium iodide.

Ultrasensitive enzyme-free electrochemical immunosensor based on hybridization chain reaction triggered double strand DNA@Au nanoparticle tag.

https://www.ncbi.nlm.nih.gov/pubmed/24468362

An ultrasensitive enzyme-free electrochemical immunoassay was developed for detection of the fg/mL level carcinoembryonic antigen (CEA) by using a double strand DNA@Au nanoparticle (dsDNA@AuNP) tag and hexaammineruthenium(III) chloride (RuHex) as the electroactive indicator. The dsDNA@AuNP was synthesized by one-pot hybrid polymerization of dsDNA on initiator DNA modified AuNPs via hybridization chain reaction. The immunosensor was prepared by covalently cross-linking capture antibody on chitosan/AuNP nanocomposite modified glass carbon electrode. The AuNPs accelerated the electron transfer and led to high detection sensitivity. With a sandwich-type immunoreaction and a biotin-streptavidin affinity reaction, the dsDNA@AuNP tag was conjugated on the immunocomplex to bring a high amount of RuHex to the electrode surface via electrostatic interaction, resulting in an amplified electrochemical signal. Under optimal conditions, the proposed sensing platform showed a wide linear detection range from 10 fg/mL to 10 ng/mL along with a detection limit of 3.2 fg/mL for CEA. The immunosensor exhibited high sensitivity and good stability, showing a promising application in early cancer diagnosis and could be extended

to sensitive electrochemical biosensing of other analytes.

Filtration capture and immunoelectrochemical detection for rapid assay of Escherichia coli O157:H7.

https://www.ncbi.nlm.nih.gov/pubmed/9617826

A new approach for rapid assay of bacteria in liquid samples is described. Cells were labeled by incubation with an enzyme-antibody conjugate and captured by filtration of the sample/conjugate mixture through a 0.2 microm filter. The enzyme-labeled cells were detected by placing the filter on the surface of an electrode, incubating with enzyme substrate, and measuring the current produced by oxidation of the electroactive enzyme product. Assay time was 25 min and a detection limit of approximately 5000 cells/ml was obtained for E. coli O157:H7. Background current due to non-specific binding of conjugate to the filter was the primary factor controlling the detection limit, and fewer than 50 cells could be detected when very small sample volumes (10 microl) were used to minimize background current.

Electroactive liquid lens driven by an annular membrane.

https://www.ncbi.nlm.nih.gov/pubmed/24690736

Unlike traditional focalization that recruits multiple moving lens elements to adjust focus, liquid lenses deliver adaptive focusing by simply tuning the surface profile of liquid or the elastomer that encloses liquid. Its simple and compact configuration, low cost, and actuation efficiency promise wide industrial, medical, and consumer applications. Dielectric elastomers (DEs), one type of commercially available soft active material, have been a good fit for creating adaptive optics. In this Letter, we present an adaptive, membrane-sealed liquid lens hydrostatically coupled to a concentric annular DE actuator. Electric actuation deforms the annular DE, which induces fluid transmission between the lens part and the actuation part for lens actuation. The maximum measured focal range was from 25.4 to 105.2 mm within 1.0 kV, which significantly outperforms the existing DE-actuated liquid lenses and eliminates the need for prestraining. The lens also enables varied focal ranges by simply adjusting its initial surface sagitta, providing flexibility for practical imaging applications.

Electropolymerization of pyrrole and immobilization of glucose oxidase in a flow system: influence of the operating conditions on analytical performance.

https://www.ncbi.nlm.nih.gov/pubmed/9642772

The in situ potentiostatic electropolymerization of pyrrole (Py) on a Pt electrode in a thin-layer amperometric cell and the entrapment of the enzyme glucose oxidase (GOx) for the determination of glucose are reported. Polypyrrole (PPy) is directly formed by continuous passage of a buffered solution of the monomer (0.4 M) and enzyme (250 U mL-1) at pH 7 at a flow rate of 0.05-0.1 mL min-1 under a constant applied potential of +0.85 V vs Ag/AgCl decreases. The electrosynthesis of PPy by injection of 500 microL of a Py + GOx solution in a carrier electrolyte consisting of 0.05 M phosphate buffer and 0.1 M KCl at pH 7.0 was also assayed. The influence of the electropolymerization conditions on the analytical response of the sensor to glucose was investigated. The analytical performance of the PPy/GOx sensor was also studied in terms of durability and storage life, as well as selectivity against electroactive species such as ascorbic acid and uric acid as a function of the thickness of the polymer film formed.

Potential shifts at electrodes coated with ion-exchange polymeric films.

https://www.ncbi.nlm.nih.gov/pubmed/18965952

Voltammetry at electrodes modified with ion-exchange polymers, named "ion exchange voltammetry", has been recently developed for characterizing and determining quantitatively ionic electroactive analytes preconcentrated at the electrode surface. Like for other voltammetric techniques, characterization is based on the position of the response on the potential scale, but an appreciable difference is frequently observed between the formal half-wave potential for redox couples incorporated within ion-exchange polymeric films and those for the same redox couples in solution as measured at bare electrodes. Such a difference has been rationalized here by a generalized equation, inferred from a suitable elaboration of the Nernst equation, whose validity has been tested by a thorough investigation performed at glassy carbon electrodes modified with either cationic (Nafion) or anionic (Tosflex) polymeric films. With this purpose, the effect of both charge and concentration of the analyte and of the loading counterion, this last introduced as the cation or anion of the supporting electrolyte, of the ion-exchange selectivity coefficients of the redox partners and of their stoichiometric coefficients, as well as of the number of electrons involved in the charge transfer has been evaluated. The results obtained agree quite well with theoretical expectations and indicate that the potential shifts found are mainly conditioned by both charge and concentration of the counterion from the supporting electrolyte and by the ratio of the ion-exchange equilibrium constants for the two redox partners involved. Other parameters considered have no influence on

the potential shift or lead to negligible effects, provided that the quantities of the redox partners incorporated within the ion-exchange coating represents less than 5% of the film capacity. Again in agreement with theoretical expectations, positive shifts are found for increasing supporting electrolyte concentrations when cationic redox species incorporated within cationic films are involved, while the opposite effect is found for anionic redox species incorporated within anionic films.

DNA-based hybridization chain reaction for an ultrasensitive cancer marker EBNA-1 electrochemical immunosensor.

https://www.ncbi.nlm.nih.gov/pubmed/24632131

An ultrasensitive and selective electrochemical immunosensor was developed for the detection of Epstein Barr virus nuclear antigen 1 (EBNA-1). Firstly, a suspension of graphene sheets (GS) and multi-walled carbon nanotubes (MWCNTs) was prepared with the aid of chitosan (CS) solution and then modified on a glassy carbon electrode (GCE). Gold nanoparticles (AuNPs) were then electrodeposited onto the surface of the GS-MWCNTs film by cyclic voltammetry (CV) to immobilize the captured antibodies. After that, specific sandwich immunoreactions were formed among the captured antibody, EBNA-1, and secondary antibody, DNA-coated carboxyl multi-wall carbon nanotubes (DNA-MWCNTs-Ab2). DNA initiator strands (S0) and secondary antibodies linked to the MWCNTs and double-helix DNA polymers were obtained by hybridization chain reaction (HCR), and here S0 on the MWCNTs propagates a chain reaction of hybridization events between two alternating hairpins to form a nicked double-helix. Finally, electroactive indicator doxorubicin hydrochloride was intercalated into the CG-GC steps between the HCR products and could produce an electrochemical signal, which was monitored by differential pulse voltammetry (DPV). Under optimum conditions, the amperometric signal increased linearly with the target concentrations (0.05-6.4ngmL(-1)), and the immunosensor exhibited a detection limit as low as 0.7pgmL(-1) (S/N=3). The proposed method showed acceptable stability and reproducibility, as well as favorable recovery for EBNA-1 in human serum. The proposed immunosensor provides a novel avenue for signal amplification and potential applications in bioanalysis and clinical diagnostics.

Supramolecular chemistry of carbon nanotubes.

https://www.ncbi.nlm.nih.gov/pubmed/23756847

This chapter aims to present recent examples of supramolecular functionalization of carbon

nanotubes. The non-covalent functionalization appears as a solution for the future applications in nanotechnologies since it allows the functionalization and manipulation of nanotubes without the introduction of sp (3) defects in the Ï€-conjugated system. Thus, the optical and electronic properties of the nanotubes remain preserved. In the first part of this chapter, we present the use of surfactant for the dispersion of nanotubes and its application for sorting. Then we report several examples of functionalization of nanotubes based on Ï€-stacking interactions with pyrene derivatives. Finally, in the last part we review the wrapping of photo/electroactive polymers around the nanotube sidewalls. We put a particular focus on polyflurorene-based polymers and we show their utilization for the separation of nanotubes in diameter and chirality.

Fast low-voltage electroactive actuators using nanostructured polymer electrolytes.

https://www.ncbi.nlm.nih.gov/pubmed/23896756

Electroactive actuators have received enormous interest for a variety of biomimetic technologies ranging from robotics and microsensors to artificial muscles. Major challenges towards practically viable actuators are the achievement of large electromechanical deformation, fast switching response, low operating voltage and durable operation. Here we report a new electroactive actuator composed of self-assembled sulphonated block copolymers and ionic liquids. The new actuator demonstrated improvements in actuation properties over other polymer actuators reported earlier, large generated strain (up to 4%) without any signs of back relaxation. In particular, the millimetre-scale displacements obtained for the actuators, with rapid response (<1â€‰s) at sub-1-V conditions over 13,500 cycles in air, have not been previously reported in the literature. The key to success stems from the evolution of the unique hexagonal structure of the polymer layer with domain size gradients beneath the cathode during actuation, which promotes the bending motion of the actuators.

Work function maps and surface topography characterization of nitroaromatic-ended dendron films on graphite.

https://www.ncbi.nlm.nih.gov/pubmed/24164921

Surface topography and work function maps were simultaneously obtained for carbon surfaces modified by a dendritic molecule: 3,5-Bis (3,5-dinitrobenzoylamino) benzoic acid. The dendrons were spontaneously assembled onto highly ordered pyrolytic graphite samples, exhibiting an increase in the surface potential. This fact is consistent with the incorporation of an

electron-acceptor functional group that remains electroactive on the surface.

A novel amperometric biosensor based on a co-crosslinked L-lysine-Î±-oxidase/overoxidized polypyrrole bilayer for the highly selective determination of L-lysine.

https://www.ncbi.nlm.nih.gov/pubmed/23998537

An amperometric biosensor for the determination of L-lysine based on L-lysine-Î±-oxidase immobilized by co-crosslinking on a platinum electrode previously modified by an overoxidized polypyrrole film is described. The optimization of experimental parameters, such as pH and flow rate, permitted to minimize significantly substrate interferences even using a low specific, commercial enzyme. The relevant biases introduced in the measurement of lysine were just about 1% for L-arginine, L-histidine and L-ornithine, roughly 4% for L-phenylalanine and L-tyrosine. The developed approach allowed linear lysine responses from 0.02 mM up to 2 mM with a sensitivity of 41 nA/(mM Ã— mm(2)) and a detection limit of 4 Î¼M (S/N=3). No appreciable loss in lysine sensitivity was observed up to about 40 days. Allowing polypyrrole layer to remove interference from electroactive compounds, the present method revealed suitable to detect L-lysine in a pharmaceutical and cheese sample, showing a good agreement with the expected values.

Improved biosensor for glucose based on glucose oxidase-immobilized silk fibroin membrane.

https://www.ncbi.nlm.nih.gov/pubmed/10230021

Based on glucose oxidase-immobilized silk fibroin membrane and oxygen electrode, the authors have developed an amperometric glucose sensor in flow-injection analysis. After the sensor was improved by the configuration of oxygen electrode and a temperature control system was added to the electrode body, its sensitivity, analytical precision, and stability were enhanced greatly. The authors first introduced a tailing inhibitor-ion pair reagent into a buffer system in the biosensor so as to eliminate all interference from hemacyte, macromolecules, and small mol wt charged species besides electroactive specie ascorbate in complex matrices. A considerably serious tailing of the biosamples, such as whole blood, plasma, serum, or urine on the sensor, based on enzyme electrode, entirely disappeared, their response times were shortened, and base lines became more smooth and stable. The glucose sensor has a broad range of linear response for glucose (up to 25.0 mmol/L) and a good correlation (gamma = 0.999) under conditions of control temperature 32.0 degrees C and 1.6 mL/min 0.02 mol/L phosphate buffer containing 0.5% tailing inhibitor (v/v).

Recoveries of glucose in these biosamples are within the range of 93.71-105.88%, and its repeatabilities for determining glucose, repeated 100 times, human blood dilution 125 times, and serum 128 times, are 1.81, 2.48, and 2.91% (RSD), respectively. The correlation analysis for 200 serum samples showed that the correlation (gamma) is 0.9934 between the glucose sensor and Worthington method for determining serum glucose used conventionally in a hospital laboratory. Moreover, the enzyme membrane used in the biosensor can be stored for a long time (over 2 yr) and measured repeatedly over 1000 times for biosamples. The glucose sensor is capable of detecting over 60 biosamples/hr.

Direct determination of cadmium and lead in whole blood by potentiometric stripping analysis.

https://www.ncbi.nlm.nih.gov/pubmed/1394983

The commercially available equipment for potentiometric stripping analysis (PSA) was tested for routine lead and cadmium determination in whole-blood samples. In contrast to anodic stripping voltammetry, PSA is not subject to background interferences from organic electroactive constituents in the sample or to the presence of dissolved oxygen (i.e., oxygen removal is not necessary). To determine lead and cadmium by PSA, it is sufficient to dilute the blood sample with an appropriate supporting electrolyte (0.5 mol/L HCl). The detection limit changes with deposition time and volume of blood sample used. For 1 mL of blood and a 1-min deposition time, the detection limit is 1 microgram/L for both elements. If the deposition time increases to 10 min, cadmium can be determined at its normal concentration in blood (the detection limit is improved to < 0.1 microgram/L). Procedures for routine determination of lead and cadmium in whole blood are presented.

Piezoelectric fiber-composite-based cantilever sensor for electric-field-induced strain measurement in soft electroactive polymer.

https://www.ncbi.nlm.nih.gov/pubmed/24081263

Polymeric materials have been widely used in electronic and electromechanical transducer applications. Because of their low elastic modulus, it is quite challenging to accurately characterize the electric-field-induced strain and elastic modulus by conventional contact methods. In this paper, a piezoelectric lead zirconate titanate (PZT) fiber-composite-based cantilever strain sensor has been investigated to accurately characterize the electric-field-induced strain response in the out-of-plane

direction of soft electroactive polymer samples. By choosing appropriate substrate material and the thickness ratio of the fiber composite to the substrate, this strain sensor can be optimized to provide high sensitivity and high flexibility simultaneously. The high voltage sensitivity can be attributed to partial decoupling of the longitudinal and transverse piezoelectric responses, the improved piezoelectric coefficient and small dielectric permittivity. The high flexibility is due to the reduced flexural spring constant of the composite-based cantilever device. Both theoretical modeling of the PZT fiber-composite-based cantilever device and experimental verification are performed in this work. The results indicate that the piezoelectric PZT fiber-composite-based cantilever strain sensor can accurately characterize the electric-field-induced small strain in electroactive soft polymers with high reliability.

Bioactive surface design based on functional composite electrospun nanofibers for biomolecule immobilization and biosensor applications.

https://www.ncbi.nlm.nih.gov/pubmed/24660809

The combination of nanomaterials and conducting polymers attracted remarkable attention for development of new immobilization matrices for enzymes. Hereby, an efficient surface design was investigated by modifying the graphite rod electrode surfaces with one-step electrospun nylon 6,6 nanofibers or 4% (w/w) multiwalled carbon nanotubes (MWCNTs) incorporating nylon 6,6 nanofibers (nylon 6,6/4MWCNT). High-resolution transmission electron microscopy study confirmed the successful incorporation of the MWCNTs into the nanofiber matrix for nylon 6,6/4MWCNT sample. Then, these nanofibrous surfaces were coated with a conducting polymer, (poly-4-(4,7-di(thiophen-2-yl)-1H-benzo[d]imidazol-2-yl)benzaldehyde) (PBIBA) to obtain a high electroactive surface area as new functional immobilization matrices. Due to the free aldehyde groups of the polymeric structures, a model enzyme, glucose oxidase was efficiently immobilized to the modified surfaces via covalent binding. Scanning electron microscope images confirmed that the nanofibrous structures were protected after the electrodeposition step of PBIBA and a high amount of protein attachment was successfully achieved by the help of high surface to volume ratio of electroactive nanofiber matrices. The biosensors were characterized in terms of their operational and storage stabilities and kinetic parameters (K(m)(app) and Imax). The resulting novel glucose biosensors revealed good stability and promising Imax values (10.03 and 16.67 Î¼A for nylon 6,6/PBIBA and nylon 6,6/4MWCNT/PBIBA modified biosensors, respectively) and long shelf life (32 and 44 days for nylon 6,6/PBIBA and nylon 6,6/4MWCNT/PBIBA modified biosensors, respectively).

Finally, the biosensor was tested on beverages for glucose detection.

[Study on the coated carbon PVC membrane selective electrode of aconitine].

https://www.ncbi.nlm.nih.gov/pubmed/2094641

Coated carbon PVC membrane selective electrode of aconitine was prepared with the Aconitine-tetraphenylborate ion-associate complex as the electroactive material. The electrode showed a linear response to aconitine within the concentration range 1.0 x 10(-2) - 5.0 x 10(-5) mol/L. The limit of detection was 6.3 x 10(-6) mol/L and the slope of the electrode was 57.6 mV/decade. The authors established a basis and a method for the control of content limit of aconitine in Shen Fu Injection with this electrode.

Electrocoating carbon fiber microelectrodes with Nafion improves selectivity for electroactive neurotransmitters.

https://www.ncbi.nlm.nih.gov/pubmed/2893860

A method which improves carbon fiber microelectrode selectivity for cationic amines by electrocoating the fiber with a thin film of the ionic polymer, Nafion, is described. The selectivity and response speed of these electrodes for the detection of electroactive cationic and anionic species found in brain extracellular fluid was evaluated using differential pulse voltammetry and chronoamperometry and compared to uncoated fibers. Carbon fiber microelectrodes electrocoated with Nafion are highly sensitive to cationic amines such as dopamine and serotonin and have minimal sensitivity to anions such as ascorbic acid and uric acid at physiological concentrations.

Conductive polymers: towards a smart biomaterial for tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/24556448

Developing stimulus-responsive biomaterials with easy-to-tailor properties is a highly desired goal of the tissue engineering community. A novel type of electroactive biomaterial, the conductive polymer, promises to become one such material. Conductive polymers are already used in fuel cells, computer displays and microsurgical tools, and are now finding applications in the field of biomaterials. These versatile polymers can be synthesised alone, as hydrogels, combined into composites or electrospun into microfibres. They can be created to be biocompatible and biodegradable. Their physical properties can easily be optimized for a specific application through

binding biologically important molecules into the polymer using one of the many available methods for their functionalization. Their conductive nature allows cells or tissue cultured upon them to be stimulated, the polymers' own physical properties to be influenced post-synthesis and the drugs bound in them released, through the application of an electrical signal. It is thus little wonder that these polymers are becoming very important materials for biosensors, neural implants, drug delivery devices and tissue engineering scaffolds. Focusing mainly on polypyrrole, polyaniline and poly(3,4-ethylenedioxythiophene), we review conductive polymers from the perspective of tissue engineering. The basic properties of conductive polymers, their chemical and electrochemical synthesis, the phenomena underlying their conductivity and the ways to tailor their properties (functionalization, composites, etc.) are discussed.

Controlled Aloin Release from Crosslinked Polyacrylamide Hydrogels: Effects of Mesh Size, Electric Field Strength and a Conductive Polymer.

https://www.ncbi.nlm.nih.gov/pubmed/28788360

The aim of this paper is to investigate the effects of hydrogel mesh size, a conductive polymer, and electric field strength on controlled drug delivery phenomena using drug-loaded polyacrylamide hydrogels prepared at various crosslinking ratios both with and without a conductive polymer system. Poly(p-phenylene vinylene), PPV, as the model conductive polymer, was used to study its ability to control aloin released from aloin-doped poly(p-phenylene vinylene)/polyacrylamide hydrogel (aloin-doped PPV/PAAM). In the passive release, the diffusion of aloin from five aloin-doped PPV/PAAM hydrogel systems each was delayed ranging from during the first three hours to during the first 14 h due to the ionic interaction between the anionic drug and PPV. After the delayed periods, aloin could diffuse continuously into the buffer solution through the PAAM matrix. The amount of aloin released from the aloin-doped PPV/PAAM rose with increasing electric field strength as a result of the three mechanisms: the expansion of PPV chains inside the hydrogel, iontophoresis, and the electroporation of the matrix pore size, combined. Furthermore, the conductive polymer and the electric field could be used in combination to regulate the amount of release drug to a desired level, to control the release rate, and to switch the drug delivery on/off.

Tuning the fluorescent response of a novel electroactive polymer with multiple stimuli.

https://www.ncbi.nlm.nih.gov/pubmed/24105939

A novel polymer featuring oligoaniline pendants that exhibits reversible electroactivity and good

electrochromic properties with high contrast value, acceptable switching times, and excellent coloration efficiency is presented. This polymer can undergo reversible changes in fluorescence in response to reductive and oxidative chemical stimulus, pH, and electrical potential. The fluorescence switching operation shows reasonable reversibility and reproducibility when subjected to multiple stimuli. In this elegant fluorescence switching system, the oligoaniline pendants are used as fluorophore and regulatory units simultaneously.

DNA interaction of [Cu(dmp)(phen-dion)] (dmp=4,7 and 2,9 dimethyl phenanthroline, phen-dion=1,10-phenanthroline-5,6-dion) complexes and DNA-based electrochemical biosensor using chitosan-carbon nanotubes composite film.

https://www.ncbi.nlm.nih.gov/pubmed/23811151

The interaction of two new water-soluble [Cu(4,7-dmp)(phen-dione)Cl]Cl (1) and [Cu(2,9-dmp)(phen-dione)Cl]Cl (2) which dmp is dimethyl-1,10-phenanthroline and phen-dion represents 1,10-phenanthroline-5,6-dion, with DNA in solution and immobilized DNA on a chitosan-carbon nanotubes composite modified glassy carbon electrode were investigated by cyclic voltammetry and UV-Vis spectroscopy techniques. In solution interactions, spectroscopic and electrochemical evidences indicate outside binding of these complexes. To clarify the binding mode of complexes, it was done competition studies with Hoechst and Neutral red as groove binder and intercalative probes, respectively. All these results indicating that, these two complexes (1) and (2) interact with DNA via groove binding and partially intercalative modes, respectively. The electrochemical characterization experiments showed that the nanocomposite film of chitosan-carbon nanotubes could effectively immobilize DNA and greatly improve the electron-transfer reactions of the electroactive molecules that latter finding is the result of strong interactions between captured DNA and Cu complexes. This result indicates that these complexes could be noble candidates as hybridization indicators in further studies. At the end, these new complexes showed excellent antitumor activity against K562 (human chronic myeloid leukemia) cell lines.

gamma-irradiation-induced grafting of poly (styrenesulfonate) to poly(tetrafluoroethylene) shielded microelectrodes.

https://www.ncbi.nlm.nih.gov/pubmed/8030794

A new method for the fabrication and polymer modification of microelectrodes is described. These

electrodes are constructed by heat sealing the electroactive material in dual shrink/melt poly(tetrafluoroethylene) (PTFE) under vacuum. The PTFE shield may be activated to provide a support upon which polymers of interest may be grafted. gamma-Irradiation was used to graft polymerize styrene to the surface. The poly-(styrene) was subsequently sulfonated with chlorosulfonic acid to form poly(styrenesulfonate). Scanning electron microscopy and Raman microspectroscopy provide evidence that the poly-(styrenesulfonate) film has been formed and extends over the electrode material. Voltammetry indicates that hexaammine-ruthenium(III) cation is preconcentrated and stabilized via an association with the polymer film.

High-performance supercapacitors based on hollow polyaniline nanofibers by electrospinning.

https://www.ncbi.nlm.nih.gov/pubmed/23586693

Hollow polyaniline (PANI) nanofibers with controllable wall thickness are fabricated by in situ polymerization of aniline using the electrospun poly(amic acid) fiber membrane as a template. A maximum specific capacitance of 601 F g(-1) has been achieved at 1 A g(-1), suggesting the potential application of hollow PANI nanofibers for supercapacitors. The superior electrochemical performance of the hollow nanofibers is attributed to their hollow structure, thin wall thickness, and orderly pore passages, which can drastically facilitate the ion diffusion and improve the utilization of the electroactive PANI during the charge-discharge processes. Furthermore, the high flexibility of the self-standing fiber membrane template provides possibilities for the facile construction and fabrication of conducting polymers with hollow nanostructures, which may find potential applications in various high-performance electrochemical devices.

XPS Study of Counterion Incorporation into Poly(vinylferrocene).

https://www.ncbi.nlm.nih.gov/pubmed/21644780

XPS provides answers to two significant issues that arise in studying electroactive polymers. First, what fraction of possible charge centers participates in the redox process? Second, what are the relative partition coefficients of two counterions that compete as charge-compensating counterions? To answer both these questions, we emersed (or immersed) poly(vinylferrocene) films from (or into) supporting electrolytes while maintaining potential control to govern the electrochemical history of the electroactive film. We found that all ferrocene units in the surface of a poly(vinylferrocene) film deposited on gold can be oxidized when the counterion is perchlorate, tetrafluoroborate,

hexafluorophosphate, tosylate, or 1,5-naphthalenedisulfonate. In answering the second question, no internal standard was needed:â€‰ the concentration ratios of the two competing ions in both water and polymer phases were used as the experimental variables. For the completely oxidized ferricinium film, we found that the partition coefficient of perchlorate ions is 67% of that of fluoroborate ions.

Surface molecularly imprinted polymers-based electrochemical sensor for bovine hemoglobin recognition.

https://www.ncbi.nlm.nih.gov/pubmed/24089215

A novel electrochemical sensor for bovine hemoglobin (BHb) recognition and detection was prepared by a surface molecularly imprinted technique. Aldehyde group-functionalized silica microspheres were modified on an Au electrode surface, and these were subsequently covalently bound with the template molecule, BHb, through imine bonds. Electropolymerization was performed to deposit polypyrrole onto the above modified electrode surface. A three-dimensional macroporous structural sensor was obtained after etching of silica and the extraction of BHb. Differential pulse voltammetry (DPV) and electrochemical impedance spectroscopy (EIS) were employed to characterize the fabrication process of the sensor using [Fe(CN)6](3-)/[Fe(CN)6](4-) as an electroactive probe. Since all imprinted cavities were situated at the surface of the polymers, the prepared sensor exhibited considerably fast binding kinetics. Compared to other non-template proteins, the sensor showed an excellent recognition capacity for BHb. Moreover, the prepared sensor also exhibited a dependent relationship between the concentration of BHb and the peak current of [Fe(CN)6](3-)/[Fe(CN)6](4-).

Water-stable, adaptive, and electroactive supramolecular ionic material and its application in biosensing.

https://www.ncbi.nlm.nih.gov/pubmed/24724737

Developing water-stable and adaptive supramolecular materials is of great importance in various research fields. Here, we demonstrate a new kind of water-stable, adaptive, and electroactive supramolecular ionic materials (SIM) that is formed from the aqueous solutions of imidazolium-based dication and dianionic dye (i.e., 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid), ABTS) through ionic self-assembly. The formed SIM not only shows good thermostability and unique optical and electrochemical properties that are raised from precursors of the SIM, but also

exhibits good water-stability, salt-stability, and adaptive encapsulation properties toward some heterocyclic cationic dye molecules. UV-vis and FT-IR results demonstrate that this encapsulation property is essentially based on the electrostatic interactions between the guest dye molecules and ABTS in the SIM. The application of the SIM prepared here is illustrated by the development of a new electrochemical sensor for NADH sensing at a low potential. This study not only opens a new avenue to the preparation of the supramolecular materials, but also provides a versatile platform for electrochemical (bio)sensing.

Superior pseudocapacitive behavior of confined lignin nanocrystals for renewable energy-storage materials.

https://www.ncbi.nlm.nih.gov/pubmed/24678040

Strong demand for high-performance energy-storage devices has currently motivated the development of emerging capacitive materials that can resolve their critical challenge (i.e., low energy density) and that are renewable and inexpensive energy-storage materials from both environmental and economic viewpoints. Herein, the pseudocapacitive behavior of lignin nanocrystals confined on reduced graphene oxides (RGOs) used for renewable energy-storage materials is demonstrated. The excellent capacitive characteristics of the renewable hybrid electrodes were achieved by synergizing the fast and reversible redox charge transfer of surface-confined quinone and the interplay with electron-conducting RGOs. Accordingly, pseudocapacitors with remarkable rate and cyclic performances (~96â€‰% retention after 3000 cycles) showed a maximum capacitance of 432 F g(-1), which was close to the theoretical capacitance of 482 F g(-1) and sixfold higher than that of RGO (93 F g(-1)). The chemical strategy delineated herein paves the way to develop advanced renewable electrodes for energy-storage applications and understand the redox chemistry of electroactive biomaterials.

Polymeric materials as artificial muscles: an overview.

https://www.ncbi.nlm.nih.gov/pubmed/24700263

The accurate selection of materials and the fine tuning of their properties represent a fundamental aspect in the realization of new active systems able to produce actuating forces, such as artificial muscles. In this regard, exciting opportunities for the design of new advanced systems are offered by materials belonging to the emerging class of functional polymers: exploiting their actuation response, specific devices can be realized. Along this direction, materials showing either

shape-memory effect (SME) or shape-change effect (SCE) have been the subject of extensive studies aimed at designing of actuators as artificial muscles. Here, we concisely review active polymers in terms of properties and main applications in artificial muscle design.

Three approaches to the development of selective bilayer amperometric biosensors for glucose by in situ electropolymerization.

https://www.ncbi.nlm.nih.gov/pubmed/10605893

Three different glucose oxidase biosensors for the enzymatic determination of glucose, based on bilayer polymer coatings consisting of polypyrrole (PPy) and poly(o-phenylenediamine), were developed. The electrode substrates are Pt metal, carbon paste and an organic conducting salt (tetrathiafulvalene-tetracyanoquinodimethane), which introduces appreciable variability in the electrode construction process. The three sensors were compared with one another and with bare and PPy monolayer-coated sensors in terms of performance in the determination of glucose in a synthetic serum sample. These configurations provide improved selectivity against the interferences of electroactive species such as ascorbic acid and uric acid, frequently present in biological samples, and the differences between them can be taken advantage of in application to different kinds of samples.

A lightweight push-pull acoustic transducer composed of a pair of dielectric elastomer films.

https://www.ncbi.nlm.nih.gov/pubmed/24181987

A lightweight push-pull acoustic transducer using dielectric elastomer films was proposed for use in advanced audio systems in homes. The push-pull structure consists of two dielectric elastomer films developed to serve as an electroactive polymer. The transducer utilizes the change in the surface area of the dielectric elastomer film, induced by an electric-field-induced change in the thickness, for sound generation. The resonance frequency of the transducer was derived from modeling the push-pull configuration to estimate the lower limit of the frequency range. Measurement results presented an advantage of push-pull driving in the suppression of harmonic distortion.

Biofuel cell for generating power from methanol substrate using alcohol oxidase bioanode and air-breathed laccase biocathode.

https://www.ncbi.nlm.nih.gov/pubmed/24727604

We report here an alcohol oxidase (AOx) based third generation bioanode for generating power from methanol substrate in a fuel cell setup using air breathed laccase biocathode. A composite three dimensional microporous matrix containing multiwalled carbon nanotubes, carbon paste and nafion was used as electroactive support for immobilization of the enzymes on toray carbon paper as supporting electrode in the fabrication of the bioelectrodes. Polyethylenimine was used to electrostatically stabilize the AOx (pI 4.3) on the anode operating on direct electrochemistry principle. Osmium tetroxide on poly (4-vinylpyridine) was used to wire the laccase for electron transfer in the biocathode. The enzymatic biofuel cell (EFC) generated an open circuit potential of 0.61 (Â±0.02) V with a maximum power density of 46 (Â±0.002) ÂµW cm(-2) at an optimum of 1M methanol, 25 Â°C and an internal resistance of 0.024 ÂµÎ©. The operation and storage half life (t1/2) of the EFC were 17.22 h and 52 days, respectively at a fixed load of 1.85 Î©. The findings have demonstrated the feasibility of developing EFC using AOx based bioanode and laccase based biocathode without applying any toxic free mediator and metal electrode supports for generating electricity.

High-speed electrically actuated elastomers with strain greater than 100%

https://www.ncbi.nlm.nih.gov/pubmed/10657293

Electrical actuators were made from films of dielectric elastomers (such as silicones) coated on both sides with compliant electrode material. When voltage was applied, the resulting electrostatic forces compressed the film in thickness and expanded it in area, producing strains up to 30 to 40%. It is now shown that prestraining the film further improves the performance of these devices. Actuated strains up to 117% were demonstrated with silicone elastomers, and up to 215% with acrylic elastomers using biaxially and uniaxially prestrained films. The strain, pressure, and response time of silicone exceeded those of natural muscle; specific energy densities greatly exceeded those of other field-actuated materials. Because the actuation mechanism is faster than in other high-strain electroactive polymers, this technology may be suitable for diverse applications.

Photodecomposition of ferrocenedicarboxylic acid in methanol to form an electroactive infinite coordination polymer and its application in bioelectrochemistry.

https://www.ncbi.nlm.nih.gov/pubmed/23869481

Accurately characterizing the product of photodecomposition of ferrocene derivatives remains a longstanding challenge due to its structural complexity and strong dependence on the solvent and

the substituent. Herein, photodecomposition of ferrocenedicarboxylic acid (FcDC) in methanol is found for the first time to form an electroactive infinite coordinate polymer (ICP) with uniform size, good water stability and photostability, and excellent electrochemical activity. The possible mechanism for the ICP formation is proposed based on the fission of the Fe-ring bond and deprotonation of FcDC under light irradiation. The dissociated Fe(2+) is first oxidized to Fe(3+) that consequently coordinates with the deprotonated ferrocene dicarboxylate to produce ICP nanoparticles. This work not only provides a new insight into the product formation of the photodecomposition of ferrocene derivatives but also offers a mild and simple route to the synthesis of electroactive ICPs.

Enzyme-modified carbon-fiber microelectrode for the quantification of dynamic fluctuations of nonelectroactive analytes using fast-scan cyclic voltammetry.

https://www.ncbi.nlm.nih.gov/pubmed/23919631

Neurotransmission occurs on a millisecond time scale, but conventional methods for monitoring nonelectroactive neurochemicals are limited by slow sampling rates. Despite a significant global market, a sensor capable of measuring the dynamics of rapidly fluctuating, nonelectroactive molecules at a single recording site with high sensitivity, electrochemical selectivity, and a subsecond response time is still lacking. To address this need, we have enabled the real-time detection of dynamic glucose fluctuations in live brain tissue using background-subtracted, fast-scan cyclic voltammetry. The novel microbiosensor consists of a simple carbon fiber surface modified with an electrodeposited chitosan hydrogel encapsulating glucose oxidase. The selectivity afforded by voltammetry enables quantitative and qualitative measurements of enzymatically generated H2O2 without the need for additional strategies to eliminate interfering agents. The microbiosensors possess a sensitivity and limit of detection for glucose of 19.4 Â± 0.2 nA mM(-1) and 13.1 Â± 0.7 Î¼M, respectively. They are stable, even under deviations from physiological normoxic conditions, and show minimal interference from endogenous electroactive substances. Using this approach, we have quantitatively and selectively monitored pharmacologically evoked glucose fluctuations with unprecedented chemical and spatial resolution. Furthermore, this novel biosensing strategy is widely applicable to the immobilization of any H2O2 producing enzyme, enabling rapid monitoring of many nonelectroactive enzyme substrates.

Pure blue-light emissive poly(oligofluorenes) with bifunctional poss in the main chain.

https://www.ncbi.nlm.nih.gov/pubmed/24677615

Emission of conjugated polymers is known to undergo bathochromic shift from solution to film formation due to Ï€-Ï€ stacking in the solid state. In this report, a series of pearl-necklace-like hybrid polymers is designed via the hydrosilylation condensation between bifunctional polyhedral oligomeric silsesquioxanes (B-POSS) and oligofluorene segments. Optoelectronic analyses unequivocally show that the presence of these interconnecting B-POSS can effectively reduce red-shift in photoluminescence and electroluminescence during film formation. These hybrid poly(oligofluorenes) display stable blue emission with high color purity. Thermal analyses also indicate that they are vitrified polymers with high glass transition temperature (up to 125 Â°C). We believe that this strategy can be extended to other conjugated systems to control color purity in electroactive materials and holds promise as new emissive materials for various applications.

Electrochemical generation of ferrylmyoglobin during oxidation of styrene with films of DNA and a poly (ester sulfonic acid) ionomer.

https://www.ncbi.nlm.nih.gov/pubmed/10443014

The chemistry of electrochemically-driven myoglobin-catalyzed oxidation of styrene was investigated in films of DNA or Eastman AQ ionomer on optically transparent electrodes. Conversion of styrene to styrene oxide proceeded via a ferrylmyoglobin radical intermediate. Ferrylmyoglobins were clearly detected by spectroelectrochemistry in films of 1-4 mm thick. The ferrylmyoglobin radical is produced by reaction of metmyoglobin (Mb) in the films with hydrogen peroxide formed by electrochemical catalytic reduction of oxygen catalyzed by Mb. Thus, electrochemically-driven styrene oxidation with these films proceeds by a 'doubly catalytic' electrode-driven reduction-oxidation pathway. Ferrylmyoglobin formation during electrolysis of Mb-DNA films in aerobic solutions was much faster, and styrene oxidation occurred with less Mb decomposition compared to the Mb-AQ films. The better performance of Mb-DNA films is correlated with a larger fraction of electroactive Mb and better stability than for the Mb-AQ films.

Encapsulation of TiO2 nanoparticles with poly(4-vinylpyridine) using surface functionalized thiol-lactam initiated radical polymerization.

https://www.ncbi.nlm.nih.gov/pubmed/23858899

A nanocomposite of TiO2 nanoparticle with an electroactive poly(4-vinylpyridine) (PVP) was synthesized via a simple surface thiol-lactam initiated radical polymerization upon grafting from

protocol. This can be achieved through the primary modification of the TiO2 surface with a silane coupling agent leading to thiol functionalized TiO2 (TiO2-SH). Subsequently, a controlled radical polymerization of 4-vinylpyridine in the presence of TiO2-SH and butyrolactam afforded PVP-g-TiO2 nanocomposites. The grafting of PVP on the surface of TiO2 was confirmed by FT-IR, TGA, XPS, EDX, TEM and SEM analyses. The UV-vis studies of the synthesized PVP-g-TiO2 nanocomposite demonstrated an exceptionally good dispersibility in organic solvents.

Nanogold-functionalized DNAzyme concatamers with redox-active intercalators for quadruple signal amplification of electrochemical immunoassay.

https://www.ncbi.nlm.nih.gov/pubmed/23488856

A novel and in situ amplified immunoassay strategy with quadruple signal amplification was designed for highly efficient electrochemical detection of low-abundance proteins (carcinoembryonic antigen, CEA, as a model) by using nanogold-functionalized DNAzyme concatamers with redox-active intercalators. To construct such an in situ amplification system, streptavidin-labeled gold nanoparticles (AuNP-SA) were initially used for the labelling of initiator strands (S0) and detection antibody (mAb2) with a large ratio (mAb2-AuNP-S0), and then two auxiliary DNA strands S1 and S2 were designed for in situ propagation of DNAzyme concatamers with the hemin/G-quadruplex format. The quadruple signal amplification was implemented by using the avidin-biotin chemistry, nanogold labels, DNA concatamers, and DNAzymes. In the presence of target CEA, the sandwiched immunocomplex was formed between the immobilized primary antibodies on the electrode and the conjugated detection antibodies on the mAb2-AuNP-S0. The carried S0 initiator strands could progress a chain reaction of hybridization events between alternating S1/S2 DNA strands to form a nicked double-helix. Upon addition of hemin, the hemin-binding aptamers could be bound to form the hemin/G-quadruplex-based DNAzymes. The formed double-helix DNA polymers could cause the intercalation of numerous electroactive methylene blue molecules. During the electrochemical measurement, the formed DNAzymes could catalyze the reduction of H2O2 in the solution to amplify the electrochemical signal of the intercalated methylene blue. Under optimal conditions, the electrochemical immunoassay exhibited a wide dynamic range of 1.0 fg mL(-1) to 20 ng mL(-1) toward CEA standards with a low detection limit of 0.5 fg mL(-1). Intra-assay and inter-assay coefficients of variation (CV) were less than 8.5% and 11.5%, respectively. No significant differences at the 0.05 significance level were encountered in the analysis of 14 clinical serum specimens between the developed immunoassay and

commercialized electrochemiluminescent (ECL) method for detection of CEA.

Differential pulse polarographic determination of poly(8-hydroxyquinoline) in the presence and absence of an insulating poly(vinyl alcohol) matrix.

https://www.ncbi.nlm.nih.gov/pubmed/12012200

The electrochemical activity of poly(8-hydroxyquinoline) (PHQ) in acid and alkaline media has been investigated by use of differential pulse polarography (DPP). The reduction peak height (I(p)) of PHQ in universal buffer solutions is not useful as an analytical signal, because it is highly affected by hydrogen evolution in acid media and appears as a small peak located at more negative potential values in alkaline media. A new and highly sensitive reduction peak (E(p)=-0.45, pH 9.25) appears, however, after addition of trace amounts of PHQ to Cu(II), or vice versa. This reduction peak is a result of the reduction of Cu(II) chelates in the PHQ-Cu(II) complex and is highly promising for the trace determination of PHQ at nanomolar and submicromolar levels. The response current (I(p)/mu A) for the reduction peak of Cu(II) chelates in a PHQ-Cu(II) matrix results in sensitivity to the concentration of PHQ at least three orders of magnitude higher than that for the reduction peak of PHQ alone under the same conditions. The limit of detection is as low as 5.264 ppb (microg L(-1)). The effect of a variety of anions and cations and of an insulating poly(vinyl alcohol) (PVA) matrix has been investigated. Electroactive PHQ-Cu(II) at a level of 0.685% could induce a current of approximately 240 nA in an insulating PVA matrix, suggesting possible application for the preparation of a PHQ-Cu(II)-PVA electroactive composite.

Nanocomposites of iridium oxide and conducting polymers as electroactive phases in biological media.

https://www.ncbi.nlm.nih.gov/pubmed/24394636

Much effort is currently devoted to implementing new materials in electrodes that will be used in the central nervous system, either for functional electrostimulation or for tests on nerve regeneration. Their main aim is to improve the charge capacity of the electrodes, while preventing damaging secondary reactions, such as peroxide formation, occurring while applying the electric field. Thus, hybrids may represent a new generation of materials. Two novel hybrid materials are synthesized using three known biocompatible materials tested in the neural system: polypyrrole (PPy), poly(3,4-ethylenedioxythiophene) (PEDOT) and iridium oxide (IrO2). In particular, PPy-IrO2 and PEDOT-IrO2 hybrid nanocomposite materials are prepared by chemical polymerization in

hydrothermal conditions, using IrO2 as oxidizing agent. The reaction yields a significant ordered new hybrid where the conducting polymer is formed around the IrO2 nanoparticles, encapsulating them. Scanning electron microscopy and backscattering techniques show the extent of the encapsulation. Both X-ray photoelectron and Fourier transform infrared spectroscopies identify the components of the phases, as well as the absence of impurities. Electrochemical properties of the final phases in powder and pellet form are evaluated by cyclic voltammetry. Biocompatibility is tested with MTT toxicity tests using primary cultures of cortical neurons grown in vitro for 6 and 9days.

Synthesis of a novel fluorescent amphiphilic chitosan biopolymer: photophysical and electrochemical behavior.

https://www.ncbi.nlm.nih.gov/pubmed/23904038

The present investigation describes for the first time, the synthesis and detailed characterization of a novel fluorescent and amphiphilic chitosan polymer (3) containing fluorescent peryleneimide chromophores for biomedical applications. The polymer 3 is moderately soluble in a wide range of organic solvents and aqueous solutions, unlike chitosan (2). The Mw of 3 and 2 determined by GPC were 467 kDa and 460 kDa, respectively. The photophysical and electrochemical properties measured in solution and solid states are engrossing. is soluble in the entire pH range and exhibits excimer emission above pH 5. In solution, 3 is electroactive but 2 is not. Whereas in the solid-state, 3 shows one quasi-reversible oxidation and reversible reduction step and 2 exhibits only one quasi-reversible oxidation step. Our results point out a new class of organic biopolymers that could yield promising potentials in many biomedical applications.

Polypyrrole-heparin composites as stimulus-responsive substrates for endothelial cell growth.

https://www.ncbi.nlm.nih.gov/pubmed/10397912

Heparin is a potent anticoagulant which can be immobilized on biomaterial surfaces to increase their hemocompatability. In the present work, we have electrochemically synthesized composites comprising heparin and the electrically conducting polymer polypyrrole. The incorporation and exposure of heparin were controlled by varying key conditions of polymer synthesis (i.e., applied current and synthesis time). The resulting composite polymers were electroactive after synthesis and the amount of heparin exposed in the polymer could be increased (up to threefold) by switching the polymers from their oxidized to reduced states. Polymer reduction was achieved by either

application of negative potentials (-0.4 to -0.7 V for 90 s) or exposure to aqueous reductant (0.1M sodium dithionite for 30 min). Heparin-polypyrrole composites remained stable after autoclaving, displaying no significant loss of electroactivity, and had a shelf life of at least 2 years postautoclaving. Finally, the composites were found to be excellent substrates for the growth of human endothelial cells.

Double network bacterial cellulose hydrogel to build a biology-device interface.

https://www.ncbi.nlm.nih.gov/pubmed/24288113

Establishing a biology-device interface might enable the interaction between microelectronics and biotechnology. In this study, electroactive hydrogels have been produced using bacterial cellulose (BC) and conducting polymer (CP) deposited on the BC hydrogel surface to cover the BC fibers. The structures of these composites thus have double networks, one of which is a layer of electroactive hydrogels combined with BC and CP. The electroconductivity provides the composites with capabilities for voltage and current response, and the BC hydrogel layer provides good biocompatibility, biodegradability, bioadhesion and mass transport properties. Such a system might allow selective biological functions such as molecular recognition and specific catalysis and also for probing the detailed genetic and molecular mechanisms of life. A BC-CP composite hydrogel could then lead to a biology-device interface. Cyclic voltammetry and electrochemical impedance spectroscopy (EIS) are used here to study the composite hydrogels' electroactive property. BC-PAni and BC-PPy respond to voltage changes. This provides a mechanism to amplify electrochemical signals for analysis or detection. BC hydrogels were found to be able to support the growth, spreading and migration of human normal skin fibroblasts without causing any cytotoxic effect on the cells in the cell culture. These double network BC-CP hydrogels are biphasic Janus hydrogels which integrate electroactivity with biocompatibility, and might provide a biology-device interface to produce implantable devices for personalized and regenerative medicine.

Minimal-Fouling enzyme electrode for continuous flow measurement of whole blood lactate.

https://www.ncbi.nlm.nih.gov/pubmed/9451796

A new membrane system evaluated in an enzyme electrode for monitoring of whole blood lactate under continuous flow conditions has been developed. The membrane confers functional haemocompatibility and has been coupled to an electrode based on amperometric detection of hydrogen peroxide with lactate oxidase interposed between the haemocompatible membrane acting

as diffusion barrier and an inner membrane excluding interfering electroactive species. Here, the enzyme electrode is combined with a flow-through measuring chamber and a double lumen catheter permitting continuous sampling and heparinization of blood. The blood contacting membranes have unique haemocompatibility properties and were produced through modification of poly(vinyl chloride), with the nonionic surfactant Pluronic F-68. On-line monitoring of whole blood samples with different amounts of added lactate was carried out to simulate fluctuations in blood lactate levels during extracorporeal monitoring and results were compared with a standard lactate analyser.

Covalent immobilization of glucose oxidase on the surface of polyaniline films graft copolymerized with acrylic acid.

https://www.ncbi.nlm.nih.gov/pubmed/9678849

Glucose oxidase (GOD) was covalently immobilized on the electroactive polyaniline (PAN) film with surface-grafted acrylic acid (AAc) polymer through the amide linkage formation between amino groups of GOD and the carboxyl groups of the grafted AAc polymer chains in the presence of a water-soluble carbodiimide. The surface structure and composition of the graft-modified and enzyme-functionalized PAN films were characterized by angle-resolved X-ray photoelectron spectroscopy (XPS). The amounts of immobilized GOD and its activity were also investigated. It was shown that the amount of immobilized GOD increased linearly with the concentration of surface-grafted AAc polymer chains. The decrease in activity of the immobilized GOD was considered to be due to, among other factors, the reduced accessibility of glucose molecules to the active sites of the enzyme and the conformational change of the GOD molecules as a result of the covalent immobilization. However, the immobilized enzyme was less sensitive to thermal inactivation as compared to that of the free form. The optimum pH value of GOD was not affected by the immobilization reaction and the pH stability range was considerably widened. The immobilized GOD also exhibits a significantly improved stability during storage in buffer solution over that of the free enzyme.

A thin-layer electrochemical detector coated with nafion film for liquid chromatography.

https://www.ncbi.nlm.nih.gov/pubmed/3429544

The selectivity and analytical application of a thin-layer electrochemical detector comprised of glassy carbon electrode coated with Nafion film were investigated. As a result of the ion-exchange characteristics of the Nafion polymer, the selectivity and stability were improved greatly. The coated

electrode has a good response only for cations with the same sensitivity as an uncoated (bare) electrode, but not for anions, and the response for neutral molecules is decreased three-fold. The diffusion of electroactive compounds in Nafion film is discussed based on the results of flow injection experiments. The peak current at the coated electrode was independent of the flow-rate of the mobile phase. Electrode poisoning due to protein adsorption was minimized. The use of 30% methanol or 10% acetonitrile in the mobile phase did not affect the performance of the coated electrode. Various analytes having three kinds of charge state, i.e., anionic, cationic and neutral, were tested. Liquid chromatography with electrochemical detection of ascorbic acid, norepinephrine, epinephrine, dopamine and uric acid was demonstrated.

Tunable lenses using transparent dielectric elastomer actuators.

https://www.ncbi.nlm.nih.gov/pubmed/23571956

Focus tunable, adaptive lenses provide several advantages over traditional lens assemblies in terms of compactness, cost, efficiency, and flexibility. To further improve the simplicity and compact nature of adaptive lenses, we present an elastomer-liquid lens system which makes use of an inline, transparent electroactive polymer actuator. The lens requires only a minimal number of components: a frame, a passive membrane, a dielectric elastomer actuator membrane, and a clear liquid. The focal length variation was recorded to be greater than 100% with this system, responding in less than one second. Through the analysis of membrane deformation within geometrical constraints, it is shown that by selecting appropriate lens dimensions, even larger focusing dynamic ranges can be achieved.

Electroactive polymers and macromolecular electronics.

https://www.ncbi.nlm.nih.gov/pubmed/17819225

Electrodes can be coated with electrochemically reactive polymers in several microstructural formats called sandwich, array, bilayer, micro-, and ion-gate electrodes. These microstructures can be used to study the transport of electrons and ions through the polymers as a function of the polymer oxidation state, which is essential for understanding the conductivity properties of these new chemical materials. The microstructures also exhibit potentially useful electrical and optical responses, including current rectification, charge storage and amplification, electron-hole pair separation, and gates for ion flow.

An interference-free and rapid electrochemical lateral-flow immunoassay for one-step ultrasensitive detection with serum.

https://www.ncbi.nlm.nih.gov/pubmed/24482801

Point-of-care testing (POCT) of biomarkers in clinical samples is of great importance for rapid and cost-effective diagnosis. However, it is extremely challenging to develop an electrochemical POCT technique retaining both ultrasensitivity and simplicity. We report an interference-free electrochemical lateral-flow immunoassay that enables one-step ultrasensitive detection with serum. The electrochemical-chemical-chemical (ECC) redox cycling combined with an enzymatic reaction of an enzyme label is used to obtain high signal amplification. The ECC redox cycling involving Ru(NH3)6(3+), enzyme product, and tris(3-carboxyethyl)phosphine (TCEP) depends on pH, because the formal potentials of an enzyme product and TCEP increase with decreasing pH although that of Ru(NH3)6(3+) is pH-independent. With consideration of the pH dependence of ECC redox cycling, a noble combination of enzyme label, substrate, and product [Î²-galactosidase, 4-amino-1-naphthyl Î²-D-galactopyranoside, and 4-amino-1-naphthol, respectively] is introduced to ensure fast and selective ECC redox cycling of the enzyme product along with a low background level. The selective ECC redox cycling at a low applied potential (0.05 V vs. Ag/AgCl) minimizes the interference effect of electroactive species (L-ascorbic acid, acetaminophen, and uric acid) in serum. A detection limit of 0.1 pg mL(-1) for troponin I is obtained only 11 min after serum dropping without the use of an additional solution. Moreover, the lateral-flow immunoassay is applicable to the analysis of real clinical samples.

Electroactive layer-by-layer plasmonic architectures based on Au nanorods.

https://www.ncbi.nlm.nih.gov/pubmed/24564705

Nanostructured films based on Au nanorods (NRs) have been obtained by layer-by-layer (LbL) assembly driven by electrostatic interaction between metal nanoparticles and polyelectrolytes. Multilayer films have been fabricated by using LbL assembly of poly(sodium styrenesulfonate) (PSS) and positively charged Au NRs on a polyelectrolyte-modified substrate. The effect of fabrication parameters, including the nature of the substrate, the polyelectrolyte initial anchoring layer, and the number of layers has been investigated by means of UV-vis absorbance spectroscopy and atomic force microscopy (AFM). The results demonstrated the dependence of morphology and plasmonic features in the multilayered nanostructured architectures from the nature of the anchoring polyelectrolyte on the substrate, the number of layers, and the kind of NR mutual assembly. In

addition, a study of the electrochemical activity at the solid/liquid interface has been carried out in order to assess charge transport through the NR multilayer by using two molecular probes in solution, namely, potassium ferricyanide, a common and well-established redox mediator with reversible behavior, and cytochrome C, a robust model redox protein. The presented systematic study of the immobilization of Au NRs opens the venue to several application areas, such as (bio)chemical sensing.

Electrochemical detection of oligopeptides through the precolumn formation of biuret complexes.

https://www.ncbi.nlm.nih.gov/pubmed/1880187

The relatively slow kinetics of formation of the electroactive Cu(II)-peptide complexes from larger (greater than 6 amino acids) peptides requires relatively high temperature and long reaction times for a postcolumn reactor. The precolumn incubation of bradykinin, Tyr8-bradykinin and insulin A chain with biuret reagent for 20 min at 60 degrees C leads to the formation of biuret complexes which can be subjected to chromatography in acidic or basic eluents. These complexes are detected electrochemically with a sensitivity similar to the Cu(II)-(ala)3 complex (1 nC/pmol at 1.0 ml/min). The influence of the column-packing material on the electrochemical detector response of the Cu-peptide complexes has also been studied.

Electrochemically mediated electrodeposition/electropolymerization to yield a glucose microbiosensor with improved characteristics.

https://www.ncbi.nlm.nih.gov/pubmed/11811410

A procedure is described that provides for electrochemically mediated deposition of enzyme and a polymer layer permselective for endogenous electroactive species. Electrodeposition was first employed for the direct immobilization of glucose oxidase to produce a uniform, thin, and compact film on a Pt electrode. Electropolymerization of phenol was then employed to form an anti-interference and protective polyphenol film within the enzyme layer. In addition, a stability-reinforcing membrane derived from (3-aminopropyl)trimethoxysilane was constructed by electrochemically assisted cross-linking. This hybrid film outside the enzyme layer contributed to the improved stability and permselectivity. The resulting glucose sensor was characterized by a short response time (<4 s), high sensitivity (1200 nA/mM x cm2), low interference from endogenous electroactive species, and working lifetime of more than 50 days.

Fabrications and Applications of Stimulus-Responsive Polymer Films and Patterns on Surfaces: A Review.

https://www.ncbi.nlm.nih.gov/pubmed/28788489

In the past two decades, we have witnessed significant progress in developing high performance stimuli-responsive polymeric materials. This review focuses on recent developments in the preparation and application of patterned stimuli-responsive polymers, including thermoresponsive layers, pH/ionic-responsive hydrogels, photo-responsive film, magnetically-responsive composites, electroactive composites, and solvent-responsive composites. Many important new applications for stimuli-responsive polymers lie in the field of nano- and micro-fabrication, where stimuli-responsive polymers are being established as important manipulation tools. Some techniques have been developed to selectively position organic molecules and then to obtain well-defined patterned substrates at the micrometer or submicrometer scale. Methods for patterning of stimuli-responsive hydrogels, including photolithography, electron beam lithography, scanning probe writing, and printing techniques (microcontact printing, ink-jet printing) were surveyed. We also surveyed the applications of nanostructured stimuli-responsive hydrogels, such as biotechnology (biological interfaces and purification of biomacromoles), switchable wettability, sensors (optical sensors, biosensors, chemical sensors), and actuators.

Propulsion of swimming microrobots inspired by metachronal waves in ciliates: from biology to material specifications.

https://www.ncbi.nlm.nih.gov/pubmed/24103844

The quest for swimming microrobots originates from possible applications in medicine, especially involving navigation in bodily fluids. Swimming microorganisms have become a source of inspiration because their propulsion mechanisms are effective in the low-Reynolds number regime. In this study, we address a propulsion mechanism inspired by metachronal waves, i.e. the spontaneous coordination of cilia leading to the fast swimming of ciliates. We analyse the biological mechanism (referring to its particular embodiment in Paramecium caudatum), and we investigate the contribution of its main features to the swimming performance, through a three-dimensional finite-elements model, in order to develop a simplified, yet effective artificial design. We propose a bioinspired propulsion mechanism for a swimming microrobot based on a continuous cylindrical electroactive surface exhibiting perpendicular wave deformations travelling longitudinally along its main axis. The simplified propulsion mechanism is conceived specifically for microrobots that embed

a micro-actuation system capable of executing the bioinspired propulsion (self-propelled microrobots). Among the available electroactive polymers, we select polypyrrole as the possible actuation material and we assess it for this particular embodiment. The results are used to appoint target performance specifications for the development of improved or new electroactive materials to attain metachronal-waves-like propulsion.

Induced redox responsiveness and electroactivity for altering the properties of micelles without external stimuli.

https://www.ncbi.nlm.nih.gov/pubmed/24737104

Control over micelle properties is vital in the field of drug delivery, and the ability to modify these properties in order to trigger dissociation is highly desirable. We prepared polymeric micelles with the ability to undergo dissociation over time without the need for external stimulation by incorporating an electroactive and redox responsive segment into amphiphilic copolymers. The incorporation of this segment also provides the ability to tailor the critical micelle concentration (CMC) and micelle size of the copolymers. Amphiphilic PEG-PLA copolymers were functionalized by coupling to an aniline pentamer in two different oxidation states (leucoemeraldine and emeraldine state). The incorporation of the electroactive and redox responsive aniline pentamer decreased the CMCs and the micelle size, independent of the oxidation state. However, the copolymers with the aniline pentamer in the leucoemeraldine state had significantly lower CMCs than the copolymers with the aniline pentamer in the emeraldine state. Simultaneously, stability tests performed on the functionalized micelles demonstrated the oxidation of the aniline segment, from the leucoemeraldine to the emeraldine state, over time. The oxidation led to an increase in the CMC, and the copolymers could thereby represent an excellent starting point for triggering drug release without external stimuli.

Potential-driven chirality manifestations and impressive enantioselectivity by inherently chiral electroactive organic films.

https://www.ncbi.nlm.nih.gov/pubmed/24500795

The typical design of chiral electroactive materials involves attaching chiral pendants to an electroactive polyconjugated backbone and generally results in modest chirality manifestations. Discussed herein are electroactive chiral poly-heterocycles, where chirality is not external to the electroactive backbone but inherent to it, and results from a torsion generated by the periodic

presence of atropisomeric, conjugatively active biheteroaromatic scaffolds, (3,3'-bithianaphthene). As the stereogenic element coincides with the electroactive one, films of impressive chiroptical activity and outstanding enantiodiscrimination properties are obtained. Moreover, chirality manifestations can be finely and reversibly tuned by the electric potential, as progressive injection of holes forces the two thianaphthene rings to co-planarize to favor delocalization. Such deformations, revealed by CD spectroelectrochemistry, are elastic and reversible, thus suggesting a breathing system.

In vitro study of electroactive tetraaniline-containing thermosensitive hydrogels for cardiac tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/24597966

Injectable hydrogels made of degradable biomaterials can function as both physical support and cell scaffold in preventing infarct expansion and promoting cardiac repair in myocardial infarction therapy. Here, we report in situ hydrogels consisting of thermosensitive PolyNIPAM-based copolymers and electroactive tetraaniline (TA). Studies showed that the addition of 2-methylene-1,3-dioxepane (MDO) provided the PolyNIPAM-based gel with biodegradability, and the introduction of tetraaniline endowed these copolymers with desirable electrical properties and antioxidant activities. The encapsulated H9c2 cells (rat cardiac myoblast) remained highly viable in the gel matrices. In vivo gel formation and histological analyses were performed in rats by subcutaneous injection and excellent biocompatibility was observed. Furthermore, the proliferation and intracellular calcium transients of H9c2 cells were also studied with (and without) electrical stimuli. Both in vitro and in vivo results demonstrated that electroactive hydrogel may be used as a promising injectable biomaterial for cardiac tissue engineering.

Ultra-wide-range electrochemical sensing using continuous electrospun carbon nanofibers with high densities of states.

https://www.ncbi.nlm.nih.gov/pubmed/24547786

Carbon-based sensors for wide-range electrochemical detection of redox-active chemical and biological molecules were fabricated by the electrospinning of polyacrylonitrile fibers directly onto a polyacrylonitrile-coated substrate followed by carbonization at 1200 Â°C. The resulting electrospun carbon nanofibers (ECNFs) were firmly attached to the substrate with good mesh integrity and had high densities of electronic states (DOS), which was achieved without need for further modifications

or the use of any additives. The mass of ECNFs deposited, and thus the electroactive surface area (ESA) of the sensor, was adjusted by varying the electrospinning deposition time, thereby enabling the systematic manipulation of the dynamic range of the sensor. A standard redox probe (Fe(CN)6(3-/4-)) was used to demonstrate that the ECNF sensor exhibits strong electrocatalytic activity without current saturation at high analyte concentrations. Dopamine was used as a model analyte to evaluate the sensor performance; we find that the ECNF device exhibits a dynamic range âˆ¼10(5) greater than that of many existing carbon-based sensors. The ECNF sensors exhibited excellent sensitivity, selectivity, stability, and reproducibility for dopamine detection.

Amperometric cholesterol biosensor based on the direct electrochemistry of cholesterol oxidase and catalase on a graphene/ionic liquid-modified glassy carbon electrode.

https://www.ncbi.nlm.nih.gov/pubmed/24211460

Cholesterol oxidase (ChOx) and catalase (CAT) were co-immobilized on a graphene/ionic liquid-modified glassy carbon electrode (GR-IL/GCE) to develop a highly sensitive amperometric cholesterol biosensor. The H2O2 generated during the enzymatic reaction of ChOx with cholesterol could be reduced electrocatalytically by immobilized CAT to obtain a sensitive amperometric response to cholesterol. The direct electron transfer between enzymes and electrode surface was investigated by cyclic voltammetry. Both enzymes showed well-defined redox peaks with quasi-reversible behaviors. An excellent sensitivity of 4.163 mA mM(-1)cm(-2), a response time less than 6s, and a linear range of 0.25-215 Î¼M (R(2)>0.99) have been observed for cholesterol determination using the proposed biosensor. The apparent Michaelis-Menten constant (KM(app)) was calculated to be 2.32 mM. The bienzymatic cholesterol biosensor showed good reproducibility (RSDs<5%) with minimal interference from the coexisting electroactive compounds such as ascorbic acid and uric acid. The CAT/ChOx/GR-IL/GCE showed excellent analytical performance for the determination of free cholesterol in human serum samples.

Layer-by-layer assembled oxidative films as general platform for electrodeless formation of conducting polymers.

https://www.ncbi.nlm.nih.gov/pubmed/24456025

Fabrication of precisely tailored layers of conductive polymers in thin film assemblies is an attractive extension of the layer-by-layer technique. This approach provides tools for fabricating thin films with customized optical and electrical properties. In this paper, we study inorganic layer-by-layer

assembled films prepared using polyphosphate and cerium(IV). It is shown that these multilayers can oxidize certain monomers from the adjacent aqueous solution to produce conducting polymer layers. We studied the thermodynamic factors that allow the aforementioned autopolymerization. A five bilayer polyphosphate/cerium(IV) film was shown to possess high oxidative power in acidic solutions. It was found that the polymerization of pyrrole, aniline and 3,4-ethylenedioxythiophene in contact with the redox active multilayer is thermodynamically favored. The rate of polymer formation and the thickness of the conducting film could be controlled by the concentration of the monomer in solution and the number of cerium/polyphosphate bilayers in the oxidative film. The oxidative polymerization of pyrrole was unambiguously recognized on UV-vis spectra with characteristic reduction and oxidation bands. The film formation was not restricted by charge diffusion and the reaction formally followed first-order kinetics. The results suggest that the reaction takes place effectively within the whole pre-existing polypyrrole film and it continues until all oxidant in the film was used. The spectral changes that are characteristic for conducting polypyrrole are shown on spectroelectrochemical analysis of the films indicating that cationic (polaron) and dicationic (bipolaron) species are involved in the redox processes of the film. The functional polymer films formed are found to be electroactive and conducting. Therefore, they fully resemble of conducting polymer films prepared using traditional electropolymerization.

A novel coated platinum electrode for oseltamivir determination in pharmaceuticals.

https://www.ncbi.nlm.nih.gov/pubmed/24582227

New coated platinum selective electrodes have been prepared and used for the determination of oseltamivir phosphate (OSL) in bulk drug solutions and in pharmaceutical preparations. Electrodes were using plasticized PVC membranes doped with ion-pair complexes based on drug-phosphomolybdate and drug-tetraphenylborate as electroactive materials. The influence of membrane composition (plasticizers and ion-pair complexes) has been investigated. Optimum performance was obtained for two polymeric membranes: PVC:o-NPPE:OSL-TPB in the ratio of 30:68:2 (%, w:w:w) and PVC:DPP:OSL-PMA in the ratio of 30:68:2 (%, w:w:w). The electrodes exhibited linear responses over large concentration ranges (1.0Ã—10(-5)-1.0Ã—10(-2) and 5.0Ã—10(-5)-5.0Ã—10(-2)M, respectively) with near-Nernstian responses (58.9 and 57.3mV/decade, respectively). The selectivity coefficients indicated good selectivity for OSL drug over a large number of organic compounds and some inorganic cations. The proposed electrodes were successfully applied to the determination of OSL in raw material and in pharmaceutical

formulations. The results were validated by comparison with a capillary electrophoresis method.

Stretchable polymeric multielectrode array for conformal neural interfacing.

https://www.ncbi.nlm.nih.gov/pubmed/24150828

A highly stretchable neural interface of concurrent robust electrical and mechanical properties is developed with a conducting polymer film as the sole conductor for both the electrodes and the leads. This neural interface offers the benefits of conducting polymer electrodes in a demanding stretchable format, including low electrode impedance and high chargeinjection capacity, due to the large electroactive surface area of the electrode.

Modulation of direct electron transfer of cytochrome c by use of a molecularly imprinted thin film.

https://www.ncbi.nlm.nih.gov/pubmed/23660694

We describe the preparation of a molecularly imprinted polymer film (MIP) on top of a self-assembled monolayer (SAM) of mercaptoundecanoic acid (MUA) on gold, where the template cytochrome c (cyt c) participates in direct electron transfer (DET) with the underlying electrode. To enable DET, a non-conductive polymer film is electrodeposited from an aqueous solution of scopoletin and cyt c on to the surface of a gold electrode previously modified with MUA. The electroactive surface concentration of cyt c was 0.5 pmol cm(-2). In the absence of the MUA layer, no cyt c DET was observed and the pseudo-peroxidatic activity of the scopoletin-entrapped protein, assessed via oxidation of Ampliflu red in the presence of hydrogen peroxide, was only 30% of that for the MIP on MUA. This result indicates that electrostatic adsorption of cyt c by the MUA-SAM substantially increases the surface concentration of cyt c during the electrodeposition step, and is a prerequisite for the productive orientation required for DET. After template removal by treatment with sulfuric acid, rebinding of cyt c to the MUA-MIP-modified electrode occurred with an affinity constant of 100,000 mol(-1) L, a value three times higher than that determined by use of fluorescence titration for the interaction between scopoletin and cyt c in solution. The DET of cyt c in the presence of myoglobin, lysozyme, and bovine serum albumin (BSA) reveals that the MIP layer suppresses the effect of competing proteins.

Polymer light-emitting electrochemical cells.

https://www.ncbi.nlm.nih.gov/pubmed/17755530

A device configuration for light emission from electroactive polymers is described. In these light-emitting electrochemical cells, a p-n junction diode is created in situ through simultaneous p-type and n-type electrochemical doping on opposite sides of a thin film of conjugated polymer that contains added electrolyte to provide the necessary counterions for doping. Light-emitting devices based on conjugated polymers have been fabricated that operate by the proposed electrochemical oxidation-reduction mechanism. Blue, green, and orange emission have been obtained with turn-on voltages close to the band gap of the emissive material.

Potentiometric thick-film sensor for the determination of the neurotransmitter acetylcholine.

https://www.ncbi.nlm.nih.gov/pubmed/7992876

A potentiometric thick-film biosensor for the determination of the neurotransmitter acetylcholine is presented. The selective membranes consist of two layers. The first is a choline- and H(+)-selective membrane made from a poly(vinyl chloride)-poly(vinyl acetate) copolymer which is plasticized with 2-nitrophenyl octyl ether. It contains 1% m/m of the ion-pair choline phosphotungstate as an electroactive compound. Both products of the enzymic cleavage, choline and H+, are detected. The second layer is placed above the first and is made from a poly(vinyl acetate)-polyethylene dispersion polymer. It is loaded with 2% m/m of acetylcholinesterase isolated from electric eel. The linear region of the response curve extends from 2 x 10(-5) to 0.01 mol dm-3 in buffer solution and undiluted horse serum. The detection limit is 5 x 10(-6) mol dm-3 and the response time is about 4 min.

Digital simulation of chronoamperometry at an electrode within a hemispherical polymer drop containing an enzyme: comparison of a hemispherical with a flat disk electrode.

https://www.ncbi.nlm.nih.gov/pubmed/23871876

Current-time and steady state current behaviour was simulated for the cases of a hemispherical and flat inlaid disk electrodes located under a hemispherical polymer drop containing an enzyme which converts a substrate diffusing into the drop into a product that is electroactive at the electrode. As well, a cylindrical electrode with length much greater than its diameter and coated with a layer of polymer/enzyme was treated. The ratio of steady state currents at the hemispherical to the disk electrode is not, as has sometimes been assumed, always equal to Ï€/2; indeed this is only approached for polymer drops with large spillover ratio, that is, having a radius much larger than that

of the electrodes. Steady state currents for all electrode geometries (including the cylinder) go through a maximum for some spillover ratio and then approach a constant value for larger spillover ratios. This constant value is the same as that for the diffusion limited current in a semi-infinite medium. For a cylindrical electrode, the steady state current tends towards zero for large spillover ratios.

Electroactive species-doped poly(3,4-ethylenedioxythiophene) films: enhanced sensitivity for electrochemical simultaneous determination of vitamins B2, B6 and C.

https://www.ncbi.nlm.nih.gov/pubmed/23871872

Herein, functionalized PEDOT films were prepared by incorporation of two electroactive species, ferrocenecarboxylic acid (Fc(-)) and ferricyanide (Fe(CN)6(4-)) as doping anions during the electropolymerization of PEDOT at glassy carbon electrodes (GCEs) from aqueous solution. The electrochemically synthesized electroactive species-doped PEDOT films have been carefully characterized by scanning electron microscopy (SEM), FTIR and UV/Vis spectra and various electrochemical techniques. Such nanostructured films combined the advantages of PEDOT (high conductivity and stability) together with electroactive species (good electrochemical activity) and were applied as electrochemical sensors for simultaneous determination of vitamin B2 (VB2), vitamin B6 (VB6) and vitamin C (VC). The results showed that the oxidation peak currents of vitamins obtained at the GCEs modified with electroactive species-doped PEDOT films were much higher than those at the ClO4(-)-doped PEDOT films and bare GCEs. The experiment results also illustrated that the sensors possessed high selectivity with no interference from other potential competing species. Moreover, the proposed sensors were successfully employed for the determination of vitamins in orange juice samples with satisfactory results.

Label-free and reagentless electrochemical detection of microRNAs using a conducting polymer nanostructured by carbon nanotubes: application to prostate cancer biomarker miR-141.

https://www.ncbi.nlm.nih.gov/pubmed/23743328

In this paper, a label-free and reagentless microRNA sensor based on an interpenetrated network of carbon nanotubes and electroactive polymer is described. The nanostructured polymer film presents very well-defined electroactivity in neutral aqueous medium in the cathodic potential domain from the quinone group embedded in the polymer backbone. Addition of microRNA miR-141 target

(prostate cancer biomarker) gives a "signal-on" response, i.e. a current increase due to enhancement of the polymer electroactivity. On the contrary, non-complementary miRNAs such as miR-103 and miR-29b-1 do not lead to any significant current change. A very low detection limit of ca. 8 fM is achieved with this sensor.

Electroactive nanoparticle directed assembly of functionalized graphene nanosheets into hierarchical structures with hybrid compositions for flexible supercapacitors.

https://www.ncbi.nlm.nih.gov/pubmed/23545560

Hierarchical structures of hybrid materials with the controlled compositions have been shown to offer a breakthrough for energy storage and conversion. Here, we report the integrative assembly of chemically modified graphene (CMG) building blocks into hierarchical complex structures with the hybrid composition for high performance flexible pseudocapacitors. The formation mechanism of hierarchical CMG/Nafion/RuO2 (CMGNR) microspheres, which is triggered by the cooperative interplay during the in situ synthesis of RuO2 nanoparticles (NPs), was extensively investigated. In particular, the hierarchical CMGNR microspheres consisting of the aggregates of CMG/Nafion (CMGN) nanosheets and RuO2 NPs provided large surface area and facile ion accessibility to storage sites, while the interconnected nanosheets offered continuous electron pathways and mechanical integrity. The synergistic effect of CMGNR hybrids on the supercapacitor (SC) performance was derived from the hybrid composition of pseudocapacitive RuO2 NPs with the conductive CMGNs as well as from structural features. Consequently, the CMGNR-SCs showed a specific capacitance as high as 160 F g(-1), three-fold higher than that of conventional graphene SCs, and a capacitance retention of >95% of the maximum value even after severe bending and 1000 charge-discharge tests due to the structural and compositional features.

A biocomputing platform with electrochemical and fluorescent signal outputs based on multi-sensitive copolymer film electrodes with entrapped Au nanoclusters and tetraphenylethene and electrocatalysis of NADH.

https://www.ncbi.nlm.nih.gov/pubmed/31663551

In this work, poly(N,N'-dimethylaminoethylmethacrylate-co-N-isopropylacrylamide) copolymer films were polymerized on the surface of Au electrodes with a facile one-step method, and Au nanoclusters (AuNCs) and tetraphenylethene (TPE) were synchronously embedded in the films, designated as P(DMA-co-NIPA)/AuNCs/TPE. Ferrocene dicarboxylic acid (FDA), an electroactive

probe in solution displayed inverse pH- and SO42--sensitive on-off cyclic voltammetric (CV) behaviors at the film electrodes. The electrocatalytic oxidation of nicotinamide adenine dinucleotide (NADH) mediated by FDA in solution could substantially amplify the CV response difference between the on and off states. Moreover, the two fluorescence emission (FL) signals from the TPE constituent at 450 nm and AuNCs component at 660 nm in the films also demonstrated SO42-- and pH-sensitive behaviors. Based on the aforementioned results, a 4-input/9-output biomolecular logic circuit was constructed with pH, Na2SO4, FDA and NADH as the inputs, and the CV signals and the FL responses at 450 and 660 nm at different levels as the outputs. Additionally, some functional non-Boolean devices were elaborately designed on an identical platform, including a 1-to-2 decoder, a 2-to-1 encoder, a 1-to-2 demultiplexer and different types of keypad locks. This work combines copolymer films, bioelectrocatalysis, and fluorescence together so that more complicated biocomputing systems could be established. This work may pave a new way to develop advanced and sophisticated biocomputing logic circuits and functional devices in the future.

PEI-coated gold nanoparticles decorated with laccase: a new platform for direct electrochemistry of enzymes and biosensing applications.

https://www.ncbi.nlm.nih.gov/pubmed/23208093

This paper describes the synthesis and characterization of PEI-coated gold nanoparticles (PEI-AuNP), which were applied as a new platform in the immobilization of laccase (LAC) originating from Aspergillus oryzae. This material (PEI-AuNP-LAC) was used in the construction of a biosensor based on a glassy carbon electrode coated with a bio-nanostructured film. The occurrence of direct electron transfer (DET) between the electroactive center of LAC and the electrode surface was observed by cyclic voltammetry (CV), suggesting that the presence of AuNP in the film acts as a bridge for electron transfer. In acetate buffer solution (pH 5.0), LAC shows a pair of well-defined redox waves with a formal potential (Eâ•°') of 0.226V vs. Ag/AgCl (3M KCl). The biosensor response indicated a surface-controlled process with an apparent electron transfer rate constant (k(s)) of 0.4 sâ•»Â¹, charge transfer coefficient (Î±) of 0.5, and surface coverage concentration (Î“) of 3.45Ã—10â•»Â¹â•° mol cmâ•»Â². The optimized biosensor showed the following limits of detection (LOD) for the phenolic compounds tested: 0.03 Î¼M for catechol and guaiacol; 0.14 Î¼M for pyrogallol and 0.21 Î¼M for hydroquinone, using square-wave voltammetry (SWV). The proposed biosensor demonstrated high sensitivity, good repeatability and reproducibility, and long-term stability (only 20% decrease in response over 90 days and after 150 measurements by SWV for

each film formed). This biosensor was successfully applied to catechol quantification in spiked water samples. Furthermore, this method showed great potential for application in the development of new devices for biosensing.

Mediatorless amperometric glucose biosensing using 3-aminopropyltriethoxysilane-functionalized graphene.

https://www.ncbi.nlm.nih.gov/pubmed/22967516

A mediatorless glucose biosensor was developed by the immobilization of glucose oxidase (GOx) to graphene-functionalized glassy carbon electrode (GCE). The surface of GCE was functionalized with graphene by incubating it with graphene dispersed in 3-aminopropyltriethoxysilane (APTES), which acted both as a dispersion agent for graphene and as an amine surface modification agent for GCE and graphene. This was followed by the covalent binding of GOx to graphene-functionalized GCE using 1-ethyl-3-[3-dimethylaminopropyl]carbodiimide hydrochloride (EDC) based crosslinking. Graphene provided signal enhancement by providing greater surface area for GOx binding, while APTES-functionalization led to a higher GOx immobilization density by providing free amino groups for crosslinking. The developed biosensor used a redox potential of -0.45 V (vs. Ag/AgCl) for detecting glucose in the diabetic pathophysiological range 0.5-32 mM. There was no interference from endogenous electroactive substances and drug metabolites. The developed biosensor was further validated for detecting blood glucose in commercial artificial blood glucose linearity standards in the range 1.4-27.9 mM. Therefore, it is ideal for diabetic blood glucose monitoring. The developed bioanalytical procedure for preparation of GOx-bound graphene-functionalized GCEs had high production reproducibility and high storage stability, which is appropriate for the commercial mass production of enzyme-bound electrodes.

Low-cost synthesis and physical characterization of thieno[3,4-c]pyrrole-4,6-dione-based polymers.

https://www.ncbi.nlm.nih.gov/pubmed/22946845

The improved synthesis of thieno[3,4-c]pyrrole-4,6-dione (TPD) monomers, including Gewald thiophene ring formation, a Sandmeyer-type reaction, and neat condensation with an amine, is presented. This protocol enables faster, cheaper, and more efficient preparation of TPD units in comparison to traditional methods. Furthermore, a series of TPD homo- and pseudohomopolymers bearing various alkyl chains was synthesized via a direct heteroarylation polymerization (DHAP)

procedure. UV-visible absorption and powder X-ray diffraction measurements revealed the relationship between the ratio of branched to linear alkyl chains and the optoelectronic properties of the polymers as well as their packing in the solid state.

A Novel Electroactive Imide Oligomer and Its Application in Anticorrosion Coating.

https://www.ncbi.nlm.nih.gov/pubmed/31947895

A novel aniline tetramer (AT) capped electroactive imide oligomer (EIO) for metal corrosion protection was successfully synthesized in this study. The chemical structure of the EIO was characterized by liquid chromatography-mass spectrometry and Fourier-transform infrared spectroscopy. Furthermore, the redox behavior of EIO was identified using electrochemical cyclic voltammetry studies. An EIO coated on a cold-rolled steel (CRS) electrode was found to possess superior corrosion resistance to polyimide (PI) on a series of electrochemical corrosion measurements in 3.5 wt.% NaCl solution over an extended period (30 days). The mechanism for the advanced corrosion protection of the PI coating on the CRS electrode could be attributed to the redox catalytic capabilities of the AT units present in the EIO. These capabilities may induce the formation of passive metal oxide layers on the CRS electrode. Scanning electron microscopy and X-ray photoelectron spectroscopy were used to analyze the surface condition of the CRS after the corrosion test. EIO- and PI-coated electrodes were identified by a series of electrochemical measurements, including corrosion potential (Ecorr), polarization resistance (Rp), and corrosion current (Icorr) measurements, along with electrochemical impedance spectroscopy (EIS).

Synthesis of a Macroporous Conjugated Polymer Framework: Iron Doping for Highly Stable, Highly Efficient Lithium-Sulfur Batteries.

https://www.ncbi.nlm.nih.gov/pubmed/30586280

Porous conjugated polymers offer enormous potential for energy storage because of the combined features of pores and extended Ï€-conjugated structures. However, the drawbacks such as low pore volumes and insolubilities of micro- and mesoporous conjugated polymers restrict the loading of electroactive materials and thus energy storage performance. Herein, we report the synthesis of iron-doped macroporous conjugated polymers for hosting sulfur as the cathode of high-performance lithium-sulfur (Li-S) batteries. The macroporous conjugated polymers are synthesized via in situ growth of poly(3-hexylthiophene) (P3HT) from reduced graphene oxide (RGO) sheets, followed by gelation of the composite (RGO- g-P3HT) in p-xylene and freeze-drying. The network structures of

the macroporous materials can be readily tuned by controlling the chain length of P3HT grafted to RGO sheets. The large pore volumes of the macroporous RGO- g-P3HT materials (ca. 34 cm3 g-1) make them excellent frameworks for hosting sulfur as cathodes of Li-S batteries. Furthermore, incorporation of Fe into the macroporous RGO- g-P3HT cathode results in reduced polarization, enhanced specific capacity (1,288, 1,103, and 907 mA h g-1 at 0.05, 0.1, and 0.2 C, respectively), and improved cycling stability (765 mA h g-1 after 100 cycles at 0.2 C). Density functional theory calculations and in situ characterizations suggest that incorporation of Fe enhances the interactions between lithium polysulfides and the P3HT framework.

Ultrafast detection and quantification of brain signaling molecules with carbon fiber microelectrodes.

https://www.ncbi.nlm.nih.gov/pubmed/22881278

Carbon fiber microelectrodes provide the ideal platform for performing ultrafast, selective measurements of electroactive brain molecules. This article highlights the current status of the use of carbon fiber microelectrodes in neurochemical measurements, outlining the most cutting edge findings and technological advances in amperometry andÂ fast-scan cyclic voltammetry.

Electroactive subwavelength gratings (ESWGs) from conjugated polymers for color and intensity modulation.

https://www.ncbi.nlm.nih.gov/pubmed/22622524

Subwavelength gratings with electroactive polymers such as poly(3-hexylthiophene) (P3HT) and poly(3,4-propylenedioxythiophene-phenylene) (P(ProDOT-Ph)) controlled the color intensity for various visible colors of diffracted light in a single device. Under the illumination of a white light, at a fixed angle of incidence, the color intensity of the diffracted light was reversibly switched from the maximum value down to 15% (85% decrease) by applying -2 to 2 V due to electrochemical (EC) reaction. All spectral colors including red, green, and blue were generated by changing the angle of incidence, and the intensity of each color was modulated electrochemically at a single EC device. With electroactive subwavelength gratings (ESWGs) of P3HT, the maximum modulation of the color intensity was observed in the red-yellow quadrant in the CIE color plot, whereas for the ESWGs of P(ProDOT-Ph), the maximum modulation of the color intensity was observed in the yellow-green and green-blue quadrants. Both ESWGs showed a memory effect, keeping their color and intensity even after power was turned off for longer than 40 hours.

Ultrasensitive electrochemical detection of ochratoxin A based on signal amplification by one-pot synthesized flower-like PEDOT-AuNFs supported on a graphene oxide sponge.

https://www.ncbi.nlm.nih.gov/pubmed/31482879

To enhance the sensitivity of an aptasensor, a novel strategy was designed to develop an electrochemical aptasensor based on poly(3,4-ethylenedioxy thiophene)-gold nanoflower (PEDOT-AuNF) composites supported on a three-dimensional graphene oxide sponge (GOS). GOS with a three-dimensional sponge-like porous structure, exhibiting excellent electrical conductivity and a large surface area, provided the first amplification of the electrochemical signal for ochratoxin A (OTA) detection. PEDOT-AuNFs, synthesized by an ionic liquid-assisted one-pot method, presented a peculiar hierarchical flower-like structure, a high electroactive surface area, and more binding sites for immobilizing the aptamer molecules by the Au-S bonds. When PEDOT-AuNFs were supported on the surface of GOS by the interaction of the Ï€-Ï€ packing between PEDOT and graphene oxide, a synergistic effect was produced to provide the second amplification for the aptasensor. PEDOT-AuNFs/GOS provided an ultrasensitive detection technique by multiple signal amplification for the electrochemical sensing of OTA. Consequently, this strategy not only endowed the aptasensor with high sensitivity but also needed no complicated signal amplification. The electrochemical sensor was fabricated successfully on a glassy carbon electrode to detect OTA with a linear response in the range of 0.01-20 ng L-1 and a limit of detection of 4.9 pg L-1. Moreover, it displayed good specificity, reproducibility and stability. The utilization of the proposed aptasensor for the quantitative determination of OTA in wine indicates that it can find promising applications in detecting OTA and even other mycotoxins in foodstuffs.

Efficient enantiorecognition of amino acids under a stimuli-responsive system: synthesis, characterization and application of electroactive rotaxane.

https://www.ncbi.nlm.nih.gov/pubmed/31580336

In this study, an electroactive rotaxane, (S,S)-crown-3, consisting of a polymeric chiral ionic liquid as a flexible axle and 18-crown-6 as the wheel, was designed and synthesized. It is worth noting that a stimuli-responsive system was developed, in which the wheel could switch its location between the chiral carbamido group and ionic pair of the ionic polymers under an external force. Next, (S,S)-crown-3 was employed as a modification on the surface of glassy electrode. In contrast to previous study, the developed probe presented a clear discrimination of an electrochemical signal in the absence of Cu(ii). Under the external force (different pH values), l-isomers of amino acids

(tryptophan, tyrosine, and cysteine) could form stable host-guest interactions with the chiral carbamido group, producing higher peak currents than the d-isomers. Compared to the absence of the crown, (S,S)-crown-3 showed much better recognition efficiency. The value of IL/ID for tryptophan could reach 39.8. In brief, the present study describes a powerful method for the synthesis of an electroactive rotaxane with great enantiorecognition capability.

Flexible conducting polymer-based cellulose substrates for on-skin applications.

https://www.ncbi.nlm.nih.gov/pubmed/31924048

Flexible electroactive cellulose-based substrates were successfully fabricated via electropolymerization of either polypyrrole (PPy) or poly(3,4-ethylenedioxythiophene) (PEDOT) in the presence of sodium dodecyl sulphate (SDS) onto platinum-coated cellulose substrates. Results showed that the conductive polymers were evenly deposited onto the platinum-coated cellulose substrates, respectively without compromising the submicro roughness topography of the substrate. In fact, nanoroughness feature was formed by the deposition of conductive polymers on the individual fibres of the cellulose paper, both of which are highly important in regulating cell adhesion, proliferation and migration. The various electroactive cellulose-based papers exhibited good mechanical and structural properties as well as good cytocompatibility by supporting the attachment and proliferation of immortalized human keratinocytes (HaCaT cells). In addition, copper (Cu2+) and the zinc (Zn2+) ions were proved to be successfully doped into these PPy- and PEDOT-cellulose substrates. The PEDOT resulted in the higher doping of Cu2+ and Zn2+ ions, which was confirmed by the ions release studies. Furthermore, the PEDOT-cellulose substrates exhibited significantly higher mechanical properties, better initial cell attachment and higher electrochemical capacitance as compared to PPy-cellulose substrates. Overall, the results suggested that the PEDOT-cellulose substrates could potentially be a better choice of smart skin dressings, integration interface between skin and artificial devices or implantable electronic materials.

Convective delivery of electroactive species to annular nanoband electrodes embedded in nanocapillary-array membranes.

https://www.ncbi.nlm.nih.gov/pubmed/22907773

Significant technological drivers motivate interest in the use of reaction sites embedded within nanometer-scale channels, and an important class of these structures is realized by an embedded annular nanoband electrode (EANE) in a cylindrical nanochannel. In this structure, the convective

delivery of electroactive species to the nanoelectrode is tightly coupled to the electrochemical overpotential via electroosmotic flow. Simulation results indicate that EANE arrays significantly outperform comparable microband electrode/microchannel structures, producing higher conversion efficiencies at low Peclet number. The results of this in-depth analysis are useful in assessing possible implementation of the EANE geometry for a wide range of electrochemical targets within microscale total analysis systems.

Synchrotron small-angle X-ray scattering studies of hemoglobin nonaggregation confined inside polymer capsules.

https://www.ncbi.nlm.nih.gov/pubmed/22823330

The effect of confinement on the structure of hemoglobin (Hb) within polymer capsules was investigated here. Hemoglobin transformed from an aggregated state in solution to a nonaggregated state when confined inside the polymer capsules. This was directly confirmed using synchrotron small-angle X-ray scattering (SAXS) studies. The radius of gyration (R(g)) and polydispersity (p) of the proteins in the confined state were smaller compared to those in solution. In fact, the R(g) value is very similar to theoretical values obtained using protein structures generated from the Protein Databank. In the temperature range (25-85 Â°C, Tm 59 Â°C), the R(g) values for the confined Hb remained constant. This observation is in contrary to the increasing R(g) values obtained for the bare Hb in solution. This suggested higher thermal stability of Hb when confined inside the polymer capsule than when in solution. Changes in protein configuration were also reflected in the protein function. Confinement resulted in a beneficial enhancement of the electroactivity of Hb. While Hb in solution showed dominance of the cathodic process (Fe(3+) â†' Fe(2+)), efficient reversible Fe(3+)/Fe(2+) redox response is observed in the case of the confined Hb. This has important protein functional implications. Confinement allows the electroactive heme to take up positions favorable for various biochemical activities such as sensing of analytes of various sizes from small to macromolecules and controlled delivery of drugs.

Recognition-driven layer-by-layer construction of multiprotein assemblies on surfaces: a biomolecular toolkit for building up chemoresponsive bioelectrochemical interfaces.

https://www.ncbi.nlm.nih.gov/pubmed/22766969

The development of soft bioelectronic interfaces with accurate compositional and topological control of the supramolecular architecture attracts intense interest in the fast-growing field of bioelectronics

and biosensing. The present study explores the recognition-driven layer-by-layer assembly of glycoenzymes onto electrode surfaces. The design of the multi-protein interfacial architecture is based on the multivalent supramolecular carbohydrate-lectin interactions between redox glycoproteins and concanavalin A (Con A) derivatives. Specifically, [Os(bpy)(2)Clpy](2+)-tagged Con A (Os-Con A) and native Con A were used to direct the assembly of horseradish peroxidase (HRP) and glucose oxidase (GOx) in a stepwise topologically controlled procedure. In our designed configuration, GOx acts as the biorecognition element to glucose stimulus, while HRP acts as the transducing element. Surface plasmon resonance (SPR) spectroscopy and quartz crystal microbalance with dissipation (QCM-D) results are combined to give a close representation of the protein surface coverage and the content of water in the protein assembly. The characterization is complemented with in situ atomic force microscopy (AFM) to give a topographical description of the layers assemblage. Electrochemical (EC) techniques were used to characterize the functional features of the spontaneously self-assembled biohybrid architecture, showing that the whole system presents efficient electron transfer and mass transport processes being able to transform micromolar glucose concentration into electrical information. In this way the combination of the electroactive and nonelectroactive Con A provides an efficient strategy to control the position and composition of the protein layers via recognition-driven processes, which defines its sensitivity toward glucose. Furthermore, the incorporation of dextran as a permeable interlayer able to bind Con A promotes the physical separation of the biochemical and transducing processes, thus enhancing the magnitude of the bioelectrochemical signal. We consider that these results are relevant for the nanoconstruction of functional biointerfaces provided that our experimental evidence reveals the possibility of locally addressing recognition, transduction and amplification elements in interfacial ensembles via LbL recognition-driven processes.

3D Printing of Polycaprolactone-Polyaniline Electroactive Scaffolds for Bone Tissue Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/31978961

Electrostimulation and electroactive scaffolds can positively influence and guide cellular behaviour and thus has been garnering interest as a key tissue engineering strategy. The development of conducting polymers such as polyaniline enables the fabrication of conductive polymeric composite scaffolds. In this study, we report on the initial development of a polycaprolactone scaffold incorporating different weight loadings of a polyaniline microparticle filler. The scaffolds are

fabricated using screw-assisted extrusion-based 3D printing and are characterised for their morphological, mechanical, conductivity, and preliminary biological properties. The conductivity of the polycaprolactone scaffolds increases with the inclusion of polyaniline. The in vitro cytocompatibility of the scaffolds was assessed using human adipose-derived stem cells to determine cell viability and proliferation up to 21 days. A cytotoxicity threshold was reached at 1% wt. polyaniline loading. Scaffolds with 0.1% wt. polyaniline showed suitable compressive strength (6.45 Â± 0.16 MPa) and conductivity (2.46 Â± 0.65 Ã— 10-4 S/cm) for bone tissue engineering applications and demonstrated the highest cell viability at day 1 (88%) with cytocompatibility for up to 21 days in cell culture.

Multiplexed electrochemical immunoassay of biomarkers using chitosan nanocomposites.

https://www.ncbi.nlm.nih.gov/pubmed/24413402

In this work, a novel and sensitive multiplexed immunoassay protocol for simultaneous electrochemical determination of alpha-fetoprotein (AFP) and carcinoembryonic antigen (CEA) was designed using functionalized chitosan composites. The immunosensing platform was prepared via immobilizing capture anti-AFP and anti-CEA on chitosan-Au nanoparticles (AuNPs) through EDC/NHS linking. The signal tags were fabricated by immobilizing electroactive redox probes - Prussian blue (PB) and ferrocenecarboxylic acid (Fc) on chitosan (CHIT), following by absorbing AuNPs to immobilize labeled anti-AFP and anti-CEA, respectively. A sandwich-type immunoassay format was employed for the simultaneous detection of AFP and CEA. The assay was based on the electrochemical oxidation/reduction of the redox species in signal tags, which has a relationship with the concentration of analytes. Experimental results revealed that the multiplexed electrochemical immunoassay enabled the simultaneous monitoring of AFP and CEA with a wide range of 0.05-100 ng mL(-1) for both AFP and CEA. The detection limits (LOD) was 0.03 ng mL(-1) for AFP and 0.02 ng mL(-1) for CEA (S/N=3). The assay results of serum samples with the proposed method were in a good agreement with the reference values from standard ELISA method. And the negligible cross-reactivity between the two analytes makes it possesses potential promise in clinical diagnosis.

Electroactive polymers: developments of and perspectives for dielectric elastomers.

https://www.ncbi.nlm.nih.gov/pubmed/23877949

We present the development and applications of dielectric elastomers. For the last 10 years the significance of this class of polymers has risen as more applications seem possible and first

products have been commercialized.

Head space voltammetry: a novel voltammetric method for volatile organics and a case study for phenol.

https://www.ncbi.nlm.nih.gov/pubmed/22939125

Present paper describes the results of a novel method which combines the Head space (HS) preconcentration of the analyte on the electrode prior to the voltammetric analysis. Thereafter, the method was called HS-Voltammetry. The performance of the method was tested upon using an electroactive and volatile molecule, phenol molecule, which gives an oxidation peak at conventional electrodes. In this study, a glassy carbon electrode was modified with polypyrrole by electropolymerization and then, the electrode was placed over the solution in a sealed vial heated gently on a hotplate with a stirrer for phenol determination. By controlling the thickness of the polymeric coating and optimizing preconcentration parameters such as vial pH and temperature, stirring rate and exposure time, a very consistent (5.2% at 5.0Ã—10(-7) M) fraction of the analyte can be extracted during a predetermined time. The oxidation peak current at 0.8 V depended linearly on the phenol concentration over a wide range (3 orders of magnitude). The detection limit was estimated as 7.0Ã—10(-8) M at 60 Â°C (S/N=3) which is well below the limit set by the European Community for phenols in wastewaters (ca. 5Ã—10(-6) M). The effect of other phenolic compounds was also examined and it was shown that head space preconcentration eliminated the interference of non-volatile phenolic acids studied. For volatile phenolic compounds, the selectivity can be maintained in cases when isolated peaks are obtained for each component. The proposed method has been applied successfully for the determination of phenol in artificial wastewater and recovery percentage was calculated as 93%.

Synthetic Biopigment Supercapacitors.

https://www.ncbi.nlm.nih.gov/pubmed/31361116

Biomass-based energy storage devices have drawn increasing attention owing to their renewability and sustainability, particularly that the heteroatom-doped carbons derived from natural polymers are regarded as the promising candidates in discovering advanced electrode materials for supercapacitors. This work has developed a facile one-pot fabrication strategy toward synthetic pheomelanin nanoparticles with controllable size and chemical composition (i.e., sulfur content) via the copolymerization of dopamine and cysteine. The resulting synthetic pigment materials possess

outstanding thermal stability and are able to directly transform into monodispersed S,N-codoped carbon spheres with unaltered morphology. Compared with conventional polydopamine-based carbon spheres, the present carbonized pheomelanin nanoparticles with electroactive sulfur atoms could possess lower charge-transfer resistance and consequently higher specific capacitance (e.g., 243 F g-1 at 1 A g-1). This research continues to inspire researchers to develop new kinds of energy storage materials based on synthetic biopigment materials.

Polymer-graphene nanocomposites as ultrafast-charge and -discharge cathodes for rechargeable lithium batteries.

https://www.ncbi.nlm.nih.gov/pubmed/22449138

Electroactive polymers are a new generation of "green" cathode materials for rechargeable lithium batteries. We have developed nanocomposites combining graphene with two promising polymer cathode materials, poly(anthraquinonyl sulfide) and polyimide, to improve their high-rate performance. The polymer-graphene nanocomposites were synthesized through a simple in situ polymerization in the presence of graphene sheets. The highly dispersed graphene sheets in the nanocomposite drastically enhanced the electronic conductivity and allowed the electrochemical activity of the polymer cathode to be efficiently utilized. This allows for ultrafast charging and discharging; the composite can deliver more than 100 mAh/g within just a few seconds.

Design of high conductive and piezoelectric poly (3,4-ethylenedioxythiophene)/chitosan nanofibers for enhancing cellular electrical stimulation.

https://www.ncbi.nlm.nih.gov/pubmed/31610306

Electroactive nanofibrous scaffold is a vital tool for the study of the various biological research fields from bioelectronics to regenerative medicine, which can provide cell preferable 3D nanofiber architecture and programmed electrical signal. However, intrinsic non-biodegradability is a major problem that hinders its widespread application in the clinic. Herein, we designed, synthesized, and characterized shell/core poly (3,4-ethylenedioxythiophene) (PEDOT)/chitosan (CS) nanofibers by combining the electrospinning and recrystallization processes. Upon incorporating a trace amount of PEDOT (1.0â€¯wt%), the resultant PEDOT/CS nanofibers exhibited low interfacial charge transfer impedance, high electrochemical stability, high electrical conductivity (up to 0.1945â€¯S/cm), and ultrasensitive piezoelectric property (output voltage of 22.5â€¯mV by a human hair prodding). With such unique electrical and conductive properties, PEDOT/CS nanofibers were further applied to

brain neuroglioma cells (BNCs) to stimulate their adhesion, proliferation, growth, and development under an optimal external electrical stimulation (ES) and a pulse voltage of 400â€¯mV/cm. ES-responsive PEDOT/CS nanofibers indeed promoted BNCs growth and development as indicated by a large number and density of axons. The synergetic interplay between external ES and piezoelectric voltage demonstrates new PEDOT-based nanofibers as implantable electroactive scaffolds for numerous applications in nerve tissue engineering, human health monitoring, brain mantle information extraction, and degradable microelectronic devices.

Electrochemically prepared composites of graphene oxide and conducting polymers: Cytocompatibility of cardiomyocytes and neural progenitors.

https://www.ncbi.nlm.nih.gov/pubmed/31546373

The cytocompatibility of cardiomyocytes derived from embryonic stem cells and neural progenitors, which were seeded on the surface of composite films made of graphene oxide (GO) and polypyrrole (PPy-GO) or poly(3,4-ethylenedioxythiophene) (PEDOT-GO) are reported. The GO incorporated in the composite matrix contributes to the patterning of the composite surface, while the electrically conducting PPy and PEDOT serve as ion-to-electron transducers facilitating electrical stimulation/sensing. The films were fabricated by a simple one-step electropolymerization procedure on electrically conducting indium tin oxide (ITO) and graphene paper (GP) substrates. Factors affecting the cell behaviour, i.e. the surface topography, wettability, and electrical surface conductivity, were studied. The PPy-GO and PEDOT-GO prepared on ITO exhibited high surface conductivity, especially in the case of the ITO/PPy-GO composite. We found that for cardiomyocytes, the PPy-GO and PEDOT-GO composites counteracted the negative effect of the GP substrate that inhibited their growth. Both the PPy-GO and PEDOT-GO composites prepared on ITO and GP significantly decreased the cytocompatibility of neural progenitors. The presented results enhance the knowledge about the biological properties of electroactive materials, which are critical for tissue engineering, especially in context stimuli-responsive scaffolds.

PEDOT:PSS for Flexible and Stretchable Electronics: Modifications, Strategies, and Applications.

https://www.ncbi.nlm.nih.gov/pubmed/31592415

Substantial effort has been devoted to both scientific and technological developments of wearable, flexible, semitransparent, and sensing electronics (e.g., organic/perovskite photovoltaics, organic

thin-film transistors, and medical sensors) in the past decade. The key to realizing those functionalities is essentially the fabrication of conductive electrodes with desirable mechanical properties. Conductive polymers (CPs) of poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) have emerged to be the most promising flexible electrode materials over rigid metallic oxides and play a critical role in these unprecedented devices as transparent electrodes, hole transport layers, interconnectors, electroactive layers, or motion-sensing conductors. Here, the current status of research on PEDOT:PSS is summarized including various approaches to boosting the electrical conductivity and mechanical compliance and stability, directly linked to the underlying mechanism of the performance enhancements. Along with the basic principles, the most cutting edge-progresses in devices with PEDOT:PSS are highlighted. Meanwhile, the advantages and plausible problems of the CPs and as-fabricated devices are pointed out. Finally, new perspectives are given for CP modifications and device fabrications. This work stresses the importance of developing CP films and reveals their critical role in the evolution of these next-generation devices featuring wearable, deformable, printable, ultrathin, and see-through characteristics.

Characterization and Application of PVDF and Its Copolymer Films Prepared by Spin-Coating and Langmuir-Blodgett Method.

https://www.ncbi.nlm.nih.gov/pubmed/31817985

Poly(vinylidene fluoride) (PVDF) and its copolymers are key polymers, displaying properties such as flexibility and electroactive responses, including piezoelectricity, pyroelectricity, and ferroelectricity. In the past several years, they have been applied in numerous applications, such as memory, transducers, actuators, and energy harvesting and have shown thriving prospects in the ongoing research and commercialization process. The crystalline polymorphs of PVDF can present nonpolar Î±, Îµ phase and polar Î², Î³, and Î´ phases with different processing methods. The copolymers, such as poly(vinylidene fluoride-trifluoroethylene) (P(VDF-TrFE)), can crystallize directly into a phase analogous to the Î² phase of PVDF. Since the Î² phase shows the highest dipole moment among polar phases, many reproducible and efficient methods producing Î²-phase PVDF and its copolymer have been proposed. In this review, PVDF and its copolymer films prepared by spin-coating and Langmuir-Blodgett (LB) method are introduced, and relevant characterization techniques are highlighted. Finally, the development of memory, artificial synapses, and medical applications based on PVDF and its copolymers is elaborated.

Artificial Muscles Powered by Glucose.

https://www.ncbi.nlm.nih.gov/pubmed/31215110

Untethered actuation is important for robotic devices to achieve autonomous motion, which is typically enabled by using batteries. Using enzymes to provide the required electrical charge is particularly interesting as it will enable direct harvesting of fuel components from a surrounding fluid. Here, a soft artificial muscle is presented, which uses the biofuel glucose in the presence of oxygen. Glucose oxidase and laccase enzymes integrated in the actuator catalytically convert glucose and oxygen into electrical power that in turn is converted into movement by the electroactive polymer polypyrrole causing the actuator to bend. The integrated bioelectrode pair shows a maximum open-circuit voltage of 0.70 Â± 0.04 V at room temperature and a maximum power density of 0.27 ÂµW cm-2 at 0.50 V, sufficient to drive an external polypyrrole-based trilayer artificial muscle. Next, the enzymes are fully integrated into the artificial muscle, resulting in an autonomously powered actuator that can bend reversibly in both directions driven by glucose and O2 only. This autonomously powered artificial muscle can be of great interest for soft (micro-)robotics and implantable or ingestible medical devices manoeuvring throughout the body, for devices in regenerative medicine, wearables, and environmental monitoring devices operating autonomously in aqueous environments.

PLA-PEG-PLA and its electroactive tetraaniline copolymer as multi-interactive injectable hydrogels for tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/23611017

Injectable hydrogels have served as biomimic scaffolds that provide a three-dimensional (3D) structure for tissue engineering or carriers for cell encapsulation in the biomedical field. In this study, the injectable electroactive hydrogels (IEHs) were prepared by introducing electrical properties into the injectable materials. Carboxyl-capped tetraaniline (CTA) as functional group was coupled with enantiomeric polylactide-poly(ethylene glycol)-polylactide (PLA-PEG-PLA), and the electroactive hydrogels were obtained by mixing the enantiomeric copolymers of CTA-PLLA-PEG-PLLA-CTA and CTA-PDLA-PEG-PDLA-CTA aqueous solutions. ultraviolet-visible spectroscopy (UV-vis) and cyclic voltammetry (CV) of the complex solution showed good electroactive properties. The gelation mechanism and intermolecular multi-interactions such as stereocomplextion, hydrogen bonding, and Ï€-Ï€ stacking were studied by Fourier transform infrared spectroscopy (FT-IR), UV-vis, and wide-angle X-ray diffraction (WAXD). Gelation properties of the complexes were also studied by

rheometer. The encapsulated cells remained highly viable in the gel matrices, suggesting that the hydrogels have excellent cytocompatibility. After subcutaneous injection, the gels were formed in situ in the subcutaneous layer, and hematoxylin-eosin (H&E) staining suggested acceptable biocompatibility of our materials in vivo. Moreover, these injectable materials, when treated with pulsed electrical stimuli, were shown to be functionally active and to accelerate the proliferation of encapsulated fibroblasts, cardiomyocytes, and osteoblasts. Hence, the IEHs possessing these excellent properties would be potentially used as in vivo materials for tissue engineering scaffold.

Hexagonally Packed Macroporous Molecularly Imprinted Polymers for Chemosensing of Follicle-Stimulating Hormone Protein.

https://www.ncbi.nlm.nih.gov/pubmed/31845570

Homogenous nanostructuration of molecularly imprinted polymer (MIP) films for follicle-stimulating hormone (FSH)-sensing was achieved by using optimized colloidal crystals as a hard mold. Introduction of a heating step after assembling colloidal crystals of silica beads promoted their adhesion. Thus, precise assembling of beads was not disturbed during further multisteps of surface imprinting, and crack-free hexagonal packing was maintained. Scanning electron microscopy imaging confirmed hexagonal packing of silica colloidal crystals as well as homogenous nanostructuration in MIP films. FSH immobilization over silica beads and later its derivatization with electroactive functional monomers was confirmed by X-ray photoelectron spectroscopy analysis. The nanostructured molecular recognition films prepared in this way were combined with an electrochemical transducer in order to design a capacitive impedimetry-based chemosensing system. It was tested for the determination of FSH in the range from 0.1 fM to 100 pM in 10 mM 2-(N-morpholino) ethane sulfonic acid buffer (pH = 4.2). The detection limit of the chemosensor was 0.1 fM, showing a high selectivity with respect to common protein interferences as well as other protein hormones of the gonadotropin family.

Induced Hydrophilicity and In Vitro Preliminary Osteoblast Response of Polyvinylidene Fluoride (PVDF) Coatings Obtained via MAPLE Deposition and Subsequent Thermal Treatment.

https://www.ncbi.nlm.nih.gov/pubmed/32013171

Recent advancements in biomedicine have focused on designing novel and stable interfaces that can drive a specific cellular response toward the requirements of medical devices or implants.

Among these, in recent years, electroactive polymers (i.e., polyvinylidene fluoride or PVDF) have caught the attention within the biomedical applications sector, due to their insolubility, stability in biological media, in vitro and in vivo non-toxicity, or even piezoelectric properties. However, the main disadvantage of PVDF-based bio-interfaces is related to the absence of the functional groups on the fluoropolymer and their hydrophobic character leading to a deficiency of cell adhesion and proliferation. This work was aimed at obtaining hydrophilic functional PVDF polymer coatings by using, for the first time, the one-step, matrix-assisted pulsed evaporation (MAPLE) method, testing the need of a post-deposition thermal treatment and analyzing their preliminary capacity to support MC3T3-E1 pre-osteoblast cell survival. As osteoblast cells are known to prefer rough surfaces, MAPLE deposition parameters were studied for obtaining coatings with roughness of tens to hundreds of nm, while maintaining the chemical properties similar to those of the pristine material. The in vitro studies indicated that all surfaces supported the survival of viable osteoblasts with active metabolisms, similar to the "control" sample, with no major differences regarding the thermally treated materials; this eliminates the need to use a secondary step for obtaining hydrophilic PVDF coatings. The physical-chemical characteristics of the thin films, along with the in vitro analyses, suggest that MAPLE is an adequate technique for fabricating PVDF thin films for further bio-applications.

Copper(II)-mediated layer-by-layer assembly of viologenthiol-functionalized carbon nanotube hybrid multilayers: preparation, characterization, morphology, and electrochemical properties.

https://www.ncbi.nlm.nih.gov/pubmed/22624584

The metal-mediated self-assembly of coordination polymers, building blocks, and metal-organic frameworks has been widely used to construct multifunctional novel materials on the molecular level. Here, we developed this technique to build up multilayers of functionalized carbon nanotubes on the basis of both intermolecular electrostatic and coordinative interactions. Positively charged electroactive viologenthiol (VSH) was first immobilized on multiwalled carbon nanotubes (MWNTs) to form MWNT-VSH hybrids with a relative content of âˆ¼9% by weight. Field emission transmission electron microscopy images revealed that the VSH molecules randomly covered the surfaces of MWNTs with a thickness of 1 to 2 nm. Then, the MWNT-VSH hybrids were used as nanoscale multidentate "ligands" (linkers) to construct metal-mediated multilayers with the use of CuAc(2) as the connectors by the layer-by-layer (LBL) method. The assembly process was monitored by

absorption and X-ray photoelectron spectroscopy as well as scanning electron and atomic force microscopy after each assembly of Cu(II) ions and MWNT-VSH hybrids. Finally, the electrochemical behaviors of the viologens in the MWNT-VS/Cu LBL multilayers were investigated.

Reversible Electronic Solid-Gel Switching of a Conjugated Polymer.

https://www.ncbi.nlm.nih.gov/pubmed/31993279

Conjugated polymers exhibit electrically driven volume changes when included in electrochemical devices via the exchange of ions and solvent. So far, this volumetric change is limited to 40% and 100% for reversible and irreversible systems, respectively, thus restricting potential applications of this technology. A conjugated polymer that reversibly expands by about 300% upon addressing, relative to its previous contracted state, while the first irreversible actuation can achieve values ranging from 1000-10 000%, depending on the voltage applied is reported. From experimental and theoretical studies, it is found that this large and reversible volumetric switching is due to reorganization of the polymer during swelling as it transforms between a solid-state phase and a gel, while maintaining percolation for conductivity. The polymer is utilized as an electroactive cladding to reduce the void sizes of a porous carbon filter electrode by 85%.

Silk Fibroin Bending Actuators as an Approach Toward Natural Polymer Based Active Materials.

https://www.ncbi.nlm.nih.gov/pubmed/31330104

This work reports on the development of ionic liquid (IL)/silk fibroin (SF) composite films as electroactive polymers actuators. Different contents (20, 40, and 60% wt) of 1-butyl-3-methylimidazolium tricyanomethanide ([Bmim][C(CN3)]) and choline dihydrogen phosphate ([Ch][DHP]) ILs were incorporated into the SF polymer matrix. Due to IL-SF interactions, morphological changes such as globule-like nanostructures are induced in the samples. High concentrations of IL promote SF Î²-sheet formation above 65%. Further, an increase in the thermal stability of the SF was observed through the incorporation of [Bmim][C(CN3)]. IL type and content allow tuning of the electrical response as well as achieving bending actuation. [Bmim][C(CN3)]/SF samples allow bending responses up to 0.5 at an applied voltage of 3 V. In conclusion, this work demonstrates the ability of IL/SF composites to act as electroactive polymer actuators and opens new perspectives in the application of natural resources for smart materials.

Proteinase-sculptured 3D-printed graphene/polylactic acid electrodes as potential biosensing platforms: towards enzymatic modeling of 3D-printed structures.

https://www.ncbi.nlm.nih.gov/pubmed/31211311

3D printing technologies are currently appealing for the research community due to their demonstrated versatility for different scientific applications. One of the most commonly used materials for 3D printing is polylactic acid (PLA), a biodegradable polymer that can be fully or partially digested by enzymes such as proteinase K. This work seeks to exploit PLA's biodegradability to selectively and reproducibly sculpt 3D-printed graphene/PLA surfaces to turn them into sensitive electroactive platforms. Proteinase K-catalyzed digestion of 3D-printed graphene/PLA electrodes is proposed as an environmentally friendly, highly controllable, and reproducible activation procedure of 3D-printed electrodes. Proteinase K digests PLA in a controllable fashion, exposing electroactive graphene sheets embedded within the 3D-printed structures to the solution and therefore achieving a tailorable electrode performance. A proof-of-concept biosensing application is proposed, based on the immobilization of enzyme alkaline phosphatase at the sculptured electrodes with the subsequent electrochemical detection of 1-naphthol in aqueous media. This work attempts to continue demonstrating the potential of 3D printing in electroanalytical applications, as well as to explore the exciting possibilities arising from merging biotechnological processes with these manufacturing procedures.

Electroactive Composite of FeCl3 -Doped P3HT/PLGA with Adjustable Electrical Conductivity for Potential Application in Neural Tissue Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/31486250

Conducting polymers (CPs) is one of intelligent biomaterials with the specific properties of reversible redox states, which have a significant effects on the cell behaviors and nerve tissue regeneration. However, the effects of CPs with different electrical conductivity on the behaviors of nerve cells are rarely reported. Therefore, a kind of Poly(3-hexylthiophene) (P3HT) with certain molecular weight is synthesized by Kumada catalyst transfer polymerization (KCTP) method and employed to prepare bioabsorbable and electroactive intelligent composites of Poly(3-hexylthiophene)/Poly(glycolide-lactide) (P3HT/PLGA). FeCl3 doping electroactive membranes with different electrical conductivities are prepared to investigate the cell behaviors. On the substrate with higher electrical conductivity, the proliferation of rat adrenal pheochromocytoma cells (PC12 cells) is significantly promoted and neurite length is increased obviously. In particular,

the most significant improvements are the neuron gene expression of Synapsin 1 and microtubule-associated protein 2 (MAP2) by the composites with high conductivity. These results suggest that P3HT/PLGA with suitable electrical conductivity have a positive role in promoting neural growth and differentiation, which is promising for advancing potential application of nerve repair and regeneration.

Osteoblast, fibroblast and in vivo biological response to poly(vinylidene fluoride) based composite materials.

https://www.ncbi.nlm.nih.gov/pubmed/23138839

Electroactive materials can be taken to advantage for the development of sensors and actuators as well as for novel tissue engineering strategies. Composites based on poly(vinylidene fluoride), PVDF, have been evaluated with respect to their biological response. Cell viability and proliferation were performed in vitro both with Mesenchymal Stem Cells differentiated to osteoblasts and Human Fibroblast Foreskin 1. In vivo tests were also performed using 6-week-old C57Bl/6 mice. It was concluded that zeolite and clay composites are biocompatible materials promoting cell response and not showing in vivo pro-inflammatory effects which renders both of them attractive for biological applications and tissue engineering, opening interesting perspectives to development of scaffolds from these composites. Ferrite and silver nanoparticle composites decrease osteoblast cell viability and carbon nanotubes decrease fibroblast viability. Further, carbon nanotube composites result in a significant increase in local vascularization accompanied an increase of inflammatory markers after implantation.

New perspectives on development of polysulfones/cellulose derivatives based ionic-exchange membranes: Dielectric response and hemocompatibility study.

https://www.ncbi.nlm.nih.gov/pubmed/31582061

Due to the increasing need from the membrane technologies for diverse applications, development of new generation of materials with electroactive properties and significant impact on the future technological systems was imposed. An innovative way of designing the membrane materials with long-term stable hydrophilicity, enhanced workability, porosity, and good biocompatibility, has been adopted by blending of quaternized polysulfone (PSFQ) with a cellulose derivative (cellulose acetate phthalate, CAP). Moreover, the quaternization effect has significantly improved the electrical performances, in terms of the ionic conductivity, electron interactions, and dielectric properties,

required by target applications, i.e., ionic-exchange membranes, IEMs. Results derived from dielectric spectroscopy confirm the enhanced dielectric quality, reflected by a low dielectric constant and dielectric loss at high frequency. Additionally, the relationship between the resulted dielectric properties and response at the blood-biomaterial interface, have confirmed their excellent performance, constituting the preliminary basis for future tests concerning their functionality as IEMs in hemodialysis.

Biosensor design using an electroactive label-based aptamer to detect bisphenol A in serum samples.

https://www.ncbi.nlm.nih.gov/pubmed/31502582

A new and simple procedure was applied to detect bisphenol A (BPA) based on a BPA aptamer and its complementary strand (Comp. Str.). An electrode was modified with a mixture of carboxylated multiwalled carbon nanotubes and chitosan. The Comp. Str. was immobilized on a modified-glassy carbon electrode (GCE) surface via covalent binding. After the incubation of the aptamer with the electrode surface, it could interact with the Comp. Str. In the presence of BPA, its aptamer will interact with the analyte, resulting in some changes in the configuration and leading to separation from the electrode surface. Due to the attached ferrocene (Fc) group on the 50 head of the aptamer, the redox current of Fc has reduced. This aptasensor can sense the level of BPA in the linear range of 0.2-2 nM, with a limit of detection of 0.38 nM and a sensitivity of 24.51 lA/Î¼M. The proposed aptasensor showed great reliability and selectivity. The acceptable selectivity is due to the specificity of BPA binding to its aptamer. The serum sample was used as a real sample; the aptasensor was able to effectively recover the spiked BPA amounts. It can on-site monitor the BPA in serum samples with acceptable recoveries.

Electroactive Composites with Block Copolymer-Templated Iron Oxide Nanoparticles for Magnetic Hyperthermia Application.

https://www.ncbi.nlm.nih.gov/pubmed/31480428

Cancer has been one of the leading causes of human death for centuries. Magnetic hyperthermia is a promising technique to confine and control cancers. However, particles used in magnetic hyperthermia leaking from where the cancers are located could compromise human health. Therefore, we developed electroactive iron oxide/block copolymer composites to tackle the leakage problem. Experimental results show that oleylamine-modified magnetic iron oxide (Fe3O4) particles

and electroactive tetraaniline (TA) could be templated in the self-assembled microstructures of sulfonated [styrene-b-(ethylene-ran-butylene)-b-styrene] (S-SEBS) block copolymers. Various amounts of Fe3O4 particles and TA oligomer were incorporated in S-SEBS block copolymer and their electroactive behavior was confirmed by exhibiting two pairs of well-defined anodic and cathodic current peaks in cyclic voltammetry tests. The heating performance of the resultant TA/Fe3O4/polymer composites improved on increasing the added amount of Fe3O4 particles and TA oligomers. Both Fe3O4 and TA can contribute to improved heating performance, but Fe3O4 possesses a greater contribution than TA does. Hence, the main source for increasing the composites' temperature is Neel relaxation loss from Fe3O4 magnetic particles.

Relaxation dynamics of poly(vinylidene fluoride) studied by dynamical mechanical measurements and dielectric spectroscopy.

https://www.ncbi.nlm.nih.gov/pubmed/22644136

The aim of this study is to analyze the mobility of polymer chains in semicrystalline poly(vinylidene fluoride) (PVDF). PVDF crystallizes from the melt in the Î± crystalline phase. The transformation from the Î± phase to the electroactive Î² phase can be induced by stretching at temperatures in the range between 80 and 140 Â°C. The spherulitic structure of the crystalline phase is deformed during stretching to form fibrils oriented in the direction of the strain. The amorphous phase confined among the crystalline lamellae is distorted as well and some degree of orientation of the polymer chains is expected. Dynamic-mechanical and dielectric spectroscopy measurements were performed in PVDF films stretched to strain ratios up to 5 at temperatures between 80 and 140 Â°C. Dynamic-mechanical measurements were conducted between -60 Â°C and melting and in this temperature range the relaxation spectra show the main relaxation of the amorphous phase (called Î²-relaxation) and at higher temperatures a relaxation related to crystallites motions (Î± (c)-relaxation). Although the mean relaxation times of the Î²-relaxation are nearly equal in PVDF before and after crystal phase transformation, a significant change of shape of the relaxation spectrum proves the effect of chain distortion due to crystal reorganization. In stretched PVDF the elastic modulus of the polymer in the direction of deformation is significantly higher than in the transversal one, as expected by chain and crystals fibril orientation. The recovery of the deformation when the sample is heated is related with the appearance of the Î± (c)-relaxation. Dielectric spectroscopy spectrum shows the main relaxation of the amorphous phase and a secondary process (Î³-relaxation) at lower temperatures. Stretching produces significant changes in the

relaxation processes, mainly in the strength and shape of the main relaxation Î². The Havriliak-Negami function has been applied to analyze the dielectric response.

Electromechanically driven variable-focus lens based on transparent dielectric elastomer.

https://www.ncbi.nlm.nih.gov/pubmed/22614602

Dielectric elastomers with low elastic stiffness and high dielectric constant are smart materials that produce large strains (up to 300%) and belong to the group of electroactive polymers. Dielectric elastomer actuators are made from films of dielectric elastomers coated on both sides with compliant electrode material. Poly(3,4-ethylenedioxythiophene) (PEDOT), which is known as a transparent conducting polymer, has been widely used as an interfacial layer or polymer electrode in polymer electronic devices. In this study, we propose the transparent dielectric elastomer as a material of actuator driving variable-focus lens system using PEDOT as a transparent electrode. The variable-focus lens module has light transmittance up to 70% and maximum displacement up to 450. When voltage is applied to the fabricated lens module, optical focal length is changed. We anticipate our research to be a starting point for new model of variable-focus lens system. This system could find applications in portable devices, such as digital cameras, camcorder, and cell phones.

Tailoring Electrospun Poly(l-lactic acid) Nanofibers as Substrates for Microfluidic Applications.

https://www.ncbi.nlm.nih.gov/pubmed/31808332

Novel microfluidic substrates based on electrospun poly(l-lactic acid) (PLLA) membranes were developed to increase the limited range of commercially available paper substrates, commonly used for the fabrication of microfluidic paper-based analytical devices. PLLA's advantageous properties include biodegradability, biocompatibility, ease of being processed in various tailored morphologies, and cost effectiveness, among others. Oriented and nonoriented electrospun PLLA membranes were fabricated using electrospinning and the influence of fiber orientation, addition of hydrophilic additives, and plasma treatments on the morphology, physicochemical properties, and capillary flow rates were evaluated and compared with the commercial Whatman paper. In addition, a proof-of-concept application based on the colorimetric detection of glucose in printed PLLA and paper-based microfluidic systems was also performed. The results show the potential of PLLA substrates for the fabrication of portable, disposable, eco-friendly, and cost-effective microfluidic systems with controllable properties that can be tailored according to specific biotechnological

application requirements, being a suitable alternative to conventional paper-based substrates.

Photoluminescent functionalized carbon quantum dots loaded electroactive Silk fibroin/PLA nanofibrous bioactive scaffolds for cardiac tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/31810038

Tissue engineering and stem cell rehabilitation are the hopeful aspects that are being investigated for the management of Myocardial Infarction (MI); cardiac patches have been used to start myocardial rejuvenation. In this study, we engineered p-phenylenediamine surface functionalized (modif-CQD) into the Silk fibroin/PLA (SF/PLA) nanofibrous bioactive scaffolds with improved physico-chemical abilities, mechanical and cytocompatibility to cardiomyocytes. The micrograph results visualized the morphological improved spherical modif-CQD have been equivalently spread throughout the SF/PLA bioactive cardiac scaffolds. The fabricated CQD@SF/PLA nanofibrous bioactive scaffolds were highly porous with fully consistent pores; effectively improved young modulus and swelling asset for the suitability and effective implantation efficacy. The scaffolds were prepared with rat cardiomyocytes and cultured for up to 7â€¯days, without electrical incentive. After 7â€¯days of culture, the scaffold pores all over the construct volume were overflowing with cardiomyocytes. The metabolic activity and viability of the cardiomyocytes in CQD@SF/PLA scaffolds were significantly higher than cardiomyocytes in Silk fibroin /PLA scaffolds. The integration of CQD also influenced greatly and increases the expression of cardiac-marker genes. The results of the present investigations evidently recommended that well-organized cardiac nanofibrous scaffold with greater cardiac related mechanical abilities and biocompatibilities for cardiac tissue engineering and nursing care applications.

Discrete Fourier Transform as applicable technique in electrochemical detection of hydrazine using multi-walled carbon nanotube/polyacrylonitrile ceramic fiber as working electrode.

https://www.ncbi.nlm.nih.gov/pubmed/23498220

Effect of "Discrete Fourier Transform" (DFT) is studied for electrochemical detection of some electroactive species using multi-walled carbon nanotube/polyacrylonitrile ceramic fiber as ultra micro electrode. Based on DFT theory, two independent phases i.e. the imaginary and real phases are evaluated during the oxidation/reduction of the quasi-reversible or irreversible electroactive species, revealing the independent components of imaginary (IImaginary) and real (IReal) currents. The results show that, in different electrochemical modes such as cyclic voltammetry (CV), the

contribution of DFT to the electrochemical signals significantly improves the detection limit of the electrochemical technique. More sensitive signals are obtained at high scan rates according to the combination of electrochemical techniques with the DFT theory. The reliability of DFT algorithm was evaluated for rapid determination of trace amount of hydrazine (N2H4) at a scan rate up to 800 V s(-1). In this study, the amounts of phase and amplitude were estimated to 1.69 and 31.57, respectively. The detection limit of hydrazine was 4.13Ã—10(-9) M. The application of this technique was also evaluated for determination of hydrazine in different industrial wastewater samples.

Artificial muscle for reanimation of the paralyzed face: durability and biocompatibility in a gerbil model.

https://www.ncbi.nlm.nih.gov/pubmed/22986911

Current management of permanent facial paralysis centers on nerve grafting and muscle transfer; however, limitations of those procedures call for other options.

Conductive hydrogels based on agarose/alginate/chitosan for neural disorder therapy.

https://www.ncbi.nlm.nih.gov/pubmed/31472854

Electroactive scaffolds derived from carbohydrate hydrogels were synthesized, resulting in a large shift in the conductivity of chitosan (CS) from 10-6 S/cm to about 10-3 S/cm, assigned to CS-oligoaniline. Several analyses including UV-vis spectroscopy and cyclic voltammetry were performed, before examining the carbohydrate-based scaffolds for their ability to recapitulate the neural tissue microenvironment. Good conductivity and resemblance of the modulus to soft tissue of the optimized hydrogels led to appropriate cellular activity and neural regeneration. The loss of dopaminergic neurons as the prominent source of dopamine in the central nervous system results in the deterioration of multiple brain functions such as voluntary movement and behavioral processes. To overcome this, olfactory ecto-mesenchymal stem cells (OE-MSCs) were induced to differentiate into dopaminergic neuron-like cells on hydrogels through a monolayer arrangement cell culture by using cocktail neurotrophic factors including sonic hedgehog (SHH), fibroblast growth factor 8 (FGF8), basic fibroblast growth factor (bFGF), glial cell line-derived neurotrophic factor (GDNF) and brain derived neurotrophic factor (BDNF). The differentiation capacity of a series of OE-MSCs on the conductive hydrogel was evaluated by real-time PCR, immunocytochemistry and flow cytometry, and the expression of tyrosine hydroxylase (TH) and dopamine transporter (DAT) neural and dopaminergic markers. The results of this study represent the first steps in designing and

implementing advanced platforms based on conductive polysaccharide hydrogels for neural disorder therapies, such as the treatment of Parkinson's disease.

Electric field-controlled benzoic acid and sulphanilamide delivery from poly(vinyl alcohol) hydrogel.

https://www.ncbi.nlm.nih.gov/pubmed/23065453

The controlled release of benzoic acid (3.31Â Ã…) and sulphanilamide (3.47Â Ã…) from poly(vinyl alcohol), PVA, hydrogels fabricated by solution casting at various cross-linking ratios, were investigated. The PVA hydrogels were characterized in terms of the degree of swelling, the molecular weight between cross-links, and the mesh size. The drug release experiment was carried out using a modified Franz diffusion cell, at a pH value of 5.5 and at temperature of 37Â°C. The amount of drug release and the diffusion coefficients of the drugs from the PVA hydrogels increased with decreasing cross-linking ratio, as a larger mesh size was obtained with lower cross-linking ratios. With the application of an electric field, the amount of drug release and the diffusion coefficient increased monotonically with increasing electric field strength, since the resultant electrostatic force drove the ionic drugs from the PVA matrix. The drug size, matrix pore size, electrode polarity, and applied electric field were shown to be influential controlling factors for the drug release rate.

Cytochrome P450 (CYP) enzymes and the development of CYP biosensors.

https://www.ncbi.nlm.nih.gov/pubmed/22809523

Cytochrome P450s (CYPs) are a large family of heme-containing monooxygenase enzymes involved in the first-pass metabolism of drugs and foreign chemicals in the body. CYP reactions, therefore, are of high interest to the pharmaceutical industry, where lead compounds in drug development are screened for CYP activity. CYP reactions in vivo require the cofactor NADPH as the source of electrons and an additional enzyme, cytochrome P450 reductase (CPR), as the electron transfer partner; consequently, any laboratory or industrial use of CYPs is limited by the need to supply NADPH and CPR. However, immobilizing CYPs on an electrode can eliminate the need for NADPH and CPR provided the enzyme can accept electrons directly from the electrode. The immobilized CYP can then act as a biosensor for the detection of CYP activity with potential substrates, albeit only if the immobilized enzyme is electroactive. The quest to create electroactive CYPs has led to many different immobilization strategies encompassing different electrode materials

and surface modifications. This review focuses on different immobilization strategies that have been used to create CYP biosensors, with particular emphasis on mammalian drug-metabolizing CYPs and characterization of CYP electrodes. Traditional immobilization methods such as adsorption to thin films or encapsulation in polymers and gels remain robust strategies for creating CYP biosensors; however, the incorporation of novel materials such as gold nanoparticles or quantum dots and the use of microfabrication are proving advantageous for the creation of highly sensitive and portable CYP biosensors.

Conductive elastomer composites for fully polymeric, flexible bioelectronics.

https://www.ncbi.nlm.nih.gov/pubmed/30672514

Flexible polymeric bioelectronics have the potential to address the limitations of metallic electrode arrays by minimizing the mechanical mismatch at the device-tissue interface for neuroprosthetic applications. This work demonstrates the straightforward fabrication of fully organic electrode arrays based on conductive elastomers (CEs) as a soft, flexible and stretchable electroactive composite material. CEs were designed as hybrids of polyurethane elastomers (PU) and poly(3,4-ethylenedioxythiophene):polystyrene sulfonate (PEDOT:PSS), with the aim of combining the electrical properties of PEDOT:PSS with the mechanical compliance of elastomers. CE composites were fabricated by solvent casting of PEDOT:PSS dispersed in dissolved PU at different conductive polymer (CP) loadings, from 5 wt% to 25 wt%. The formation of PEDOT:PSS networks within the PU matrix and the resultant composite material properties were examined as a function of CP loading. Increased PEDOT:PSS loading was found to result in a more connected network within the PU matrix, resulting in increased conductivity and charge storage capacity. Increased CP loading was also determined to increase the Young's modulus and reduce the strain at failure. Biological assessment of CE composites showed them to mediate ReNcell VM human neural precursor cell adhesion. The increased stiffness of CE films was also found to promote neurite outgrowth. CE sheets were directly laser micromachined into a functional array and shown to deliver biphasic waveforms with comparable voltage transients to Pt arrays in in vitro testing.

Reversibly Assembled Electroconductive Hydrogel via a Host-Guest Interaction for 3D Cell Culture.

https://www.ncbi.nlm.nih.gov/pubmed/30714715

The study of cells responding to an electroconductive environment is impeded by the lack of a

method, which would allow the encapsulation of cells in an extracellular matrix-like 3D electroactive matrix, and more challengingly, permit a simple mechanism to release cells for further characterization. Herein, we report a polysaccharide-based conductive hydrogel system formed via a Î²-cyclodextrin-adamantane host-guest interaction. Oxidative polymerization of 3,4-ethylenedioxythiophene (EDOT) in the presence of adamantyl-modified sulfated alginate (S-Alg-Ad) results in bio-electroconductive polymer PEDOT:S-Alg-Ad, which can form hydrogel with poly-Î²-cyclodextrin (PÎ²-CD). The PEDOT:S-Alg-Ad/PÎ²-CD hydrogels can be tuned on aspects of mechanical and electrical properties, exhibit self-healing feature, and are injectable. Electron microscopy suggested that the difference in stiffness and conductivity is associated with the nacre-like layered nanostructures when different sizes of PEDOT:S-Alg-Ad nanoparticles were used. Myoblast C2C12 cells were encapsulated in the conductive hydrogel and exhibited proliferation rate comparable to that in nonconductive S-Alg-Ad/PÎ²-CD hydrogel. The cells could be released from the hydrogels by adding the Î²-CD monomer. Astonishingly, the conductive hydrogel can dramatically promote myotube-like structure formation, which is not in the non-electroconductive hydrogel. The ability to embed and release cells in an electroconductive environment will open new doors for cell culture and tissue engineering.

Conductive carbon nanofiber interpenetrated graphene architecture for ultra-stable sodium ion battery.

https://www.ncbi.nlm.nih.gov/pubmed/31477733

Long-term stability and high-rate capability have been the major challenges of sodium-ion batteries. Layered electroactive materials with mechanically robust, chemically stable, electrically and ironically conductive networks can effectively address these issues. Herein we have successfully directed carbon nanofibers to vertically penetrate through graphene sheets, constructing robust carbon nanofiber interpenetrated graphene architecture. Molybdenum disulfide nanoflakes are then grown in situ alongside the entire framework, yielding molybdenum disulfide@carbon nanofiber interpenetrated graphene structure. In such a design, carbon nanofibers prevent the restacking of graphene sheets and provide ample space between graphene sheets, enabling a strong structure that maintains exceptional mechanical integrity and excellent electrical conductivity. The as-prepared sodium ion battery delivers outstanding electrochemical performance and ultrahigh stability, achieving a remarkable specific capacity of 598 mAh g-1, long-term cycling stability up to 1000 cycles, and an excellent rate performance even at a high current density up to

10â€‰Aâ€‰g-1.

Highly Crystalline and Semiconducting Imine-Based Two-Dimensional Polymers Enabled by Interfacial Synthesis.

https://www.ncbi.nlm.nih.gov/pubmed/31943664

Single-layer and multi-layer 2D polyimine films have been achieved through the interfacial synthesis methods, which have provided attractive prospects for their functions as electroactive layers in optoelectronic devices. However, it remains a great challenge to achieve the maximum degree of crystallinity in the 2D polyimines, which largely limits the long-range transport properties. Here we employ a surfactant-monolayer-assisted interfacial synthesis (SMAIS) method for the successful preparation of porphyrin and triazine containing polyimine-based 2D polymer (PI-2DP) films with square and hexagonal lattices, respectively. The synthetic PI-2DP films are featured with polycrystalline multilayers with tunable thickness from 6 to 200 nm and large crystalline domains (100-150 nm in size). Intrigued by high crystallinity and the presence of electroactive porphyrin moieties, the optoelectronic properties of PI-2DP are investigated by time-resolved terahertz spectroscopy. Typically, the porphyrin-based PI-2DP 1 film exhibits a p -type semiconductor behavior with a band gap of 1.38 eV and hole mobility as high as 0.01 cm 2 V -1 s -1 , superior to the previously reported polyimine based materials. This work paves the way for the controlled synthesis of large-area and highly crystalline 2D polyimines which may benefit to fully exploiting their properties for optoelectronic devices.

In vivo biocompatibility of PLGA-polyhexylthiophene nanofiber scaffolds in a rat model.

https://www.ncbi.nlm.nih.gov/pubmed/23971031

Electroactive polymers have applications in tissue engineering as a physical template for cell adhesion and carry electrical signals to improve tissue regeneration. Present study demonstrated the biocompatibility and biodegradability of poly(lactide-co-glycolide)-poly(3-hexylthiophene) (PLGA-PHT) blend electrospun scaffolds in a subcutaneous rat model. The biocompatibility of PLGA-undoped PHT, PLGA-doped PHT, and aligned PLGA-doped PHT nanofibers was evaluated and compared with random PLGA fibers. The animals were sacrificed at 2, 4, and 8 weeks; the surrounding tissue along with the implant was removed to evaluate biocompatibility and biodegradability by histologic analysis and GPC, respectively. Histology results demonstrated that all scaffolds except PLGA-undoped PHT showed decrease in inflammation over time. It was observed

that the aligned PLGA-doped PHT fibers elicited moderate response at 2 weeks, which further reduced to a mild response over time with well-organized tissue structure and collagen deposition. The degradation of aligned nanofibers was found to be very slow when compared to random fibers. Further, there was no reduction in the molecular weight of undoped form of PHT throughout the study. These experiments revealed the biocompatibility and biodegradability of PLGA-PHT nanofibers that potentiate it to be used as a biomaterial for various applications.

A review of integrating electroactive polymers as responsive systems for specialized drug delivery applications.

https://www.ncbi.nlm.nih.gov/pubmed/23852673

Electroactive polymers (EAPs) are promising candidate materials for the design of drug delivery technologies, especially in conditions where an "on-off" drug release mechanism is required. To achieve this, EAPs such as polyaniline, polypyrrole, polythiophene, ethylene vinyl acetate, and polyethylene may be blended into responsive hydrogels in conjunction with the desired drug to obtain a patient-controlled drug release system. The "on-off" drug release mechanism can be achieved through the environmental-responsive nature of the interpenetrating hydrogel-EAP complex via (i) charged ions initiated diffusion of drug molecules; (ii) conformational changes that occur during redox switching of EAPs; or (iii) electroerosion. These release mechanisms are not exhaustive and new release mechanisms are still under investigation. Therefore, this review seeks to provide a concise incursion and critical overview of EAPs and responsive hydrogels as a strategy for advanced drug delivery, for example, controlled release of neurotransmitters, sulfosalicyclic acid from cross-linked hydrogel, and vaccine delivery. The review further discusses techniques such as linear sweep voltammetry, cyclic voltammetry, impedance spectroscopy, and chronoamperometry for the determination of the redox capability of EAPs. The future implications of the hydrogel-EAP composites include, but not limited to, application toward biosensors, DNA hybridizations, microsurgical tools, and miniature bioreactors and may be utilized to their full potential in the form of injectable devices as nanorobots or nanobiosensors.

Improving the Electrochemical Performance and Stability of Polypyrrole by Polymerizing Ionic Liquids.

https://www.ncbi.nlm.nih.gov/pubmed/31935858

Polypyrrole (PPy) based electroactive materials are important building blocks for the development of

flexible electronics, bio-sensors and actuator devices. As the properties and behavior of PPy depends strongly on the operating environment-electrolyte, solvent, etc., it is desirable to plant immobile ionic species into PPy films to ensure stable response. A premade ionic polymer is not optimal in many cases, as it enforces its own structure on the conducting polymer, therefore, polymerization during fabrication is preferred. Pyrrole (Py) was electropolymerized at low temperature together with a polymerizable ionic liquid (PIL) monomer in a one-step polymerization, to form a stable film on the working electrode. The structure and morphology of the PPyPIL films were investigated by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDX), Fourier-transform infrared (FTIR) spectroscopy and solid-state NMR (ssNMR) spectroscopy. The spectroscopy results confirmed the successful polymerization of Py to PPy and PIL monomer to PIL. The presence of (TFSI-) anions that balance the charge in PPyPIL was confirmed by EDX analysis. The electrical properties of PPyPIL in lithium bis(trifluoromethanesulfonyl)-imide (LiTFSI) aqueous and propylene carbonate solutions were examined with cyclic voltammetry (CV), chronoamperometry, and chronopotentiometry. The blend of PPyPIL had mixed electronic/ionic conductive properties that were strongly influenced by the solvent. In aqueous electrolyte, the electrical conductivity was 30 times lower and the diffusion coefficient 1.5 times higher than in the organic electrolyte. Importantly, the capacity, current density, and charge density were found to stay consistent, independent of the choice of solvent.

Micropatterned surfaces functionalized with electroactive peptides for detecting protease release from cells.

https://www.ncbi.nlm.nih.gov/pubmed/23181468

Matrix metalloproteinases (MMPs) regulate composition of the extracellular matrix and play a critical role in cancer, fibrosis, and wound healing. This article describes a novel peptide-based electrochemical biosensor for detecting activity of cell-secreted protease MMP9. In this sensing strategy, a peptide specific to MMP9 was modified with a redox label (methylene blue (MB)) and immobilized on microfabricated 300 Î¼m diameter Au electrodes. Challenging the electrodes with known concentrations of MMP9 resulted in the cleavage of the MB containing peptide fragment and caused a decrease in electrical signal measured by square wave voltammetry (SWV). The limit of detection for MMP9 was determined to be 60 pM with a linear range extending to 50 nM. In preparation to detect cell-secreted MMP9, glass surfaces with Au electrode arrays were further micropatterned with poly(ethylene glycol) (PEG) gel to define annular cell adhesive regions next to

electrodes and render the remainder of the surface nonfouling. The surfaces were further modified with CD14 antibody to promote attachment of monocytes. The peptide-modified electrode arrays were integrated into PDMS microfluidic devices and incubated with U-937 cells, transformed monocytes known to produce MMPs. These studies revealed a 3-fold higher electrochemical signal from âˆ¼400 activated monocytes after 10 min activation compared to nonactivated monocytes. Whereas this article focuses on MMP9 detection, the general strategy of employing redox-labeled peptides on electrodes should be broadly applicable for detection of other proteases and should have clinical as well as basic science applications.

Rapid, sensitive detection of neurotransmitters at microelectrodes modified with self-assembled SWCNT forests.

https://www.ncbi.nlm.nih.gov/pubmed/22823497

Carbon nanotube (CNT) modification of microelectrodes can result in increased sensitivity without compromising time response. However, dip coating CNTs is not very reproducible and the CNTs tend to lay flat on the electrode surface which limits access to the electroactive sites on the ends. In this study, aligned CNT forests were formed using a chemical self-assembly method, which resulted in more exposed CNT ends to the analyte. Shortened, carboxylic acid functionalized single-walled CNTs were assembled from a dimethylformamide (DMF) suspension onto a carbon-fiber disk microelectrode modified with a thin iron hydroxide-decorated Nafion film. The modified electrodes were highly sensitive, with 36-fold higher oxidation currents for dopamine using fast-scan cyclic voltammetry than bare electrodes and 34-fold more current than electrodes dipped in CNTs. The limit of detection (LOD) for dopamine was 17 Â± 3 nM at a 10 Hz repetition rate and 65 Â± 7 nM at 90 Hz. The LOD at 90 Hz was the same as a bare electrode at 10 Hz, allowing a 9-fold increase in temporal resolution without a decrease in sensitivity. Similar increases were observed for other cationic catecholamine neurotransmitters, and the increases in current were greater than for anionic interferents such as ascorbic acid and 3,4-dihydroxyphenylacetic acid (DOPAC). The CNT forest electrodes had high sensitivity at 90 Hz repetition rate when stimulated dopamine release was measured in Drosophila . The sensitivity, temporal resolution, and spatial resolution of these CNT forest modified disk electrodes facilitate enhanced electrochemical measurements of neurotransmitter release in vivo.

Electroactive nanofibers mats based on poly(l-lactic acid)/poly(ortho-ethoxyaniline) blends

for biological applications.

https://www.ncbi.nlm.nih.gov/pubmed/31546378

The combination of scaffolds with desirable topographic characteristics and the use of electrical stimulus consist of a strategy to repair and regenerate tissues. An interesting approach to obtain electroactive scaffolds with the aforementioned features comprises on the use of conducting polymers which can be blended with other biocompatible polymers. In this work, poly(l-lactic acid) (PLLA) and poly(ortho-ethoxyaniline) (POEA) were synthesized and PLLA/POEA mats were prepared for the first time by electrospinning technique. Topographic characterization of PLLA/POEA showed a tunable mean diameter of the nanofibers by changing the electrospinning parameters. The presence of POEA into the blend was confirmed by X-ray photoelectron and Fourier-transform infrared spectroscopy analyses. Differential scanning calorimetry curves of PLLA/POEA exhibited shift positions of Tc and absence of the exothermic peak related to the characteristic isomerization process of POEA at high temperatures. The thermal analysis results indicate a favored miscibility between the polymers which is likely resulted from the strong interaction between polymers functionalities. The homogenous distribution of POEA chains throughout the scaffold rendered redox reversibility property for the mats. Biocompatibility results showed non-cytotoxic features for PLLA/POEA, attesting this novel system as a promising candidate for biological applications.

The preparation of hollow AgPt@Pt core-shell nanoparticles loaded on polypyrrole nanosheet modified electrode and its application in immunosensor.

https://www.ncbi.nlm.nih.gov/pubmed/31494386

The designed synthesis of efficient materials can significantly enhance the performance of electrochemical immunoassay in the detection of diseases, pesticide residues and environmental pollutants. The hollow AgPt@Pt core-shell nanoparticles (AgPt@Pt HNs) have exhibited high catalytic efficiency to the hydrogen peroxide (H2O2) reduction for its high mass activity from their hollow structure. Their limitation of instability can be overcome by loading on polypyrrole nanosheet (PPy NS). Besides, PPy NS exhibits good conductivity, and there exists environmentally-friendly method for its synthetic. Thus, AgPt@Pt HNs loaded on PPy NS (AgPt@Pt HNs/PPy NS) exhibits high catalytic efficiency to the reduction of H2O2 and good stability. Furthermore, the quick electron transfer of AgPt@Pt HNs/PPy NS modified glassy carbon electrode has been evidenced by the finding that the large constant of apparent electron transfer rate has also enlarged the current signal

when the amount of electron is invariant. The modified electrode has fabricated a label-free amperometric immunosensor to detect sensitively prostate-specific antigen (PSA) with H2O2 as the electroactive material. The immunosensor in hollow core-shell nanosheet structure exhibiting good detection performance of PSA shows its promising applications in the clinical diagnosis.

Sensing of glycoprotein via a biomimetic sensor based on molecularly imprinted polymers and graphene-Au nanoparticles.

https://www.ncbi.nlm.nih.gov/pubmed/23304694

A novel strategy was proposed for preparing a highly sensitive glycoprotein sensor based on molecularly imprinted polymers (MIP), which was electropolymerized with o-phenylenediamine and 3-aminophenylboronic acid monohydrate in the presence of template molecules (bovine serum albumin (BSA)). Sensitivity improved dramatically owing to the application of a graphene-Au nanoparticles hybrid as the electrode modifier, and the immobilization of a large amount of 6-ferrocenylhexanethiol, as the electroactive species, onto nanoparticles. The quantification of BSA was realized by detecting the electrochemical oxidation signal of 6-ferrocenylhexanethiol, which was bonded onto the electrode. Under optimized conditions, a good relationship was obtained between the response current and logarithm of BSA concentration in the range of 1.0 Ã— 10(-11) to 1.0 Ã— 10(-5) g mL(-1) with a detection limit of 7.5 Ã— 10(-12) g mL(-1) (S/N = 3). The resulting MIP sensor displayed good selectivity, reproducibility and stability.

Nafion-CNT coated carbon-fiber microelectrodes for enhanced detection of adenosine.

https://www.ncbi.nlm.nih.gov/pubmed/22606688

Adenosine is a neuromodulator that regulates neurotransmission. Adenosine can be monitored using fast-scan cyclic voltammetry at carbon-fiber microelectrodes and ATP is a possible interferent in vivo because the electroactive moiety, adenine, is the same for both molecules. In this study, we investigated carbon-fiber microelectrodes coated with Nafion and carbon nanotubes (CNTs) to enhance the sensitivity of adenosine and decrease interference by ATP. Electrodes coated in 0.05 mg mL(-1) CNTs in Nafion had a 4.2 Â± 0.2 fold increase in current for adenosine, twice as large as for Nafion alone. Nafion-CNT electrodes were 6 times more sensitive to adenosine than ATP. The Nafion-CNT coating did not slow the temporal response of the electrode. Comparing different purine bases shows that the presence of an amine group enhances sensitivity and that purines with carbonyl groups, such as guanine and hypoxanthine, do not have as great an enhancement after

Nafion-CNT coating. The ribose group provides additional sensitivity enhancement for adenosine over adenine. The Nafion-CNT modified electrodes exhibited significantly more current for adenosine than ATP in brain slices. Therefore, Nafion-CNT modified electrodes are useful for sensitive, selective detection of adenosine in biological samples.

Strategies to Control Performance of 3D-Printed, Cable-Driven Soft Polymer Actuators: From Simple Architectures to Gripper Prototype.

https://www.ncbi.nlm.nih.gov/pubmed/30960772

The following is a study of the performance of soft cable-driven polymer actuators produced by multimaterial 3D printing. We demonstrate that the mechanical response of the polymer actuator with an embedded cable can be flexibly tuned through the targeted selection of actuator architecture. Various strategies, such as the addition of discrete or periodic stiff inserts, the sectioning of the actuator, or the shifting of the cable channel are employed to demonstrate ways to achieve more controllable deformed shape during weight lifting or reduce the required actuation force. To illustrate these concepts, we design and manufacture a prototype of the soft polymer gripper, which is capable of manipulating small, delicate objects. The explored strategies can be utilized in other types of soft actuators, employing, for instance, actuation by means of electroactive polymers.

Enhanced Stability and Driving Performance of GOâ•»Ag-NW-based Ionic Electroactive Polymer Actuators with Triton X-100-PEDOT:PSS Nanofibrils.

https://www.ncbi.nlm.nih.gov/pubmed/31109120

Ionic electroactive polymers (IEAPs) have received considerable attention for their flexibility, lightweight composition, large displacement, and low-voltage activation. Recently, many metal-nonmetal composite electrodes have been actively studied. Specifically, graphene oxide-silver nanowire (GO-Ag NW) composite electrodes offer advantages among IEAPs with metal-nonmetal composite electrodes. However, GO-Ag NW composite electrodes still show a decrease in displacement owing to low stability and durability during driving. Therefore, the durability and stability of the IEAPs with metal-nonmetal composite electrodes must be improved. One way to improve the device durability is coating the electrode surface with a protective layer. This layer must have enough flexibility and suitable electrical properties such that it does not hinder the IEAPs' driving. Herein, a poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT:PSS) protective

layer and 4-(1,1,3,3-tetramethylbutyl)phenyl-polyethylene glycol (Triton X-100) are applied to improve driving performance. Triton X-100 is a nonionic surfactant that transforms the PEDOT:PSS capsule into a nanofibril structure. In this study, a mixed Triton X-100/PEDOT:PSS protective layer at an optimum weight ratio was coated onto the GO-Ag NW composite-electrode-based IEAPs under various conditions. The IEAP actuators based on GO-Ag NW composite electrodes with a protective layer of PEDOT:PSS treated with Triton X-100 showed the best stability and durability.

An electrochemical aptasensor based on eATRP amplification for the detection of bisphenol A.

https://www.ncbi.nlm.nih.gov/pubmed/31508622

Herein, a novel aptasensor was constructed for ultrasensitive detection of bisphenol A (BPA). In this method, an electrochemically mediated atom transfer radical polymerization (eATRP) signal amplification strategy was applied to BPA detection for the first time. The 5'-end modified sulfhydryl group and the 3'-end modified azide group hairpin DNA were immobilized on a gold electrode through an Au-S bond. The double-stranded DNA was formed by the hybridization of an aptamer and a single-stranded DNA partially paired with the hairpin DNA. In the presence of BPA, the aptamer combined with BPA and the single-stranded DNA was released to open the hairpin structure, making the azide groups at the 3' end exposed. Subsequently the initiator of eATRP was introduced into hairpin DNA through click chemistry reaction and eATRP was conducted for the polymerization of the electroactive probe ferrocene methyl methacrylate (FMMA). As a result, the ultrasensitive detection of BPA was realized, and the detection limit of this aptasensor was as low as 59 aM and a good selectivity was obtained in the presence of 100-fold structural analogs. The application of this aptasensor was evaluated by detecting BPA in pure water samples, and recoveries were in the range of 95.23-98.40%, holding promising applications in biological analysis.

Synthesis of biodegradable and electroactive tetraaniline grafted poly(ester amide) copolymers for bone tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/22909313

Biodegradable poly(ester amide)s have recently been used as biomaterials due to their desirable chemical and biological characteristics as well as their mechanical properties, which are amendable for material processing. In this study, electroactive tetraaniline (TA) grafted poly(ester amide)s were successfully synthesized and characterized. The poly(ester amide)s-graft-tetraaniline copolymers

(PEA-g-TA) exhibited good electroactivity, mechanical properties, and biodegradability. The biocompatibility of the PEA-g-TA copolymers in vitro was systematically studied, which demonstrated that they were nontoxic and led to favorable adhesion and proliferation of mouse preosteoblastic MC3T3-E1 cells. Moreover, the PEA-g-TA copolymers stimulated by pulsed electrical signal could serve to promote the differentiation of MC3T3-E1 cells compared with TCPs. Hence, the biodegradable and electroactive PEA-g-TA copolymers possessed the properties in favor of the long-time potential application in vivo (electrical stimulation directly to the desired area) as bone repair scaffold materials in tissue engineering.

A highly sensitive molecular structural probe applied to in situ biosensing of metabolites using PEDOT:PSS.

https://www.ncbi.nlm.nih.gov/pubmed/31589342

A large amount of research within organic biosensors is dominated by organic electrochemical transistors (OECTs) that use conducting polymers such as poly(3,4-ethylene dioxythiophene) doped with poly(styrenesulfonate) (PEDOT:PSS). Despite the recent advances in OECT-based biosensors, the sensing is solely reliant on the amperometric detection of the bioanalytes. This is typically accompanied by large undesirable parasitic electrical signals from the electroactive components in the electrolyte. Herein, we present the use of in situ resonance Raman spectroscopy to probe subtle molecular structural changes of PEDOT:PSS associated with its doping level. We demonstrate how such doping level changes of PEDOT:PSS can be used, for the first time, on operational OECTs for sensitive and selective metabolite sensing while simultaneously performing amperometric detection of the analyte. We test the sensitivity by molecularly sensing a lowest glucose concentration of 0.02â€‰mM in phosphate-buffered saline solution. By changing the electrolyte to cell culture media, the selectivity of in situ resonance Raman spectroscopy is emphasized as it remains unaffected by other electroactive components in the electrolyte. The application of this molecular structural probe highlights the importance of developing biosensing probes that benefit from high sensitivity of the material's structural and electrical properties while being complimentary with the electronic methods of detection.

A new dual-signalling electrochemical sensing strategy based on competitive host-guest interaction of a Î²-cyclodextrin/poly(N-acetylaniline)/graphene-modified electrode: sensitive electrochemical determination of organic pollutants.

https://www.ncbi.nlm.nih.gov/pubmed/23520127

Based on the competitive host-guest interaction between a Î²-cyclodextrin/poly(N-acetylaniline)/electrogenerated-graphene (Î²-CD/PNAANI/EG) film and probe or target molecules, a new dual-signalling electrochemical sensing method has been developed for the sensitive and selective determination of organic pollutants. As a model system, rhodamineâ€…B (RhB) and 1-aminopyrene (1-AP) were adopted as the probe and target molecules, respectively. Due to the host-guest interaction, RhB molecules can enter into the hydrophobic inner cavity of Î²-CD, and the Î²-CD/PNAANI/EG-modified glassy carbon electrode displays a remarkable oxidation peak due to RhB. In the presence of 1-AP, competitive association to Î²-CD occurs and the RhB molecules are displaced by 1-AP. This results in a decreased oxidation peak current of RhB and the appearance of an oxidation peak current for 1-AP, and the changes of these signals correlate linearly with the concentration of 1-AP. When the value Î”I(1-AP)+âˆ£Î”I(RhB)âˆ£ (Î”I(1-AP) and Î”I(RhB) are the change values of the oxidation peak currents of 1-AP and RhB, respectively) is used as the response signal to quantitatively determine the concentration of 1-AP, the detection limit is much lower than that given by using Î”I(1-AP) or Î”I(RhB) as the response signal. This dual-signalling sensor can provide more sensitive target recognition and will have important applications in the sensitive and selective electrochemical determination of electroactive organic pollutants.

Resolving sub-molecular binding and electrical switching mechanisms of single proteins at electroactive conducting polymers.

https://www.ncbi.nlm.nih.gov/pubmed/23074088

Polymer-based electrodes for interfacing biological tissues are becoming increasingly sophisticated. Their many functions place them at the cross-roads of electromaterials, biomaterials, and drug-delivery systems. For conducting polymers, the mechanism of conductivity requires doping with anionic molecules such as extracellular matrix molecules, a process that distinguishes them as biomaterials and provides a means to control interactions at the cellular-electrode interface. However, due to their complex structure, directly observing the selective binding of target molecules or proteins has so far eluded researchers. This situation is compounded by the polymer's ability to adopt different electronic states that alter the polymer-dopant interactions. Here, the ability to resolve sub-molecular binding specificity between sulfate and carboxyl groups of dopants and heparin binding domains of human plasma fibronectin is demonstrated. The interaction exploits a form of biological 'charge complementarity' to enable specificity. When an electrical signal is applied

to the polymer, the specific interaction is switched to a non-specific, high-affinity binding state that can be reversibly controlled using electrochemical processes. Both the specific and non-specific interactions are integral for controlling protein conformation and dynamics. These details, which represent the first direct measurement of biomolecular recognition between a single protein and any type of organic conductor, give new molecular insight into controlling cellular interactions on these polymer surfaces.

A Mussel-Inspired Persistent ROS-Scavenging, Electroactive, and Osteoinductive Scaffold Based on Electrochemical-Driven In Situ Nanoassembly.

https://www.ncbi.nlm.nih.gov/pubmed/31106983

Conductive polymers are promising for bone regeneration because they can regulate cell behavior through electrical stimulation; moreover, they are antioxidative agents that can be used to protect cells and tissues from damage originating from reactive oxygen species (ROS). However, conductive polymers lack affinity to cells and osteoinductivity, which limits their application in tissue engineering. Herein, an electroactive, cell affinitive, persistent ROS-scavenging, and osteoinductive porous Ti scaffold is prepared by the on-surface in situ assembly of a polypyrrole-polydopamine-hydroxyapatite (PPy-PDA-HA) film through a layer-by-layer pulse electrodeposition (LBL-PED) method. During LBL-PED, the PPy-PDA nanoparticles (NPs) and HA NPs are in situ synthesized and uniformly coated on a porous scaffold from inside to outside. PDA is entangled with and doped into PPy to enhance the ROS scavenging rate of the scaffold and realize repeatable, efficient ROS scavenging over a long period of time. HA and electrical stimulation synergistically promote osteogenic cell differentiation on PPy-PDA-HA films. Ultimately, the PPy-PDA-HA porous scaffold provides excellent bone regeneration through the synergistic effects of electroactivity, cell affinity, and antioxidative activity of the PPy-PDA NPs and the osteoinductivity of HA NPs. This study provides a new strategy for functionalizing porous scaffolds that show great promise as implants for tissue regeneration.

Electrochemomechanical Behavior of Polypyrrole-Coated Nanofiber Scaffolds in Cell Culture Medium.

https://www.ncbi.nlm.nih.gov/pubmed/31200448

Glucose-gelatin nanofiber scaffolds were made conductive and electroactive by chemical (conductive fiber scaffolds, CFS) and additionally electrochemical polypyrrole deposition (doped with

triflouromethanesulfonate CF3SO3-, CFS-PPyTF). Both materials were investigated in their linear actuation properties in cell culture medium (CCM), as they could be potential electro-mechanically activated cell growth substrates. Independent of the deposition conditions, both materials showed relatively stable cation-driven actuation in CCM, based on the flux of mainly Na+ ions from CCM. The surprising result was attributed to re-doping by sulfate anions in CCM, as also indicated by energy-dispersive X-ray (EDX) spectroscopy results. Overall, the electrochemically coated material outperformed the one with just chemical coating in conductivity, charge density and actuation response.

Graphene-wrapped polyaniline hollow spheres as novel hybrid electrode materials for supercapacitor applications.

https://www.ncbi.nlm.nih.gov/pubmed/23517224

Polyaniline hollow spheres (PANI-HS)@electrochemical reduced graphene oxide (ERGO) hybrids with core-shell structures have been fabricated via a solution-based coassembly process. The hollow nanostructured designing for the PANI-HS greatly enlarges the specific surface area, providing high electroactive regions and short diffusion lengths for both charge and ion transport. The wrapping of ERGO sheets on the PANI-HS can offer highly conductive pathways by bridging individual PANI-HS together, thus facilitating the rate and cycling performance of supercapacitors. The specific capacitance of PANI-HS36@ERGO hybrids can reach 614 F g(-1) at a current density of 1 A g(-1). Furthermore, the capacitance of the PANI-HS36@ERGO hybrids maintains 90% after 500 charging/discharging cycles at a current density of 1 A g(-1), indicating a good cycling stability. The greatly enhanced electrochemical performance can be ascribed to the synergic effects of the two components of PANI-HS and ERGO, suggesting that the PANI-HS@ERGO hybrids as novel electrode materials may have potential applications in high-performance energy storage devices.

Analytical Platform To Characterize Dopant Solution Concentrations, Charge Carrier Densities in Films and Interfaces, and Physical Diffusion in Polymers Utilizing Remote Field-Effect Transistors.

https://www.ncbi.nlm.nih.gov/pubmed/30816046

Characterizing doping effects in a conductive polymer and physical diffusion in a passive polymer were performed using a remote-gate field-effect transistor (RG FET) detection system that was able to measure the electrical potential perturbation of a polymer film coupled to the gate of a silicon FET.

Poly(3-hexylthiophene) (P3HT) film doped using various concentrations of 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4TCNQ) solutions imposed additional positive potentials on the P3HT RG, resulting in a lower threshold voltage (Vth) on the n-channel silicon FET. Changes in Vth were related to the induced hole concentrations and hole mobility in P3HT films by using our Vth shifting model for the RG FET. We discovered that the electron-donating P3HT and even inorganic materials, indium tin oxide and gold, showed similar electrical potential perturbations dependent on the concentration of F4TCNQ in overlying solutions as the dopant radical anions maximally covered the surfaces. This suggests that there are limited electroactive sites for F4TCNQ binding on electron donor surfaces which results in a similar number of positive charges in film materials forming dipoles with the F4TCNQ radical counteranions. The effect of electron acceptors such as 7,7,8,8-tetracyanoquinodimethane and tetracyanoethylene was compared to that of F4TCNQ in terms of Vth shift using our analytical tool, with differences attributed to acceptor size and reduction potential. Meanwhile, this FET analysis tool offered a means of monitoring the physical diffusion of small molecules, exemplified by F4TCNQ, in the passive polymer polystyrene, driven by concentration gradients. The technique allows for nondestructive, nonspectroscopic, ambient characterization of electron donor-acceptor interactions at surfaces.

Tellurium-nanowire-coated glassy carbon electrodes for selective and sensitive detection of dopamine.

https://www.ncbi.nlm.nih.gov/pubmed/22483356

Tellurium-nanowire-coated glassy carbon electrodes (TNGCEs) have been fabricated and employed for selective and sensitive detection of dopamine (DA). TNGCEs were prepared by direct deposition of tellurium nanowires, 600 Â± 150 nm in length and 16 Â± 3 nm in diameter, onto glassy carbon electrodes, which were further coated with Nafion to improve their selectivity and stability. Compared to the GCE, the TNGCE is more electroactive (by approximately 1.9-fold) for DA, and its selectivity toward DA over ascorbic acid (AA) and uric acid (UA) is also greater. By applying differential pulse voltammetry, at a signal-to-noise ratio of 3, the TNGCE provides a limit of detection of 1 nM for DA in the presence of 0.5mM AA and UA. Linearity (R(2)=0.9955) of the oxidation current at 0.19 V against the concentration of DA is found over the range 5 nM-1 Î¼M. TNGCEs have been applied to determine the concentration of dopamine to be 0.59 Â± 0.07 Î¼M in PC12 cells.

Procedure for fabricating biofunctional nanofibers.

https://www.ncbi.nlm.nih.gov/pubmed/22987140

Electrospinning is an effective processing method for preparing nanofibers decorated with functional groups. Nanofibers decorated with functional groups may be utilized to study material-biomarker interactions i.e. act as biosensors with potential as single molecule detectors. We have developed an effective approach for preparing functional polymers where the functionality has the capacity of specifically binding with a model protein. In our model system, the functional group is 2,4-dinitrophenyl (DNP) and the protein is anti-DNP IgE (Immunoglobulin E). The functional polymer, Î±,Ï‰-bi[2,4-dinitrophenyl caproic][poly(ethylene oxide)-b-poly(2-methoxystyrene)-b-poly(ethylene oxide)] (CDNP-PEO-P2MS-PEO-CDNP), is prepared by anionic living polymerization. The difunctional initiator utilized in the polymerization was prepared by electron transfer reaction of Î±-methylstyrene and potassium (mirror) metal. The 2-methoxystyrene monomer was added first to the initiator, followed by the addition of the second monomer, ethylene oxide, and finally the living polymer was terminated by methanol. The Î±,Ï‰-dihydroxyl polymer [HO-PEO-P2MS-PEO-OH] was reacted with N-2,4-DNP-âˆ-amino caproic acid, by DCC coupling, resulting in the formation of Î±,Ï‰-bi[2,4-dinitrophenylcaproic][poly(ethyleneoxide)-b-poly(2-methoxystyrene)-b-poly(ethylene oxide)] (CDNP-PEO-P2MS-PEO-CDNP). The polymers were characterized by FT-IR, (1)H NMR and Gel Permeation Chromatography (GPC). The molecular weight distributions of the polymers were narrow (1.1-1.2) and polymers with molecular weights greater than 50,000 was used in this study. The polymers were yellow powders and soluble in tetrahydrofuran. A water soluble CDNP-PEO-P2MS-PEO-CDNP/ DMEG (dimethoxyethylene glycol) complex binds and achieves steady state binding with solution IgE within a few seconds. Higher molecular weight (water insoluble i.e. around 50,000) CDNP-PEO-P2MS-PEO-CDNP polymers, containing 1% single wall carbon nanotubes (SWCNT) were processed into electroactive nanofibers (100 nm to 500 nm in diameter) on silicon substrate. Fluorescence spectroscopy shows that anti-DNP IgE interacts with the nanofibers by binding with the DNP functional groups decorating the fibers. These observations suggest that appropriately functionalized nanofibers hold promise for developing biomarker detection device.

Enhanced Figures of Merit for a High-Performing Actuator in Electrostrictive Materials.

https://www.ncbi.nlm.nih.gov/pubmed/30966298

The overall performance of an electrostrictive polymer is rated by characteristic numbers, such as its transverse strain, blocking force, and energy density, which are clearly limited by several

parameters. Besides the geometrical impact, intrinsic material parameters, such as the permittivity coefficient as well as the Young's modulus and the breakdown electric field, have strong influences on the actuation properties of an electroactive polymer and thus on the device's overall behavior. As a result, an analysis of the figures of merit (FOMs) involving all relevant material parameters for the transverse strain, the blocking force, and the energy density was carried out, making it possible to determine the choice of polymer matrix in order to achieve a high actuator performance. Another purpose of this work was to demonstrate the possibility of accurately measuring the free deflection without the application of an external force and inversely measuring the blocking force under quasi-static displacement. The experimental results show good electrostrictive characteristics of the plasticized terpolymer under relatively low electric fields.

Nanoparticle Doped PEDOT for Enhanced Electrode Coatings and Drug Delivery.

https://www.ncbi.nlm.nih.gov/pubmed/31583857

In order to address material limitations of biologically interfacing electrodes, modified silica nanoparticles are utilized as dopants for conducting polymers. Silica precursors are selected to form a thiol modified particle (TNP), following which the particles are oxidized to sulfonate modified nanoparticles (SNPs). The selective inclusion of hexadecyl trimethylammonium bromide allows for synthesis of both porous and nonporous SNPs. Nonporous nanoparticle doped polyethylenedioxythiophene (PEDOT) films possess low interfacial impedance, high charge injection (4.8 mC cm-2), and improved stability under stimulation compared to PEDOT/poly(styrenesulfonate). Porous SNP dopants can serve as drug reservoirs and greatly enhance the capability of conducting polymer-based, electrically controlled drug release technology. Using the SNP dopants, drug loading and release is increased up to 16.8 times, in addition to greatly expanding the range of drug candidates to include both cationic and electroactive compounds, all while maintaining their bioactivity. Finally, the PEDOT/SNP composite is capable of precisely modulating neural activity in vivo by timed release of a glutamate receptor antagonist from coated microelectrode sites. Together, this work demonstrates the feasibility and potential of doping conducting polymers with engineered nanoparticles, creating countless options to produce composite materials for enhanced electrical stimulation, neural recording, chemical sensing, and on demand drug delivery.

Tunable, dynamic and electrically stimulated lectin-carbohydrate recognition on a

glycan-grafted conjugated polymer.

https://www.ncbi.nlm.nih.gov/pubmed/22673452

An electroactive platform for multivalent, reversible and electrically stimulated lectin-carbohydrate recognition based on mannose-functionalized conjugated polymer is reported and tuned by electrocopolymerization of mixture of tri(ethylene glycol)-functionalized EDOT and its Î±-mannose conjugate.

A Novel Application of Electroactive Polyimide Doped with Gold Nanoparticles: As a Chemiresistor Sensor for Hydrogen Sulfide Gas.

https://www.ncbi.nlm.nih.gov/pubmed/31766447

This research paper presents a new application of electroactive polyimide doped with gold nanoparticles (PI/AuNPs) as a chemiresistor sensor for detecting hydrogen sulfide gas. The synthesis of PI/AuNPs was done in a simple 3-step process of polymerization using the as prepared amine-capped aniline trimer (ACAT), followed by imidization, and doping. Spectral analyses via FTIR, LC-MS and 1H-NMR confirmed the formation of amine-capped aniline trimer with a MW of 288 g mol-1. Comparison of ACAT, BSAA, and PI FTIR spectra showed successful polymerization of the last, while XRD validated the incorporation of metal nanoparticles onto the polymer matrix, showing characteristic diffraction peaks corresponding to gold. Furthermore, TEM, and FE-SEM revealed the presence of well-dispersed Au nanoparticles with an average diameter of about 60 nm. The electroactive PI/AuNPs-based sensor showed a sensitivity of 0.29% ppm-1 H2S at a linear concentration range of 50 to 300 ppm H2S (r = 0.9777). The theoretical limit of detection was found at 0.142 ppm or 142 ppb H2S gas. The sensor provided a stable response reading at an average response time of 43 Â± 5 s, which was easily recovered after an average time of 99 Â± 5 s. The sensor response was highly repeatable and reversible, with RSD values of 8.88%, and 8.60%, respectively. Compared with the performance of the conventional conducting polyaniline also doped with gold nanoparticles (PANI/AuNPs), the fabricated electroactive PI/AuNPs exhibited improved sensing performance making it a potential candidate in monitoring H2S in the environment and for work-related safety.

Electrically switchable polypyrrole film for the tunable release of progesterone.

https://www.ncbi.nlm.nih.gov/pubmed/23442078

Intrinsically conducting polymers, such as polypyrrole (PPy), have been utilized for drug delivery

purposes as drug release rates can be tuned by electrical stimulation. Electrical stimulation can be used to switch the redox state of PPy, subsequently changing the electrostatic charge and volume of the polymer. Most literature to date has focused on the delivery of charged bioactives. This study aimed to prepare a PPy film formulation where the release rate of the uncharged drug progesterone could be electrically tuned.

Biomedical Application of ElectroactiveÂ Polymers in Electrochemical Sensors: A Review.

https://www.ncbi.nlm.nih.gov/pubmed/31426613

Conducting polymers are of interest due to their unique behavior on exposure to electric fields, which has led to their use in flexible electronics, sensors, and biomaterials. The unique electroactive properties of conducting polymers allow them to be used to prepare biosensors that enable real time, point of care (POC) testing. Potential advantages of these devices include their low cost and low detection limit, ultimately resulting in increased access to treatment. This article presents a review of the characteristics of conducting polymer-based biosensors and the recent advances in their application in the recognition of disease biomarkers.

Electrohydrodynamic 3D printing of layer-specifically oriented, multiscale conductive scaffolds for cardiac tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/31380883

Mimicking the hierarchical microarchitecture of native myocardium in vitro plays an important role in cardiac tissue engineering. Here we present a novel strategy to produce multiscale conductive scaffolds with layer-specific fiber orientations for cardiac regeneration by combining solution-based and melt-based electrohydrodynamic (EHD) printing techniques. Polycaprolactone (PCL) microfibers were printed by melt-based EHD printing and the fiber orientation was flexibly controlled in a layer-by-layer manner according to user-specific design. The as-printed microfibrous scaffolds can provide the seeded cells necessary contact cues to guide layer-specific cellular alignments. Sub-microscale conductive fibers were simultaneously incorporated inside the well-organized PCL scaffolds by solution-based EHD printing, which significantly improved the conductivity as well as the cellular adhesion and proliferation capacity. The multiscale conductive scaffolds can further direct the multiple-layer alignments of primary cardiomyocytes and facilitate cardiomyocyte-specific gene expressions, which exhibited enhanced synchronous beating behavior compared with pure microfibrous scaffolds. It is envisioned that the proposed hybrid EHD printing technique might

provide a promising strategy to fabricate multifunctional micro/nanofibrous scaffolds with biomimetic architectures, electrical conductivity and even biosensing properties for the regeneration of electroactive tissues.

Simultaneous decolorization and bioelectricity generation in a dual chamber microbial fuel cell using electropolymerized-enzymatic cathode.

https://www.ncbi.nlm.nih.gov/pubmed/22612728

Effect of cathodic enzymatic decolorization of reactive blue 221 (RB221) on the performance of a dual-chamber microbial fuel cell (MFC) was investigated. Immobilized laccase on the surface of a modified graphite electrode was used in the cathode compartment in order to decolorize the azo dye and enhance the oxygen reduction reaction. First, methylene blue which is an electroactive polymer was electropolymerized on the surface of a graphite bar to prepare the modified electrode. Utilization of the modified electrode with no enzyme in the MFC increased the power density up to 57% due to the reduction of internal resistance from 1000 to 750 Î©. Using the electropolymerized-enzymatic cathode resulted in 65% improvement of the power density and a decolorization efficiency of 74%. Laccase could act as a biocatalyst for oxygen reduction reaction along with catalyzing RB221 decolorization. Treatment of RB221 with immobilized laccase reduced its toxicity up to 5.2%. Degradation products of RB221 were identified using GC-MS, and the decomposition pathway was proposed. A discussion was also provided as to the mechanism of dye decolorization on the enhancement of the MFC performance.

Multifunctional Platform Based on Electroactive Polymers and Silica Nanoparticles for Tissue Engineering Applications.

https://www.ncbi.nlm.nih.gov/pubmed/30423943

Poly(vinylidene fluoride) nanocomposites processed with different morphologies, such as porous and non-porous films and fibres, have been prepared with silica nanoparticles (SiNPs) of varying diameter (17, 100, 160 and 300 nm), which in turn have encapsulated perylenediimide (PDI), a fluorescent molecule. The structural, morphological, optical, thermal, and mechanical properties of the nanocomposites, with SiNP filler concentration up to 16 wt %, were evaluated. Furthermore, cytotoxicity and cell proliferation studies were performed. All SiNPs are negatively charged independently of the pH and more stable from pH 5 upwards. The introduction of SiNPs within the polymer matrix increases the contact angle independently of the nanoparticle diameter. Moreover,

the smallest ones (17 nm) also improve the PVDF Young's modulus. The filler diameter, physico-chemical, thermal and mechanical properties of the polymer matrix were not significantly affected. Finally, the SiNPs' inclusion does not induce cytotoxicity in murine myoblasts (C2C12) after 72 h of contact and proliferation studies reveal that the prepared composites represent a suitable platform for tissue engineering applications, as they allow us to combine the biocompatibility and piezoelectricity of the polymer with the possible functionalization and drug encapsulation and release of the SiNP.

Structure-Property Relationships in Hybrid Cellulose Nanofibrils/Nafion-Based Ionic Polymer-Metal Composites.

https://www.ncbi.nlm.nih.gov/pubmed/31003420

Herein, we report the production of ionic polymer-metal composites (IPMCs) hybridized with cellulose nanofibrils (CNF) as a partial substitute for NafionÂ®. The aim is not only to reduce the production cost and enhance respective mechanical/thermal properties but also to bestow a considerable degree of biodegradability to such products. Formulations with different CNF/NafionÂ® ratios were produced in a thin-film casting process. Crack-free films were air-dried and plated by platinum (Pt) through an oxidation-reduction reaction. The produced hybrids were analyzed in terms of thermal stability, mechanical and morphological aspects to examine their performance compared to the Nafion-based IPMC prior to plating process. Results indicated that films with higher CNF loadings had improved tensile strengths and elastic moduli but reduced ductility. Thermogravimetric analysis (TGA) showed that the incorporation of CNF to the matrix reduced its thermal stability almost linearly, however, the onset of decomposition point remained above 120 Â°C, which was far above the temperature the composite membrane is expected to be exposed to. The addition of a cross-linking agent to the formulations helped with maintaining the integrity of the membranes during the plating process, thereby improving surface conductivity. The focus of the current study was on the physical and morphological properties of the films, and the presented data advocate the potential utilization of CNF as a nontoxic and sustainable bio-polymer for blending with perfluorosulfonic acid-based co-polymers, such as NafionÂ®, to be used in electroactive membranes.

A highly selective potentiometric sensor of molybdate based on a mu-oxo-bridged manganeseporphyrin dimer.

https://www.ncbi.nlm.nih.gov/pubmed/16837744

A novel high-selective potentiometric sensor for molybdate was prepared with a PVC membrane combining mu-oxo-bis[5,10,15,20-tetra(p-methylphenyl)porphinatomanganese(III)] [[Mn(p-Me)TPP](2)O] as an electroactive material and 2-nitrophenyl octyl ether (o-NPOE) as a plasticizer in the percentage ratio of 3:65:32, [Mn(p-Me)TPP](2)O:o-NPOE:PVC (w:w). The sensor exhibited a linear response with a Nernstian slope of 30.5 mV per decade within a concentration range of 2.1 x 10(-6) to 1.0 x 10(-1) M MoO4(2-), with a working pH range from 5.0 to 12.5, and a fast response time of less than 15 s. The electrode showed improved selectivity toward molybdate with respect to common coexisting anions compared to monometalloporphyrin counterparts. Several electroactive materials and solvent mediators were compared and the experimental conditions were optimized. The sensor is preliminary applied to the assay of MoO4(2-) in corrosion inhibitor samples with satisfactory results.

An Easy-to-Implement Toolkit to Create Versatile and High-Performance HASEL Actuators for Untethered Soft Robots.

https://www.ncbi.nlm.nih.gov/pubmed/31380206

For soft robots to have ubiquitous adoption in practical applications they require soft actuators that provide well-rounded actuation performance that parallels natural muscle while being inexpensive and easily fabricated. This manuscript introduces a toolkit to rapidly prototype, manufacture, test, and power various designs of hydraulically amplified self-healing electrostatic (HASEL) actuators with muscle-like performance that achieve all three basic modes of actuation (expansion, contraction, and rotation). This toolkit utilizes easy-to-implement methods, inexpensive fabrication tools, commodity materials, and off-the-shelf high-voltage electronics thereby enabling a wide audience to explore HASEL technology. Remarkably, the actuators created from this easy-to-implement toolkit achieve linear strains exceeding 100%, a specific power greater than 150 W kg-1, and â‰ˆ20% strain at frequencies above 100 Hz. This combination of large strain, extreme speed, and high specific power yields soft actuators that jump without power-amplifying mechanisms. Additionally, an efficient fabrication technique is introduced for modular designs of HASEL actuators, which is used to develop soft robotic devices driven by portable electronics. Inspired by the versatility of elephant trunks, the above capabilities are combined to create an untethered continuum robot for grasping and manipulating delicate objects, highlighting the wide potential of the introduced methods for soft robots with increasing sophistication.

Direct electrochemistry of alcohol oxidase using multiwalled carbon nanotube as electroactive matrix for biosensor application.

https://www.ncbi.nlm.nih.gov/pubmed/23000393

Rapid detection of alcohol is important in clinical diagnosis and fermentation industry. An octameric alcohol oxidase (AOx) (Mr 675 kDa) from Pichia pastoris, immobilized on multiwalled carbon nanotubes-NafionÂ® (MWCNT-Nf) matrix and encapsulated with polyethylenimine (PEI) on gold electrode (AuE), showed a redox peak at 0.21V (vs. Ag/AgCl electrode at pH 7.5) for oxidation of alcohol. The electron transfer rate constant and surface coverage of the immobilized AOx were 1.69Â±0.15 sâ•»Â¹ and 2.43Ã—10â•»Â¹Â² mol cmâ•»Â², respectively. Studies on response and kinetics of Au-MWCNT-Nf-AOx-PEI bioelectrodes for alcohol showed a linear response in the range of 8 Î¼M-42 Î¼M, response time of 55 s for steady state current, and detection limit of 5 Î¼M. The bioelectrode retains ~90% of the original response even after four weeks when stored in potassium phosphate buffer pH 7.5 at 4 Â°C. The fabricated bioelectrode was found to exclude interference caused by the common electroactive species such as ascorbic acid, uric acid, lactic acid, glucose and urea. The bioelectrode also showed reliable response characteristics in blood serum samples. The findings of the investigation have established the direct electrochemistry of the AOx protein and its potential biosensor application for quantitative detection of alcohol in blood serum.

In vitro and in vivo toxicity of rinsed and aged nanocellulose-polypyrrole composites.

https://www.ncbi.nlm.nih.gov/pubmed/22615139

Novel composites of nanocellulose and the conducting polymer polypyrrole (PPy) are herein suggested as potential candidates for active ion-extraction membranes in electrochemically controlled hemodialysis. This study has defined processing parameters to obtain a biocompatible nanocellulose-PPy composite, and for the first time, the effect of the composite aging on cell viability has been studied. The influence of rinsing and extraction process steps, as well as aging under different conditions (i.e. in air, at -20Â°C and in argon), on the electroactivity and cytotoxicity of a PPy-nanocellulose composite has been investigated. The biocompatibility evaluation was based on indirect toxicity assays with fibroblasts and monocyte cell lines and an acute toxicity test in mice, while the electroactivity was evaluated by cyclic voltammetry experiments. The as-prepared composite did not induce any cytotoxic response in vitro or in vivo. Extensive rinsing and 48 h incubation in biological buffer previous to the preparation of the culture medium extracts were, however, necessary to obtain a noncytotoxic composite. The as-prepared composite was also found

to exhibit acceptable electrochemical performance, which was retained upon 4 weeks storage in argon atmosphere. It was shown that aging of the composite had a negative effect on biocompatibility, regardless of the storage condition. Thus, to allow for longtime storage of electroactive nanocellulose-PPy hemodialysis membranes, the degradation of PPy upon storage must be controlled. The present results show that the biocompatibility of PPy composites depends on the rinsing and pretreatment of the composite material as well as the aging of the material.

Constant Potential Amperometric Flow-Injection Analysis of Ions and Neutral Molecules Transduced by Electroactive (Conductive) Polymers.

https://www.ncbi.nlm.nih.gov/pubmed/31117405

We first report on constant potential (dc) amperometric flow-injection analysis (FIA) transduced by electroactive (conductive) polymers. Amperometric response is caused by the polymer recharging in order to maintain the electrode potential at a constant level when (i) ions are crossing the film|solution interface and polarizing electrode|film interface or (ii) ions or neutral molecules are specifically interacting with the polymer recharging it. The response under constant solution flow is a current peak and in flow-injection mode is a couple of current peaks directed opposite of the first sharp, analytically valuable peak. In both constant flow and flow-injection regimes, the peak current is dependent on analyte concentrations; obviously, the FIA mode provides more advantageous analytical characteristics. Constant potential amperometric flow-injection analysis is shown for boronate- and sulfate-functionalized polyanilines as well as for Prussian Blue, a member of the inorganic polymer family. As a proof of concept, the successful dc amperometric detection of lactate in human sweat with boronate-functionalized polyaniline has been shown. The proposed approach would revolutionize the field of conductive/electroactive polymer-supported ion sensing with the introduction of reliable and robust amperometry as a valuable alternative to existing potentiometry.

Electrochemical DNA Biosensing via Electrochemically Controlled Reversible Addition-Fragmentation Chain Transfer Polymerization.

https://www.ncbi.nlm.nih.gov/pubmed/30620562

Sensitive and selective sensing of biological molecules is fundamental to disease diagnosis and infectious disease surveillance. Herein, an ultrasensitive and highly selective electrochemical DNA biosensor is described by exploiting the electrochemically controlled reversible addition-fragmentation chain-transfer (eRAFT) polymerization as a signal amplification strategy and

the peptide nucleic acid (PNA) probes as the recognition elements. Specifically, the PNA probes with a thiol at their 5'-terminals are anchored to a gold electrode surface (via gold-sulfur self-assembly) for sequence-specific recognition of target DNA (tDNA) fragments, of which the phosphate sites serve as the anchorages for the targeted labeling (via the well-established phosphate-Zr4+-carboxylate chemistry) of the carboxyl-group-containing chain-transfer agents (CTAs) for the succedent eRAFT polymerization, wherein the initiating radicals are generated through electrochemical reduction of aryl diazonium salts under a potentiostatic condition. In the presence of ferrocenylmethyl methacrylate (FcCHâ••CH2) as the monomer, the grafting of polymer chains from the CTA-anchored sites as a result of the eRAFT polymerization brings numerous electroactive Fc tags to the electrode surface, outputting a high electrochemical sensing signal even in the presence of trace amounts of tDNA fragments. Under the optimized conditions, the linear range of the described electrochemical DNA biosensor spans from 10 aM to 10 pM (R2 = 0.998), with an attomolar detection limit (4.1 aM) being achieved. Moreover, the described electrochemical DNA biosensor is highly selective and applicable to the sensing of tDNA fragments in complex serum samples. Given its high efficiency, easy operation, and low cost, this biosensor shows great promise in real applications.

An electrochemical study of two self-dopable water-soluble aniline derivatives: electrochemical deposition of copolymers.

https://www.ncbi.nlm.nih.gov/pubmed/22567565

An electrochemical study of two water-soluble aniline derivatives, N-(3-sulfopropyl) aniline (AnPS) and N-(3-sulfopropyl) p-aminodiphenylamine (DAnPS), in aqueous acidic electrolytic solutions containing different kinds of doping anions (Clâ€‰(-), SO(4)â€‰(2-), and ClO(4)â€‰(-)) was carried out. At sufficiently high anodic potential, the sulfonated aniline derivatives undergo oxidation processes yielding cation-radical and dimer intermediates, but no polymer deposition was observed on the working electrode surface. Experimental results showed that both aniline derivatives are electroactive compounds exhibiting redox behaviour in the range of potential of -0.2â€‰V-1.6â€‰V. Due to the self-doping effect induced by sulfonic groups, AnPS and DAnPS compounds have good electroactivity even in neat water solution. By adding a small amount of aniline into electrolytic system, thin layers of copolymers were deposited on the working electrode surface. The copolymer layers formed on the electrodes show a highly orientational and positional order, confirmed by AFM and XRD spectroscopic techniques. During the anodic oxidation processes

some distinct colour changes were observed.

Electroactive Smart Polymers for Biomedical Applications.

https://www.ncbi.nlm.nih.gov/pubmed/30654487

The flexibility in polymer properties has allowed the development of a broad range of materials with electroactivity, such as intrinsically conductive conjugated polymers, percolated conductive composites, and ionic conductive hydrogels. These smart electroactive polymers can be designed to respond rationally under an electric stimulus, triggering outstanding properties suitable for biomedical applications. This review presents a general overview of the potential applications of these electroactive smart polymers in the field of tissue engineering and biomaterials. In particular, details about the ability of these electroactive polymers to: (1) stimulate cells in the context of tissue engineering by providing electrical current; (2) mimic muscles by converting electric energy into mechanical energy through an electromechanical response; (3) deliver drugs by changing their internal configuration under an electrical stimulus; and (4) have antimicrobial behavior due to the conduction of electricity, are discussed.

A highly efficient nano-cluster artificial peroxidase and its direct electrochemistry on a nano complex modified glassy carbon electrode.

https://www.ncbi.nlm.nih.gov/pubmed/22790375

A nano-cluster with highly efficient peroxide activity was constructed based on nafion (NF) and cytochrome c (Cyt c). UV-Vis spectrometry and transmission electron microscopy (TEM) methods were utilized for characterization of the nano-structured enzyme or artificial peroxidase (AP). The nano-cluster was composed of a Chain-Ball structure, with an average ball size of about 40 nm. The Michaelis-Menten (K(m)) and catalytic rate (k(cat)) constants of the AP were determined to be 2.5 Â± 0.4 ÂµM and 0.069 Â± 0.001 s(-1), respectively, in 50 mM PBS at pH 7.0. The catalytic efficiency of the AP was evaluated to be 0.028 Â± 0.005 ÂµM(-1) s(-1), which was 39 Â± 5% as efficient as the native horseradish peroxidase (HRP). The AP was also immobilized on a functional multi-wall carbon nanotube (MWNCTs)-gold colloid nanoparticles (AuNPs) nano-complex modified glassy carbon (GC) electrode. The cyclic voltammetry of AP on the nano complex modified GC electrode showed a pair of well-defined redox peaks with a formal potential (EÂ°') of -45 Â± 2 mV (vs. Ag/AgCl) at a scan rate of 0.05 V/s. The heterogeneous electron transfer rate constant (k(s)) was evaluated to be 0.65 s(-1). The surface concentration of electroactive AP on GC electrode (Î“) was 7

Ã— 10(-10) mol cm(-2). The apparent Michaelis-Menten constant (K(m)(app)) was 0.23 nM.

Simple synthesis of palladium nanoparticles, Î²-phase formation, and the control of chain and dipole orientations in palladium-doped poly(vinylidene fluoride) thin films.

https://www.ncbi.nlm.nih.gov/pubmed/22747424

Palladium nanoparticles (Pd-NP's) are prepared by a simple one-step procedure when poly(vinylidene fluoride) (PVDF) is used as a polymer stabilizer. High-quality Pd-NP-doped PVDF thin films are fabricated where the heat-controlled spin-coating technique is adopted. The effect of Pd-NP's on the crystal modifications and lamellae orientation in PVDF films is investigated using Fourier transform infrared-grazing incidence reflection absorption spectroscopy. The electroactive Î² phase and edge-on crystalline lamellae are found to be formed preferentially in Pd-NP-doped PVDF films. As a result, Pd-NP-doped PVDF ultrathin films gave a very good discernible contrast between the written and erased data bits, which suggests that they can be used as a scanning-probe-microscopy-based ferroelectric memory device or a ferroelectric gate field-effect transistor memory device in the future.

s-Benzylthiuronium PVC matrix membrane sensor for potentiometric determination of cationic surfactants in some pharmaceutical formulation.

https://www.ncbi.nlm.nih.gov/pubmed/16540278

The construction and characteristic performance of s-benzylthiuronium (s-BT)-PVC membrane sensor responsive for cetylpyridinium chloride (CPC) are described. The sensor is based on the use of s-BT-tetraphenylborate (TPB) ion pair as electroactive material in PVC matrix in presence of dioctylphthalate as solvent mediator. The membrane sensor shows a fast, stable and near Nernstian response for CPC over the concentration range of 6 x 10(-6)-1 x 10(-3)M at 25 degrees C and pH range 6-12 with cationic slope of 57.0+/-0.4. The lower detection limit is 4 x 0(-6)M and the response time is 10-30 s. Selectivity coefficients for CPC relative to a number of different species were investigated, which there is negligible intereferences are caused by most of investigated cations, anions, and some organic compounds. The determination of 2.0-350.0 microg/ml of CPC in aqueous solutions shows an average recovery of 98.8%and a mean relative standard deviation of 1.87% at 64.0 microg/ml. The determination of CPC in mouthwash pharmaceutical solution gave results that compare favorably with those obtained by the British pharmacopoeia method. The s-benzylthiuronium electrode has been utilized as an end point indicator electrode for some

precipitation titration reactions involving CPC as titrant.

High Electromechanical Deformation Based on Structural Beta-Phase Content and Electrostrictive Properties of Electrospun Poly(vinylidene fluoride- hexafluoropropylene) Nanofibers.

https://www.ncbi.nlm.nih.gov/pubmed/31694289

The poly(vinylidene fluoride-hexafluoropropylene) (P(VDF-HFP)) polymer based on electrostrictive polymers is essential in smart materials applications such as actuators, transducers, microelectromechanical systems, storage memory devices, energy harvesting, and biomedical sensors. The key factors for increasing the capability of electrostrictive materials are stronger dielectric properties and an increased electroactive Î²-phase and crystallinity of the material. In this work, the dielectric properties and microstructural Î²-phase in the P(VDF-HFP) polymer were improved by electrospinning conditions and thermal compression. The P(VDF-HFP) fibers from the single-step electrospinning process had a self-induced orientation and electrical poling which increased both the electroactive Î²-crystal phase and the spontaneous dipolar orientation simultaneously. Moreover, the P(VDF-HFP) fibers from the combined electrospinning and thermal compression achieved significantly enhanced dielectric properties and microstructural Î²-phase. Thermal compression clearly induced interfacial polarization by the accumulation of interfacial surface charges among two Î²-phase regions in the P(VDF-HFP) fibers. The grain boundaries of nanofibers frequently have high interfacial polarization, as they can trap charges migrating in an applied field. This work showed that the combination of electrospinning and thermal compression for electrostrictive P(VDF-HFP) polymers can potentially offer improved electrostriction behavior based on the dielectric permittivity and interfacial surface charge distributions for application in actuator devices, textile sensors, and nanogenerators.

Synthesis and electropolymerization of fullerene-terthiophene dyads.

https://www.ncbi.nlm.nih.gov/pubmed/12948185

Fullerene derivatives having a terthiophene unit connected by a triple bond were newly synthesized and the electroactive polymers were obtained by electrolytic oxidation of the terthiophene moiety.

Direct electrochemistry of hemoglobin on graphene and titanium dioxide nanorods composite modified electrode and its electrocatalysis.

https://www.ncbi.nlm.nih.gov/pubmed/23202353

A biocompatible sensing platform based on graphene (GR) and titanium dioxide (TiOâ‚‚) nanorods for the immobilization of hemoglobin (Hb) was adopted in this paper. The GR-TiOâ‚‚-Hb composite-modified carbon ionic liquid electrode was constructed through a simple casting method with Nafion as the film forming material. UV-Vis and FT-IR spectra confirmed that Hb retained its native structure in the composite film. Direct electron transfer of Hb incorporated into the composite was realized with a pair of quasi-reversible redox waves appeared, indicating that the presence of GR-TiOâ‚‚ nanocomposite on the electrode surface could facilitate the electron transfer rate between the electroactive center of Hb and the substrate electrode. Hb modified electrode showed excellent electrocatalytic activity to the reduction of trichloroacetic acid in the concentration range from 0.6 to 21.0 mmol Lâ•»Â¹. These results indicated that GR-TiOâ‚‚ nanocomposite could be a friendly biocompatible interface for immobilizing biomolecules and keeping their native structure. The fabricated biosensor displayed the advantages such as high sensitivity, good reproducibility and long-term stability.

Incorporation of fused tetrathiafulvalenes (TTFs) into polythiophene architectures: varying the electroactive dominance of the TTF species in hybrid systems.

https://www.ncbi.nlm.nih.gov/pubmed/16494321

A novel polythienylenevinylene (PTV) and two new polythiophenes (PTs), featuring fused tetrathiafulvalene (TTF) units, have been prepared and characterized by ultraviolet-visible (UV-vis) and electron paramagnetic resonance (EPR) spectroelectrochemistry. All polymers undergo two sequential, reversible oxidation processes in solution. Structures in which the TTF species is directly linked to the polymer backbone (2 and 4) display redox behavior which is dictated by the fulvalene system. Once the TTF is spatially removed from the polymer chain by a nonconjugated link (polymer 3), the electroactivity of both TTF and polythiophene moieties can be detected. Computational studies confirm the delocalization of charge over both electroactive centers (TTF and PT) and the existence of a triplet dication intermediate. PTV 4 has a low band gap (1.44 eV), is soluble in common organic solvents, and is stable under ambient conditions. Organic solar cells of polymer 4:[6,6]-phenyl-C(61) butyric acid methyl ester (PCBM) have been fabricated. Under illumination, a photovoltaic effect is observed with a power conversion efficiency of 0.13% under AM1.5 solar simulated light. The onset of photocurrent at 850 nm is consistent with the onset of the pi-pi absorption band of the polymer. Remarkably, UV-vis spectroelectrochemistry of polymer 4 reveals

that the conjugated polymer chain remains unchanged during the oxidation of the polymer.

Poly(amido amine)-based mannose-glycodendrimers as multielectron redox probes for improving lectin sensing.

https://www.ncbi.nlm.nih.gov/pubmed/23286545

An easy-to-prepare series of electroactive poly(amido amine) (PAMAM)-based dendrimers of generations G0 to G2 having mannopyranosylferrocenyl moieties in the periphery to detect carbohydrate-protein interactions is reported. The synthesis involved the functionalization of the PAMAM surface with azidomethylferrocenyl groups and subsequent coupling of mannoside units by the Cu(I)-catalyzed Huisgen reaction. The binding affinity of the series of electroactive glycodendrimers was studied by isothermal titration calorimetry (ITC) and differential pulse voltammetry (DPV). Upon complexation of the glycodendrimers conjugates with prototypical concanavalin A (Con A), voltammograms showed a decrease of the peak current. Such dendrimers showed a notable improvement of redox sensing abilities toward Con A when compared with mono- and divalent analogues, based on both the glycoside multivalent and ferrocene dendritic effects.

Construction and characterization of potentiometric sensor for the determination of oxytetracycline hydrochloride.

https://www.ncbi.nlm.nih.gov/pubmed/15081348

The construction and performance of plastic membrane (PME) oxytetracycline hydrochloride (OTC)-selective electrodes, based on three types of ion-pairs, OTC-tetraphenylborate (TPB), OTC-phosphotungstate (PT) and OTC-silicotungstate (SiT), as the electroactive substance in a plasticized PVC membrane with dibutylphthalate (DBP), were described. Furthermore, internal solid contact sensors (ISCS) OTC-selective sensors, based on a conducting polypyrrole (PPy) film immobilized on a platinum or glassy carbon electrode surface casted by a plasticized PVC membrane were constructed and evaluated. A novel optimization methodology in a numerical expression, comprehensive quality index (CQI) for a sensor, was used to optimize the composition of the membrane in the preparation of PME and screen the parameter of electropolymerization in the preparation of ISCS. Several PMEs and ISCSs were fully characterized and evaluated. An ISCS (Pt/PPy/PVC (OTC-TPB)) showed an excellent Nernstian response over the linear concentration range of 4.0 x 10(-7)-5.0 x 10(-2) M with the slope of 60.6 mV per decade (at 25 degrees C). The limit of detection was 1.0 x 10(-7) M of OTC (0.03 ppm). The response time was <25 s. The sensor

was successfully used for the analysis of OTC in pharmaceutical formulation by using direct potentiometry.

Formation Features of Hybrid Nanocomposites Based on Polydiphenylamine-2-Carboxylic Acid and Single-Walled Carbon Nanotubes.

https://www.ncbi.nlm.nih.gov/pubmed/31337093

Hybrid nanocomposites based on electroactive polydiphenylamine-2-carboxylic acid (PDPAC) and single-walled carbon nanotubes (SWCNTs) were obtained for the first time. Polymer-carbon nanomaterials were synthesized via in situ oxidative polymerization of diphenylamine-2-carboxylic acid (DPAC) in the presence of SWCNTs by two different ways. Hybrid SWCNT/PDPAC nanocomposites were prepared both in an acidic medium and in the heterophase system in an alkaline medium. In the heterophase system, the monomer and the SWCNTs are in the organic phase (chloroform) and the oxidant (ammonium persulfate) is in an aqueous solution of ammonium hydroxide. The chemical structure, as well as the electrical and thermal properties of the developed SWCNT/PDPAC nanocomposite materials were investigated.

Bioelectrocatalysis at carbon nanotubes.

https://www.ncbi.nlm.nih.gov/pubmed/31931987

This paper summarizes several examples of enzyme immobilization and bioelectrocatalysis at carbon nanotubes (CNTs). CNTs offer substantial improvements on the overall performance of amperometric enzyme electrodes mainly due to their unique structural, mechanical and electronic properties such as metallic, semi-conducting and superconducting electron transport. Unfortunately, their water insolubility restrains the kick-off in some particular fields. However, the chemical functionalization of CNTs, non-covalent and covalent, attracted a remarkable interest over the past several decades boosting the development of electrochemical biosensors and enzymatic fuel cells (EFCs) based on two different types of communications: mediated electron transfer (MET)-type, where the use of redox mediators, small electroactive molecules (freely diffusing or bound to side chains of flexible redox polymers), which are able to shuttle the electrons between the enzyme active site and the electrode (second electron transfer generation system); direct electron transfer (DET)-type between the redox group of the enzyme and the electrode surface (third electron transfer generation system).

Nanocellulose electroconductive composites.

https://www.ncbi.nlm.nih.gov/pubmed/23512106

Cellulose-based electroconductive composites can be prepared by combining conducting electroactive materials with hydrophilic biocompatible cellulose. Inorganic nanoparticles, such as metal ions and oxides, carbon nanotubes, graphene and graphene oxide, conducting polymers, and ionic liquids (through doping, blending or coating) can be introduced into the cellulose matrix. Such composites can form a biocompatible interface for microelectronic devices, and provide a biocompatible matrix or scaffold for electrically stimulated drug release devices, implantable biosensors, and neuronal prostheses. Here the benefits of combining conventional and bacterial cellulose with these electroactive composites are described and future applications are considered.

In-channel indirect amperometric detection of nonelectroactive anions for electrophoresis on a poly(dimethylsiloxane) microchip.

https://www.ncbi.nlm.nih.gov/pubmed/16152662

In the present paper, we describe a microfluidics-based sensing system for nonelectroactive anions under negative separation electric field by mounting a single carbon fiber disk working electrode (WE) in the end part of a poly(dimethylsiloxane) microchannel. In contrast to work in a positive separation electric field described in our previous paper (Anal. Chem. 2004, 76, 6902-6907), here the electrochemical reduction reaction at the WE is not coupled with the separation high-voltage (HV) system, whereas the electrochemical oxidation reaction at the WE is coupled with the separation HV system. The electroactive indicator is the carbon fiber WE itself but not dissolved oxygen. This provides a convenient and sensitive means for the determination of nonelectroactive anions by amperometry. The influences of separation voltage, detection potential, and the distance between the WE and the separation channel outlet on the response of the detector have been investigated. The present detection mode is successfully used to electrochemically detect F-, Cl-, SO4(2-), CH3COO-, H2PO4-. Based on the preliminary results, a detection limit of 2 microM and a dynamic range up to three orders of magnitude for Cl- could be achieved.

N-Cadherin- and L1-functionalised conducting polymers for synergistic stimulation and guidance of neural cell growth.

https://www.ncbi.nlm.nih.gov/pubmed/23422593

Conducting polymers are promising materials for advanced neuroprostheses and neural repair

devices. However, these challenging technologies demand stable presentation of multiple biomolecules on the polymer surface and fabrication of scaffolds suitable for implantation. We electrosynthesised poly(3,4-ethylenedioxythiophene) doped with poly[(4-styrenesulfonic acid)-co-(maleic acid)] (PEDOT:PSS-co-MA) on gold-coated surfaces or carbon microfibres, functionalised the polymer by covalent immobilisation of anti-IgG antibodies and subsequent binding of N-Cadherin and L1 recombinant proteins, and used these materials as substrates for culturing cerebral cortex neurons. N-Cadherin and L1 were much more effective than polylysine in promoting axonal elongation and collateralisation on the polymer. However, N-Cadherin also induced cell migration and dendritic extension and branching, whereas L1 inhibited dendrites. Dual functionalisation with N-Cadherin and L1 produced synergistic effects on neuronal growth that could not be achieved with either of the proteins when used alone. PEDOT:PSS-co-MA electrosynthesised on carbon microfibres showed good electrochemical properties and, when biofunctionalised with N-Cadherin or L1, stimulated very long and guided axonal elongation. Finally, electrochemical impedance spectroscopy, cyclic voltammetry and chronoamperometry showed that the good electrical properties of PEDOT:PSS-co-MA were not degraded by covalent peptide attachment, indicating that this polymer is suitable for multiple biofunctionalisation of electroactive surfaces in neuroprosthetic and lesion-bridging applications.

Electrically conductive nanomaterials for cardiac tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/31176755

Patient deaths resulting from cardiovascular diseases are increasing across the globe, posing the greatest risk to patients in developed countries. Myocardial infarction, as a result of inadequate blood flow to the myocardium, results in irreversible loss of cardiomyocytes which can lead to heart failure. A sequela of myocardial infarction is scar formation that can alter the normal myocardial architecture and result in arrhythmias. Over the past decade, a myriad of tissue engineering approaches has been developed to fabricate engineered scaffolds for repairing cardiac tissue. This paper highlights the recent application of electrically conductive nanomaterials (carbon and gold-based nanomaterials, and electroactive polymers) to the development of scaffolds for cardiac tissue engineering. Moreover, this work summarizes the effects of these nanomaterials on cardiac cell behavior such as proliferation and migration, as well as cardiomyogenic differentiation in stem cells.

Martensitic organic crystals as soft actuators.

https://www.ncbi.nlm.nih.gov/pubmed/31768232

Being capable of rapid and complete structure switching, the martensitic phase transitions in molecular crystals are thought to hold a tremendous potential as thermally driven organic actuators. However, the mechanical engineering parlance in the assessment of their performance is not immediately legible to the chemistry research community that starts to explore these materials, and the unavailability of performance indices has precluded molecular crystals from being considered in the device design process. Here, we demonstrate that an organic martensite, hexamethylbenzene, can be used to perform work that is comparable to that of most actuator classes. Millimeter-size single crystals of this material undergo a transition between two forms by uniaxial expansion at a rate of 6.36(2) mm s-1, exerting force in the range 10-100 mN. The force-to-weight ratio of the crystals is on the order of 104 and is superior to that of some living creatures. An actuator performance chart reveals that the performance of this material is close to that of nanomuscles, electrostatic actuators and voice coils, with a strain higher than that of electro/magnetostrictive actuators and ceramic piezoelectrics and stress higher than that of the electroactive polymers, MEMS devices, nanomuscles, voice coils, and some solenoids. Moreover, the crystals of this material are mechanically compliant and can be reversibly bent and shaped to fit the desired application. Altogether, the results point to the untapped potential of molecular crystals as rapid and efficient soft, organic actuators.

Fast self-healing and rebuildable polyphosphate-based metallo-gels with mixed ionic-electronic conductivity.

https://www.ncbi.nlm.nih.gov/pubmed/30165299

The development of self-healing materials opens perspectives to fabricate devices with unprecedented lifetimes and recyclability that can be integrated with flexible electronics. However, the timescale at which these materials operate remains an important challenge to overcome. This article describes the fast self-healing behavior of aluminum/iron polyphosphate metallo-gels and their hybrids with polyaniline and gives a detailed investigation of their electrical behaviors. The samples can be cut, molded and healed by manual handling. The rebuilding process is mediated by water uptake and was directly observed by environmental scanning electron microscopy. Metallo-gels with and without polyaniline can be mixed to give homogeneous samples, where the conducting polymer is uniformly distributed within the inorganic matrix. Cyclic voltammetry

experiments showed that polyaniline behaves within the metallo-gel in the same manner as it does in aqueous electrolytes. Furthermore, polyaniline adds electronic conductivity to the originally ion-conducting polyphosphate metallo-gel, as demonstrated by impedance spectroscopy. The ionic and electronic conductivities are 1.3-1.7â€¯Ã—â€¯10-2 SÂ·cm-1 and 5.2â€¯Ã—â€¯10-4 SÂ·cm-1, respectively. Such properties result from the "free" and "bound" water within the hydrogel network and the dynamic nature of the aluminum-phosphate interactions within the supramolecular network. The features presented here make these materials good candidates to be used as moldable electroactive binders in carbon-based electrodes and in all-solid-state flexible separators for repairable electrochemical capacitors and batteries.

Long-range flow-induced alignment of self-assembled rosette nanotubes on Si/SiOx and poly(methyl methacrylate)-coated Si/SiOx.

https://www.ncbi.nlm.nih.gov/pubmed/15600312

Helical rosette nanotubes are obtained through the self-assembly of low molecular weight synthetic modules in water. Here we demonstrate that despite their dynamic nature, these materials respond very well to directional fluid flow and assume long-range order on flat substrates. Persistence length, order, and packing of the rosette nanotubes were found to depend dramatically on the surface properties of both the substrate and the nanotubes and vary from well-ordered long-range 2D films to bundled nanotubes or amorphous conglomerates. While flow-induced long-range alignment of dynamic nanostructures is unprecedented, the chemical tunability of the rosette nanotubes is anticipated to offer a versatile means for investigating the basis of interfacial forces in self-assembled organo-silicon devices and their effect on the stability and physical properties of organic nanostructures on electroactive surfaces.

Electroactive layer-by-layer films of heme protein-coated polystyrene latex beads with poly(styrene sulfonate).

https://www.ncbi.nlm.nih.gov/pubmed/15614357

In this work, a novel two-step construction strategy for protein layer-by-layer assembly films was proposed. In the first step, positively charged hemoglobin (Hb) or myoglobin (Mb) at pH 5.0 was adsorbed on the negatively charged surface of 500 nm diameter-sized polystyrene (PS) latex beads, forming core-shell structured PS-protein particles. In the next step, the PS-protein particles were further assembled layer by layer with oppositely charged poly(styrene sulfonate)(PSS) on various

solid surfaces under suitable conditions. Cyclic voltammetry (CV), quartz crystal microbalance (QCM), and UV-vis spectroscopy were used to monitor the growth of {(PS-protein)/PSS}(n) films. The stable {(PS-protein)/PSS}(n) films modified on pyrolytic graphite (PG) electrodes demonstrated good electroactivity in protein-free buffer, which was originated from protein heme Fe(III)/Fe(II) redox couples, and the electroactivity extended to six (PS-protein)/PSS bilayers. UV-vis spectroscopy showed that Hb and Mb in the films retained their near-native structure in the medium pH range. {(PS-protein)/PSS}(n) films catalyzed electrochemical reduction of oxygen, hydrogen peroxide, trichloroacetic acid (TCA) and nitrite with a significant lowering of overpotential, and displayed better catalytic activity than corresponding cast PS-protein films.

Current and future developments in artificial muscles using electroactive polymers.

https://www.ncbi.nlm.nih.gov/pubmed/16293100

For decades, electroactive polymers received relatively little attention due to their limited actuation capability. However, in the last 15 years, a series of electroactive polymer materials have emerged that produce a significant shape or size change in response to electrical stimulation. These materials have the closest functional similarity to biologic muscles, enabling the engineering of novel capabilities that were, up until recently, impossible to achieve. Efforts are underway to address the many challenges that are hampering the practical application of these materials, and recent progress has already led to dramatic capability improvements. Various novel mechanisms and devices were demonstrated including robotic fish, catheter steering elements, robotic arms, miniature grippers, loudspeakers, active diaphragms, Braille display and dust-wipers. For developers of future medical devices, these materials are offering numerous advantages for their flexibility, fracture toughness and controllability, as well as low mass and low power requirements. This article provides a review of the current status, challenges and potential near-future applications of these materials.

An amperometric glucose biosensor based on poly(o-aminophenol) and Prussian blue films at platinum electrode.

https://www.ncbi.nlm.nih.gov/pubmed/14654053

Prussian blue (PB), as a good catalyst for the reduction of hydrogen peroxide, has been combined with nonconducting poly(o-aminophenol) (POAP) film to assemble glucose biosensor. Compared with PB-modified enzymatic biosensor, the biosensor based on glucose oxidase immobilized in

POAP film at PB-modified electrode shows much improved stability (78% remains after 30 days) in neutral medium. Additionally, the biosensor, at an applied potential of 0.0 V, exhibits other good characteristics, such as relative low detection limit (0.01 mM), short response time (within 5s), large current density (0.28 mA/cm2), high sensitivity (24 mAM(-1)cm(-2)), and good antiinterferent ability. The apparent activation energy of enzyme-catalyzed reaction and apparent Michaelis-Menten constant are 34.2 KJmol(-1) and 10.5 mM, respectively. In addition, effects of temperature, applied potential used in the determination, pH value of the detection solution, and electroactive interferents on the amperometric response of the sensor were investigated and are discussed.

Organic cross-linked electropolymers as supported oxidation catalysts: poly((tetrakis(9,9'-spirobifluorenyl)porphyrin)manganese) films.

https://www.ncbi.nlm.nih.gov/pubmed/15285685

Anodic oxidation of free base and manganese complexes of tetraspirobifluorenylporphyrins leads to the coating of the working electrode by insoluble electroactive poly(9,9'-spirobifluorene-free and manganese porphyrin) films which electrochemical behavior and physicochemical properties are described. After removal from the electrode, the manganese-complexed polymers were evaluated as catalysts for the oxidation of alkenes by iodobenzene diacetate or iodosylbenzene. The results show that the reactions proceeded very efficiently at room temperature with good yields. The electrosynthesized polymer catalysts can be recycled by simple filtration and reused even up to the eighth cycle without loss of activity and selectivity. These results represent an important improvement over those previously described for manganese-porphyrin-catalyzed epoxidation reactions.

Assessment of in vitro bioactivity of hyaluronic acid and sulfated hyaluronic acid functionalized electroactive polymer.

https://www.ncbi.nlm.nih.gov/pubmed/15530038

Electrically conductive polypyrrole (PPY) was surface functionalized with hyaluronic acid (HA) and sulfated hyaluronic acid (SHA) to improve its surface biocompatibility. The immobilization of HA on the PPY film was facilitated by the use of a cross-linker having the appropriate functional groups. The biological activity of the HA functionalized PPY film was assessed by means of an in vitro PC12 cell culture. The cell attachment on different substrates was studied and determined by bicinchoninic acid protein analysis. Cell attachment on the HA functionalized PPY film surface was significantly

enhanced in the presence of nerve growth factor. The SHA functionalized PPY film was obtained by the sulfonation of the immobilized HA using pyridinesulfonate. The retention of the biological activity of the immobilized HA after sulfonation was evaluated by the in vitro assessment of the plasma recalcification time (PRT) and platelet adhesion on the substrate. The PRT observed from the SHA functionalized PPY film was significantly prolonged compared with the HA functionalized PPY. Some reduction of platelet adhesion was observed for the SHA functionalized PPY film, compared with that of the HA functionalized PPY film.

3D Hybrid Scaffolds Based on PEDOT:PSS/MWCNT Composites.

https://www.ncbi.nlm.nih.gov/pubmed/31165066

Conducting polymer scaffolds combine the soft-porous structures of scaffolds with the electrical properties of conducting polymers. In most cases, such functional systems are developed by combining an insulating scaffold matrix with electrically conducting materials in a 3D hybrid network. However, issues arising from the poor electronic properties of such hybrid systems, hinder their application in many areas. This work reports on the design of a 3D electroactive scaffold, which is free of an insulating matrix. These 3D polymer constructs comprise of a water soluble conducting polymer (PEDOT:PSS) and multi-walled carbon nanotubes (MWCNTs). The insertion of the MWCNTs in the 3D polymer matrix directly contributes to the electron transport efficiency, resulting in a 7-fold decrease in resistivity values. The distribution of CNTs, as characterized by SEM and Raman spectroscopy, further define the micro- and nano-structural topography while providing active sites for protein attachment, thereby rendering the system suitable for biological/sensing applications. The resulting scaffolds, combine high porosity, mechanical stability and excellent conducting properties, thus can be suitable for a variety of applications ranging from tissue engineering and biomedical devices to (bio-) energy storage.

Carbon fibre-based microbiosensors for in vivo measurements of acetylcholine and choline.

https://www.ncbi.nlm.nih.gov/pubmed/15967355

This report describes technical improvements to the manufacture of a carbon fibre electrode for the stable and sensitive detection of H2O2 (detection limit at 0.5 microM). This electrode was also modified through the co-immobilisation of acetylcholinesterase (AChE) and/or choline oxidase (ChOx) in a bovine serum albumin (BSA) membrane for the development of a sensor for in vivo measurements of acetylcholine and choline. Amperometric measurements were performed using a

conventional three-electrode system forming part of a flow-injection set-up at an applied potential of 800-1100 mV relative to an Ag/AgCl reference electrode. The optimised biosensor obtained was reproducible and stable, and exhibited a detection limit of 1 microM for both acetylcholine and choline. However, due to the high operating potential used, the biosensor was prone to substantial interference from other electroactive compounds, such as ascorbic acid. Therefore, in a further step, a mediated electron transfer approach was used that incorporated horseradish peroxidase into an osmium-based redox hydrogel layered onto the active surface of the electrode. Afterwards, a Nafion layer and a coating containing AChE and/or ChOx co-immobilised in a BSA membrane were successively deposited. This procedure further increased the selectivity of the biosensor, when operated in the same flow-injection system but at an applied potential of -50 mV relative to an Ag/AgCl reference electrode. The sensor exhibited good selectivity and a high sensitivity over a concentration range (0.3-100 microM) suitable for the measurement of choline and acetylcholine in vivo.

Electrodes modified with 3D graphene composites: a review on methods for preparation, properties and sensing applications.

https://www.ncbi.nlm.nih.gov/pubmed/29736826

Three-dimensional (3D) porous networks of planar 2D graphene have attractive features with respect to sensing. These include a large electroactive surface area, good inner and outer surface contact with the analyte, ease of loading with (bio)catalysts, and good electrochemical sensitivity. 3D free-standing graphene can even be used directly as an electrode. This review (with 140 refs.) covers the progress made in the past years. Following an introduction into the field (including definitions), a large section is presented that covers methods for the synthesis of 3D graphene (3DG) (including chemical vapor deposition, hydrothermal methods, lithography, support assisted synthesis and chemical deposition, and direct electrochemical methods). The nextÂ section covers the key features of 3DG and its composites for use in electrochemical sensors. This section is subdivided into sections on the uses of 3D porous graphene, 3DG composites with metals and metal oxides, composites consisting of 3DG and organic polymers, and electrodes modified with 3DG, 3DGs decorated with carbon nanotubes, and others. The review concludes with a discussion of future perspectives and current challenges. Graphical Abstract A schematic of the key characteristics of three-dimensional (3D) graphene.

Polyaniline, an electroactive polymer, supports adhesion and proliferation of cardiac myoblasts.

https://www.ncbi.nlm.nih.gov/pubmed/16411609

Conductive polymers, such as polypyrrole, have recently been studied as potential surfaces/matrices for cell- and tissue-culture applications. We have investigated the adhesion and proliferation properties of H9c2 cardiac myoblasts on a conductive polyaniline substrate. Both the non-conductive emeraldine base (PANi) and its conductive salt (E-PANi) forms of polyaniline were found to be biocompatible, viz., allowing for cell attachment and proliferation and, in the case of E-PANi, maintaining electrical conductivity. By comparison to tissue-culture-treated polystyrene (TCP), the initial adhesion of H9c2 cells to both PANi and E-PANi was slightly reduced by 7% ($P < 0.05$, $n = 18$). By contrast, the overall rate of cell proliferation on the conductive surfaces, although initially decreased, was similar to control TCP surfaces. After 6 days in culture on the different surfaces, the cells formed confluent monolayers which were morphologically indistinguishable. Furthermore, we observed that E-PANi, when maintained in an aqueous physiologic environment, retained a significant level of electrical conductivity for at least 100 h, even though this conductivity gradually decreased by about 3 orders of magnitude over time. These results demonstrate the potential for using polyaniline as an electroactive polymer in the culture of excitable cells and open the possibility of using this material as an electroactive scaffold for cardiac and/or neuronal tissue engineering applications that require biocompatibility of conductive polymers.

Immobilization of DNA onto poly(dimethylsiloxane) surfaces and application to a microelectrochemical enzyme-amplified DNA hybridization assay.

https://www.ncbi.nlm.nih.gov/pubmed/16459608

This paper describes immobilization of DNA onto the interior walls of poly(dimethylsiloxane) (PDMS) microsystems and its application to an enzyme-amplified electrochemical DNA assay. DNA immobilization was carried out by silanization of the PDMS surface with 3-mercaptopropyltrimethoxysilane to yield a thiol-terminated surface. 5'-acrylamide-modified DNA reacts with the pendant thiol groups to yield DNA-modified PDMS. Surface-immobilized DNA oligos serve as capture probes for target DNA. Biotin-labeled target DNA hybridizes to the PDMS-immobilized capture DNA, and subsequent introduction of alkaline phosphatase (AP) conjugated to streptavidin results in attachment of the enzyme to hybridized DNA. Electrochemical detection of DNA hybridization benefits from enzyme amplification. Specifically, AP converts

electroinactive p-aminophenyl phosphate to electroactive p-aminophenol, which is detected using an indium tin oxide interdigitated array (IDA) electrode. The IDA electrode eliminates the need for a reference electrode and provides a steady-state current that is related to the concentration of hybridized DNA. At present, the limit of detection of the DNA target is 1 nM in a volume of 20 nL, which corresponds to 20 attomoles of DNA.

OLED and PLED devices employing electrogenerated, intramolecular charge-transfer fluorescence.

https://www.ncbi.nlm.nih.gov/pubmed/12728549

The light generating mechanism of a series of light emitting diodes with electron donor-bridge-acceptor systems (D-b-A) as the emitting species was examined by constructing model diodes based on small organic molecules (OLEDs) as well as on molecularly doped electroactive (poly-N-vinylcarbazole, PVK) and insulating (polystyrene, PS) polymers (PLEDs). The direct electrogeneration of an intramolecular charge-transfer (CT) fluorescence of the donor-bridge-acceptor systems occurred readily in OLED devices with a D-b-A system as the emissive layer. In diodes with PS as the host matrix, hole-injection and electron-injection occurred directly in the D-b-A molecules residing close to the anode and the cathode, respectively. In the PVK diodes, hole-injection occurred primarily into PVK and the positive charge carrier was subsequently trapped on the D-b-A molecule, whereas electron-injection at the cathode side occurred directly into the D-b-A molecules. Charge-hopping between neighboring molecules then occurred until a hole and electron resided on the same molecule, which is equivalent to the formation of the CT excited state, and which finally relaxed by intramolecular charge recombination under the emission of CT fluorescence.

Selective detection of L-glutamate using a microfluidic device integrated with an enzyme-modified pre-reactor and an electrochemical detector.

https://www.ncbi.nlm.nih.gov/pubmed/12835043

A microfluidic device integrated with a nanoliter volume enzyme pre-reactor and an enzyme-modified electrode was developed for the highly selective continuous measurement of glutamate (Glu). The device consists mainly of two glass plates. One plate incorporates an electrochemical cell that consists of working electrode (WE), reference electrode (RE) and counter electrode (CE). The WE is modified with a bilayer film of Os-polyvinylpyrridine-based mediator

containing horseradish peroxidase (Os-gel-HRP). The WE was operated at -50 mV versus Ag. The other plate has a thin layer flow channel integrated with a pre-reactor. The reactor has a number of micropillars (20 microm in diameter, 20 microm high and separated from each other by a 20 microm gap) modified with ascorbate oxidase (AAOx) to eliminate L-ascorbic acid (AA). The enzymatic oxidation of AA is superior to that obtained with our previously reported pre-electrolysis type micro-reactor since electrochemically reversible transmitters such as catecholamines do not provide a cathodic current at the WE. In addition, the high operation potential of the pre-reactor causes unknown electroactive species, which also cause interference at the detection electrode. As a result, we were able to detect 1 microM Glu continuously at a low flow rate even when AA concentration was 100 microM.

Novel poly (vinyl chloride) matrix membrane electrodes for the determination of phenolic pollutants in waste water.

https://www.ncbi.nlm.nih.gov/pubmed/12697221

The construction and electrochemical response characteristics of poly (vinyl chloride) matrix membrane sensors for seven phenolic compounds (phenol, o-cresol, p-cresol, p-chlorophenol, o-nitrophenol, alpha-naphthol and beta-naphthol) are described. The membranes incorporate ion association complexes of these seven phenolic anions with phenanthroline-iron(II) as electroactive materials. These sensors show linear response for phenol, o-cresol, p-cresol, p-chlorophenol, o-nitrophenol, alpha-naphthol, and beta-naphthol over wide concentration ranges, with an average anionic slope 54.3 mV per concentration decade. The suggested sensors exhibit fast response time (1 min), low determination limits (1 x 10(-5)M), good stability (2-3 weeks), reasonable selectivity to phenolic compounds in the presence of other water pollutants. The average percentage recovery was 99.78+/-0.088 for individual phenolates and 99.61+/-0.198 for phenolates in mixtures. The investigated sensors were successfully used for direct potentiometric determination of traces of these phenolic compounds in wastewater samples. Results with mean accuracy of 99.74+/-0.29%, 99.82+/-0.36%, 99.65+/-0.47%, 99.73+/-0.37%, 99.77+/-0.30%, 99.86+/-0.31% and 99.91+/-0.22% was obtained for the seven sensors, respectively. These results were compared with data obtained using the British pharamacopial method (The British Pharmacopoeia, Her Majesty's Stationary Office, London, 1993) and others (Clarke's Isolation and Identification of Drugs in Pharmaceuticals Body Fluids and Post-mortem Materials, 2nd Edition, The Pharmaceutical Press, London, 1998).

Electroactive and degradable supramolecular microgels.

https://www.ncbi.nlm.nih.gov/pubmed/31642835

In this work, we synthesized electroactive and degradable microgels based on biomacromolecular building blocks, which enable the controlled release of therapeutic drugs. Functional chitosan-poly(hydroquinone) (Ch:PHQ) microgels exhibiting redox-active and pH-sensitive properties were synthesized by an oxidative polymerization in an inverse miniemulsion system. Physically crosslinked microgels were formed by polymerization of hydroquinone in the presence of chitosan through the formation of hydrogen bonds between PHQ and Ch. A series of microgel samples with variable Châ€‰:â€‰PHQ ratios were synthesized. These obtained microgels exhibit pH-responsive properties due to the protonation/deprotonation of amino-groups of chitosan in the microgel system. Poly(hydroquinone) is a redox-active polymer exhibiting a two-electron/proton-transfer behavior and conveys this property to the microgels as confirmed by cyclic voltammetry. In addition, the microgels can be switched by electrochemical means: they swell in the oxidized state or shrink in the reduced state. In the presence of urea or lysozyme, the microgels undergo a fast degradation due to the disruption of hydrogen bonds acting as physical crosslinks in the microgel networks or due to the cleavage of glucosidic linkages of the incorporated chitosan scaffold, respectively. Doxorubicin (DOX), an anticancer drug, could be effectively encapsulated into the microgels and released in the presence of an enzyme, indicating that these biodegradable microgels could be used as drug delivery vehicles for tumor cells.

Anion- and solvent-directed assembly in silver bis(thioimidazolyl)methane chemistry and the silver-sulfur interaction.

https://www.ncbi.nlm.nih.gov/pubmed/16499376

The effect of metal complexation on the structure and properties of the electroactive bis(1-methylthioimidazolyl)methane linkage isomers CH2(N-tim)2 (L1) and CH2(S-tim)2 (L2) has been explored. Coordination polymers {[Ag(L1)2]X}n (X = BF4, PF6) are formed by bridging L1 between tetrahedral silver centers giving two-dimensional cationic sheets composed of AgS(4) linkages; the anions are sandwiched between sheets. Cyclic dimers {[Ag2(L2)2]X2} (X = BF4, PF6, OSO2CF3) are formed when L2:AgX ratios are lower than 1.5. When L2:AgPF6 was 1.5 or higher, the complex [Ag4(L2)5](PF5)4 could be isolated as a solvate. The NMR, IR, electrochemical, and ESI+ mass spectral data of this latter compound indicate that extensive dissociation to the cyclic dimer and free ligand occurs in solution. Finally, a Cambridge Structural Database search was

performed to provide insight into reasonable silver-sulfur bond distances, since literature values appeared to vary widely between 2.3 and 3.2 A. It was found that these distances increase with increasing coordination number of silver. The average distances for 2-, 3-, 4-, 5-, and 6-coordinate silver were found to be 2.40, 2.52, 2.62, 2.70, and 2.75 A, respectively.

The development of a reagentless lactate biosensor based on a novel conducting polymer.

https://www.ncbi.nlm.nih.gov/pubmed/16263338

A reagentless lactate biosensor is described, based on an electropolymerized copolymer film poly(5-hydroxy-1,4-naphthoquinone-co-5-hydroxy-3-acetic acid-1,4-naphthoquinone). The quinone group, as part of the polymer backbone, is electroactive and very stable in neutral aqueous medium. It can therefore act as an immobilized mediator for the enzyme recycling, at a working potential much lower than those commonly reported in the literature for other mediators. Experimental conditions for amperometric measurements (temperature, pH) are studied, especially the interference between quinone and molecular oxygen to investigate the enzyme/quinone recycling kinetic. Some well-known interferents are shown to have no measurable effect on the amperometric curves.

Electroactive core-shell nanocluster films of heme proteins, polyelectrolytes, and silica nanoparticles.

https://www.ncbi.nlm.nih.gov/pubmed/15544404

Novel protein core-shell nanocluster films were assembled layer by layer on solid surfaces. In the first step, positively charged heme protein hemoglobin (Hb) or myoglobin (Mb) and negatively charged poly(styrenesulfonate) (PSS) were alternately adsorbed on the surface of SiO2 nanoparticles, forming core-shell SiO2-(protein/PSS)m nanoclusters. In the second step, the SiO2-(protein/PSS)m nanoclusters and polycationic poly(ethylenimine) (PEI) were assembled layer by layer on various solid substrates, forming [[SiO2-(protein/PSS)m]/PEI]n films. Various techniques were used to characterize the nanoclusters and monitor the film growth. [[SiO2-(protein/PSS)m]/PEI]n films at pyrolytic graphite (PG) electrodes exhibited well-defined, chemically reversible cyclic voltammetric reduction-oxidation peaks characteristic of the heme Fe(III)/Fe(II) redox couples. The proteins in the films retained near native conformations in the medium pH range, and the films catalyzed electrochemical reduction of oxygen and hydrogen peroxide. Advantages of the nanocluster films over the simple [SiO2/protein]n layer-by-layer films

include a larger fraction of electroactive protein and higher specific biocatalytic activity. Using this approach, biocatalytic activity can be tailored and controlled by varying the number of bilayers deposited on the nanoparticle cores and the number of nanocluster layers on electrodes.

Fabrication of three-dimensional composite textile electrodes by metal-organic framework, zinc oxide, graphene and polyaniline for all-solid-state supercapacitors.

https://www.ncbi.nlm.nih.gov/pubmed/29960905

Textile electrode materials have attracted intense attention in the flexible supercapacitor field due to their flexibility, light weight, hierarchical porosity and mechanical robustness. However, their electrochemical performance is not good due to the low conductivity, ineffective ion diffusion and small electroactive surface area. In this study, a three-dimensional (3D) textile electrode material was constructed by utilizing ZIF-8 (Zeolitic Imidazolate Framework), metal oxides, conductive polymers and graphene sheets. The polyaniline/ZnO/ZIF-8/graphene/polyester textile electrode exhibited good electrochemical performance with a high areal capacitance of 1.378â€¯F/cm2 at 1â€¯mA/cm2 and high stability under different mechanical deformations. A flexible all-solid-state symmetric supercapacitor device was further fabricated, which can provide a high energy density of 235â€¯Î¼Wh/cm3 at a power density of 1542â€¯Î¼W/cm3.

Voltammetric sensor for oxidized DNA using ultrathin films of osmium and ruthenium metallopolymers.

https://www.ncbi.nlm.nih.gov/pubmed/15362921

Films containing [Os(bpy)2(PVP)10Cl]+ and [Ru(bpy)2(PVP)10Cl]+ metallopolymers were assembled layer by layer on pyrolytic graphite electrodes to make sensors that selectively detect oxidized DNA. These films showed reversible, independent electrochemistry for electroactive Os3+/Os2+ and Ru3+/Ru2+ centers, with formal potentials of 0.34 and 0.76 V vs SCE, respectively. The combination of ruthenium and osmium metallopolymers in the films provided a catalytic Os square wave voltammetry (SWV) peak that is mainly selective for 8-oxoguanine and the detection of other oxidized nucleobases from the Ru peak. The method is applicable to measurements on DNA in solution or DNA incorporated into films. Using the Os SWV peak, 1 oxidized nucleobase in 6000 was detected. The sensor is simple and inexpensive, and the approach may be useful for the detection of oxidized DNA as a clinical biomarker for oxidative stress.

Self-sacrificial label assisted electroactivity conversion of sensing interface for ultrasensitive electrochemical immunosensor.

https://www.ncbi.nlm.nih.gov/pubmed/31170656

Sensitivity amplification strategies in electrochemical immunoassays are mainly limited by redox signal leaking, degradation of catalytic activity caused by layers of decoration and the large hindrance effect caused by immunoprobes. Herein, we developed an innovative sensitivity amplification strategy based on the self-sacrificial label-assisted electroactivity conversion of a sensing interface, utilizing Fe3+-loaded polydopamine (Fe3+-PDA) nanoparticles as the self-sacrificial labels, which can be decomposed under acidic conditions and release Fe3+. When the assembled sensing interface was immersed in a prussian blue (PB) precursor solution (a mixed solution of 0.1â€¯M KCl, 0.1M HCl and 1â€¯mM K3Fe(CN)6), the as-formed sandwich-type structure was destroyed due to the decomposition of Fe3+-PDA caused by HCl in PB precursor solution, resulting in the reduce of interface resistance. The released Fe3+ reacted with the PB precursor solution and triggered the growth of electroactive PB nanoparticles (PB NPs) on the sensing interface. Assisted by self-sacrificial Fe3+-PDA, the sensing interface was converted from electrochemically inactive to electroactive with a strong redox signal, high catalytic activity, and decreased interface resistance. The PB NPs can catalyse H2O2 to amplify the redox signal, thus improving sensitivity. The redox signal and catalysts were generated in the final assembly step, which can avoid signal leaking and decreases of catalytic activity caused by layers of decoration. The decomposition of Fe3+-PDA can eliminate the large hindrance effect of the immunoprobe. Ultrasensitive quantification of carbohydrate antigen 125 (CA 125) was realized with a detection range from 0.00001 to 1000 U mL-1 and detection limit of 0.25â€¯Ã—â€¯10-6 U mL-1.

A facile DNA strand displacement reaction sensing strategy of electrochemical biosensor based on N-carboxymethyl chitosan/molybdenum carbide nanocomposite for microRNA-21 detection.

https://www.ncbi.nlm.nih.gov/pubmed/30240965

Herein, we report a facile enzyme-free microRNA (miRNA) target-triggered strand displacement reaction (SDR) amplification strategy with ferrocene (Fc) as a signal molecule to fabricate a two-dimensional electroactive molybdenum carbide (Mo2C)-based biosensor. In the presence of miRNA-21, SDR was initiated and many hairpin DNA1 (HDNA1) and hairpin DNA2 (HDNA2) duplexes, which could be captured by probe DNA leading the Fc-modified HDNA2 close to the

electrode surface, were produced continuously. MiRNA-21 could be detected by monitoring the redox signal of Fc. The prepared N-carboxymethyl chitosan/Mo2C nanocomposite featured excellent conductivity, great dispersion, and multiple functional groups (amine groups). When the nanocomposite was introduced to a miRNA biosensor electrode interface to ensure its strong connection to the DNA probe, the developed miRNA-21 biosensor demonstrated a reliable linear range of 1.0â€¯fM to 1.0â€¯nM with a detection limit of 0.34â€¯fM and showed good selectivity, reproducibility, and stability. The biosensor was employed to detect miRNA-21 in human serum samples, and it showed great potential in the early clinical diagnosis of various genetic diseases.

A amperometric immunosensor for sensitive detection of circulating tumor cells using a tyramide signal amplification-based signal enhancement system.

https://www.ncbi.nlm.nih.gov/pubmed/30731350

Herein, tyramide signal amplification (TSA)-based electrochemical immunosensor was exploited for highly sensitive detection of CTCs. In this immunosensor, the nucleolin-targeting aptamer AS1411 (CP) was used to specifically capture tumor cells, and a TSA-based signal enhancement system consisting of Pt NPs@HRP@CP composite as catalytic probe and tyramine functionalized infinite coordination polymer (ICPs@Tyr) as electroactive signal tag was applied to improve the detection sensitivity. Using HeLa cell as the model CTCs, after a sandwich reaction, CP-HeLa-Pt NPs@HRP@CP bioconjugates were formed on the electrode. Millions of ICPs@Tyr could be layer-by-layer deposited onto the target cell membrane by the catalysis of Pt NPs@HRP@CP. The developed immunorsensor could detect HeLa cell with a wide dynamic range from 2 to 2â€¯Ã—â€¯104 cells/mL and a detection limit of 2 cells/mL. Most importantly, the amperometric immunosensor was successfully applied to discriminate tumor cells from white blood cells, exhibiting high specificity and sensitivity. In conclusion, this work demonstrates that the TSA-based signal enhancement system might be a potential alternative tool for the electrochemical measurement of trace amounts of CTCs in clinical diagnosis.

Layer-by-Layer Assembly of Free-Standing Nanofilms by Controlled Rolling.

https://www.ncbi.nlm.nih.gov/pubmed/29708348

A water surface not only provides a habitat to many living organisms but also opens up new possibilities to develop state-of-the-art technologies. Here, we show a technology for the layer-by-layer assembly of free-standing nanofilms by controlled rolling. The water surface is

exploited as an ideal platform for rolling a nanofilm, allowing adhesion control and frictionless feeding. The nanofilm floating on the water surface is attached to a tube by van der Waals adhesion and is rolled up by the rotation of the tube. This method can assemble diverse film materials including metals, polymers, and two-dimensional materials, with an easy control of the number of layers. Furthermore, heterogeneous and spiral structures of the nanofilm are achieved. Various applications such as a stretchable tubular electrode, an electroactive polymer tube actuator, and a superelastic nanofilm tube are demonstrated. We believe this work can potentially lead to a breakthrough in the nanofilm assembly processes.

Dielectric Elastomer Artificial Muscle: Materials Innovations and Device Explorations.

https://www.ncbi.nlm.nih.gov/pubmed/30698006

Creating an artificial muscle has been one of the grand challenges of science and engineering. The invention of such a flexible, versatile, and power efficient actuator opens the gate for a new generation of lightweight, highly efficient, and multifunctional robotics. Many current artificial muscle technologies enable low-power mobile actuators, robots that mimic efficient and natural forms of motion, autonomous robots and sensors, and lightweight wearable technologies. They also have serious applications in biomedical devices, where biocompatibility, from a chemical, flexibility, and force perspective, is crucial. It remains unknown which material will ultimately form the ideal artificial muscle. Anything from shape memory alloys (SMAs) to pneumatics to electroactive polymers (EAPs) realize core aspects of the artificial muscle goal. Among them, EAPs most resemble their biological counterparts, and they encompass both ion-infusion and electric field based actuation mechanisms. Some of the most investigated EAPs are dielectric elastomers (DEs), whose large strains, fracture toughness, and power-to-weight ratios compare favorably with natural muscle. Although dielectric elastomer actuators (DEAs) only entered the artificial muscle conversation in the last 20 years, significant technological progress has reflected their high potential. Research has focused on solving the core issues surrounding DEAs, which includes improving their operational ranges with regard to temperature and voltage, adding new functionality to the materials, and improving the reliability of the components on which they depend. Mechanisms designed to utilize their large-strain actuation and low stiffness has also attracted attention. This Account covers important research by our group and others in various avenues such as decreasing viscoelastic losses in typical DE materials, increasing their dielectric constant, and countering electromechanical instability. We also discuss variable stiffness polymers, specifically bistable electroactive polymers,

which, notably, open DEAs to structural applications typically unattainable for soft-actuator technologies. Furthermore, we explore advancements related to highly compliant and transparent electrodes, a crucial component of DEAs capable of achieving high actuation strain. We then cover noteworthy applications, including several novel devices for soft robotics and microfluidics, and how those applications fit within other major developments in the field. Finally, we conclude with a discussion of the remaining challenges facing current DEA technology and speculate on research directions that may further advance DE-based artificial muscles as a whole. This Account serves as a stepping stone into the field of EAPs, which, through the work of researchers worldwide, are positioned as a potential challenger to conventional actuator technologies.

[Membrane-selective electrodes for drug analysis. Note II].

https://www.ncbi.nlm.nih.gov/pubmed/16607814

Seven membrane-selective electrodes with PVC matrix and liquid-membrane for N-butylscopolamine with different electroactive materials are presented. These electrodes have a linear response in the concentration range of 10(-6) - 10(-2) M N-butylscopolamine bromide, with a detection limit between 4.58 x 10(-7)M and 1.09 x 10(-6)M. These electrodes were used with good results for quantitative assay by direct potentiometry and potentiometric titration of N-butylscopolamine bromide from pharmaceutical formulations. Recovery was between 95.50% and 99.20% for N-butylscopolamine bromide of injectable solutions.

Electroresponsive Ionic Liquid Crystal Elastomers.

https://www.ncbi.nlm.nih.gov/pubmed/31348584

This paper describes the preparation, physical properties, and electric bending actuation of a new class of active materials-ionic liquid crystal elastomers (iLCEs). It is demonstrated that iLCEs can be actuated by low-frequency AC or DC voltages of less than 1 V. The bending strains of the unoptimized first iLCEs are already comparable to the well-developed ionic electroactive polymers. Additionally, iLCEs exhibit several novel and superior features, such as the alignment that increases the performance of actuation, the possibility of preprogrammed actuation patterns at the level of the cross-linking process, and dual (thermal and electric) actuations in hybrid samples. Since liquid crystal elastomers are also sensitive to magnetic fields and can also be light sensitive, iLCEs have far-reaching potentials toward multiresponsive actuations that may have so far unmatched properties in soft robotics, sensing, and biomedical applications.

A dual-electrode approach for highly selective detection of glucose based on diffusion layer theory: experiments and simulation.

https://www.ncbi.nlm.nih.gov/pubmed/15643665

A dual-electrode configuration for the highly selective detection of glucose in the diffusion layer of the substrate electrode is presented. In this approach, a glassy carbon electrode (GCE, substrate) modified with a conductive layer of glucose oxidase/Nafion/graphite (GNG) was used to create an interference-free region in its diffusion layer by electrochemical depletion of interfering electroactive species. A Pt microelectrode (tip, 5 microm in radius) was located in the diffusion layer of the GNG-modified GCE (GNG-G) with the help of scanning electrochemical microscopy. Consequently, the tip of the electrode could sense glucose selectively by detecting the amount of hydrogen peroxide (H2O2) formed from the oxidization of glucose on the glucose oxidase layer. The influences of parameters, including tip-substrate distance, substrate potential, and electrolyzing time, on the interference-removing efficiency of this dual-electrode approach have been investigated systematically. When the electrolyzing time was 30 s, the tip-substrate distance was 1.8 a (9.0 microm) (where a is the radius of the tip electrode), the potentials of the tip and substrate electrodes were 0.7 V and 0.4 V, respectively, and a mixture of ascorbic acid (0.3 mM), uric acid (0.3 mM), and 4-acetaminophen (0.3 mM) had no influence on the glucose detection. In addition, the current-time responses of the tip electrode at different tip-substrate distances in a solution containing interfering species were numerically simulated. The results from the simulation are in good agreement with the experimental data. This research provides a concept of detection in the diffusion layer of a substrate electrode, as an interference-free region, for developing novel microelectrochemical devices.

Aptamer based voltammetric biosensor for Mycobacterium tuberculosis antigen ESAT-6 using a nanohybrid material composed of reduced graphene oxide and a metal-organic framework.

https://www.ncbi.nlm.nih.gov/pubmed/30019137

The 6-kDa early secretory antigenic target referred to as ESAT-6 is a virulence factor secreted by Mycobacterium tuberculosis (MTB). This work describes a voltammetric aptasensor for ultrasensitive detection of ESAT-6. Reduced graphene oxide doped with metal-organic framework (MOF-rGO) was deposited on a glassy carbon electrode (GCE). This increases the immobilization of electroactive Toluidine Blue (TB) and facilitates the electron transfer from TB to the modified GCE. Platinum/gold core/shell (Pt@Au) nanoparticles were used to assemble thiolated ESAT-6 binding

aptamer (EBA) on a modified electrode and to further amplify the response to TB. The modified GCE, typically operated at -0.36Â V (vs. SCE), has a linear response in 1.0â€‰Ã—â€‰10-4 to 2.0â€‰Ã—â€‰102Â ngâ‹…mL-1 ESAT-6 concentration range, and the limit of detection (LOD) for ESAT-6 is as low as 3.3â€‰Ã—â€‰10-5Â ngâ‹…mL-1. It exhibits satisfactory specificity and reproducibility when analyzing spiked human serum. Graphical abstract Schematic presentation of a voltammetric aptasensor for Mycobacterium tuberculosis antigen ESAT-6 using a glassy carbon electrode modified withÂ reduced graphene oxide (rGO) and aÂ metal-organic framework (MOF). The limit of detection for ESAT-6 is as low as 3.3â€‰Ã—â€‰10-5Â ng/mL.

Polymeric matrix membrane sensors for sensitive potentiometric determination of some beta-blockers in pharmaceutical preparations.

https://www.ncbi.nlm.nih.gov/pubmed/12852460

Five poly(vinyl chloride) matrix membrane sensors responsive to some beta-blockers (atenolol, bisoprolol, metoprolol, propranolol and timolol) are described and characterized. The sensors are based on the use of the ion-association complexes of the beta-blocker cations with tungstophosphate anion as electroactive materials. The performance characteristics of these sensors, evaluated according to IUPAC recommendations, reveal fast, stable and near-Nernstian response for 10(-2)-2 x 10(-7) mol l(-1) of different beta-blockers over the pH range 2-9. Many inorganic and organic cations as well as drug excipients and diluents normally used in drug formulations do not interfere. The sensors are used for direct potentiometry of beta-blockers in some pharmaceutical preparations. Validation of the method according to the quality assurance standards shows suitability of the proposed sensors for use in the quality control assessment of these drugs. Results with an average recovery of 99.1% and a mean standard deviation of +/- 1.3% of the nominal are obtained which compare fairly well with data obtained using the British Pharmacopoeia method.

Electrosynthesized poly(pyrrole)/poly(2-naphthol) bilayer membrane as an effective anti-interference layer for simultaneous determination of acethylcholine and choline by a dual electrode amperometric biosensor.

https://www.ncbi.nlm.nih.gov/pubmed/16169212

Several neural diseases appear related to the neurotransmitter acethylcholine (ACh) and its metabolite choline (Ch) brain levels so that their simultaneous determination is essential. A

cross-talk and interference free dual electrode amperometric biosensor for the simultaneous determination of both analytes has been developed. Acetylcholinesterase (AChE) and choline oxidase (ChO) were immobilized by glutaraldehyde co-crosslinking with bovine serum albumin. A very efficient rejection of electroactive interferents has been achieved by a novel electrosynthesized polymeric bilayer membrane composed by overoxidised poly(pyrrole) and poly(2-naphthol) films. Sensitivities towards several electroactive interferents ranged from ca. 0.04% (e.g. ascorbate) to ca. 0.3% (e.g. dopamine) of those relevant to ACh and Ch (11 and 15 microA/microM, respectively). Detection limits (at S/N=3) in flow injection analysis were ca. 100 nM for both ACh and Ch at the ChO-AChE electrode and ca. 40 nM for Ch at the ChO sensor. Biosensor performances appear more than adequate for brain tissue homogenates and cerebrospinal fluids analysis where average levels in the low micromolar range are typically found.

Electrochemical immunosensor for cholera toxin using liposomes and poly(3,4-ethylenedioxythiophene)-coated carbon nanotubes.

https://www.ncbi.nlm.nih.gov/pubmed/16478102

A sensitive method for the detection of cholera toxin (CT) using an electrochemical immunosensor with liposomic magnification followed by adsorptive square-wave stripping voltammetry is described. Potassium ferrocyanide-encapsulated and ganglioside (GM1)-functionalized liposomes act as highly specific recognition labels for the amplified detection of cholera toxin. The sensing interface consists of monoclonal antibody against the B subunit of CT that is linked to poly(3,4-ethylenedioxythiophene) coated on Nafion-supported multiwalled carbon nanotube caste film on a glassy carbon electrode. The CT is detected by a "sandwich-type" assay on the electronic transducers, where the toxin is first bound to the anti-CT antibody and then to the GM1-functionalized liposome. The potassium ferrocyanide molecules are released from the bounded liposomes on the electrode by lyses with methanolic solution of Triton X-100. The released electroactive marker is measured by adsorptive square-wave stripping voltammetry. The sandwich assay provides the amplification route for the detection of the CT present in ultratrace levels. The calibration curve for CT had a linear range of 10(-14)-10(-7)g mL(-1). The detection limit of this immunosensor was 10(-16) g of cholera toxin (equivalent to 100 microL of 10(-15) g mL(-1)).

An amperometric hydrogen peroxide sensor based on immobilization of hemoglobin in poly(o-aminophenol) film at iron-cobalt hexacyanoferrate-modified gold electrode.

https://www.ncbi.nlm.nih.gov/pubmed/15745755

A series of hybrid iron-cobalt hexacyanoferrate (FeCoHCF) films were electrodeposited on gold electrodes from solutions containing 6mM Fe(CN)(6)(3-) with different concentrations of Co(2+) and Fe(3+). FeCoHCF films deposited from solutions with different molar ratios of iron were studied by cyclic voltammetry, and their solid states were characterized by Fourier transform infrared spectroscopy. The kind of FeCoHCF film that deposited from a solution with a molar ratio of iron of 0.4 showed the largest response current to H(2)O(2) and was characterized by energy-dispersive X-ray spectroscopy. Therefore, the optimized FeCoHCF film was combined with nonconducting poly(o-aminophenol) (POAP) film that entrapped the hemoglobin (Hb) to construct hydrogen peroxide biosensor. The response current of the Hb/POAP/FeCoHCF/Au electrode (29.8 nA) was nearly 40 and was 1.5 times that of the Hb/POAP/Au (0.7 nA) and POAP/FeCoHCF/Au (20 nA) electrodes, respectively. The Michaelis-Menten constant of Hb in the Hb/POAP/FeCoHCF/Au film was 9.31 mM. These results show that the immobilized Hb in the Hb/POAP/FeCoHCF/Au film exhibits higher catalytic activity and larger response current to H(2)O(2) by the mediation of FeCoHCF. In addition, effects of applied potential, solution pH, and electroactive interferent on the response current of the Hb/POAP/FeCoHCF/Au electrode were investigated in detail.

UV-vis spectroscopic study of Co(II)/Co(III) oxidation in poly[M-protoporphyrins] films and their interaction with axial ligands.

https://www.ncbi.nlm.nih.gov/pubmed/15911396

A bathochromic shift for both Soret and Q bands in the polyCo(III)PP were indicative of Co(III) oxidation state in film. The presence of an isosbestic point indicates a chemical equilibrium between polyCo(III)PP (band I) in polyCo(III)PP with water as axial neutral ligand (band II). Concentration levels of iodide of 10(-1) M showed irreversible broadening of Soret band with a maximum shift from 400 nm to 380 nm attributed to film reduction. The thiocyanate anion shows a remarkable effect on polyCo(III)PP spectra. The degree of configuration interaction for Q and B transitions is nearly constant in air and water for Ni(II)PP, Cu(II)PP and Zn(II)PP films. The poly[Co(III)-protoporphyrin IX] showed strong deviation from the pattern. This result indicates that the Co atom does not present a planar conformation in polyCo(III)PP which is consistent with the less packed structure of this film. The apparent diffusion coefficients (D') were calculated for electroactive species using the polyNi(II)PP chemically modified electrode, with an experiment short enough to avoid preconcentration. D' was compared with D (diffusion coefficient), obtained with the bare working

electrode. Apparent diffusion coefficients (D') changed regularly with molecular volume indicating certain molecular sieving effect.

Cladophora Cellulose: Unique Biopolymer Nanofibrils for Emerging Energy, Environmental, and Life Science Applications.

https://www.ncbi.nlm.nih.gov/pubmed/31290643

Because of its natural abundance, hierarchical fibrous structure, mechanical flexibility, potential for chemical modification, biocompatibility, renewability, and abundance, cellulose is one of the most promising green materials for a bio-based future and sustainable economy. Cellulose derived from wood or bacteria has dominated the industrial cellulose market and has been developed to produce a number of advanced materials for applications in energy storage, environmental, and biotechnology areas. However, Cladophora cellulose (CC) extracted from green algae has unprecedented advantages over those celluloses because of its high crystallinity (>95%), low moisture adsorption capacity, excellent solution processability, high porosity in the mesoporous range, and associated high specific surface area. The unique physical and chemical properties of CC can add new features to and enhance the performance of nanocellulose-based materials, and these attributes have attracted a great deal of research interest over the past decade. This Account summarizes our recent research on the preparation, characterization, functionalization, and versatile applications of CC. Our aim is to provide a comprehensive overview of the uniqueness of CC with respect to material structure, properties, and emerging applications. We discuss the potential of CC in energy storage, environmental science, and life science, with emphasis on applications in which its properties are superior to those of other nanocellulose forms. Specifically, we discuss the production of the first-ever paper battery based on CC. This battery has initiated a rising interest in the development of sustainable paper-based energy storage devices, where cellulose is used as a combined building block and binder for paper electrodes of various types in combination with carbon, conducting polymers, and other electroactive materials. High-active-mass and high-mass-loading paper electrodes can be made in which the CC acts as a high-surface-area and porous substrate while a thin layer of electroactive material is coated on individual nanofibrils. We have shown that CC membranes can be used directly as battery separators because of their low moisture content, high mesoporosity, high thermal stability, and good electrolyte wettability. The safety, stability, and capacity of lithium-ion batteries can be enhanced simply by using CC-based separators. Moreover, the high chemical modifiability and adjustable porosity of dried CC papers

allow them to be used as advanced membranes for environmental science (water and air purification, pollutant adsorption) and life science (virus isolation, protein recovery, hemodialysis, DNA extraction, bioactive substrates). Finally, we outline some concluding perspectives on the challenges and future directions of CC research with the aim to open up yet unexplored fields of use for this interesting material.

Simultaneous determination of isoproterenol, acetaminophen, folic acid, propranolol and caffeine using a sensor platform based on carbon black, graphene oxide, copper nanoparticles and PEDOT:PSS.

https://www.ncbi.nlm.nih.gov/pubmed/29567183

We explored the use of carbon black (CB), graphene oxide (GO), copper nanoparticles (CuNPs) and poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT:PSS) as electrode materials for the simultaneous determination of isoproterenol, acetaminophen, folic acid, propranolol and caffeine. The designed nanostructured surface was widely characterized by scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), contact angle measurements and electrochemistry. From electrochemical characterization assays carried out towards the potassium ferricyanide redox probe, fast electron transfer kinetics and a considerably higher electroactive surface area were observed for the modified electrodic surface based on CB, GO, CuNPs and PEDOT:PSS film. Using square-wave voltammetry (SWV), well defined and resolved anodic peaks were detected for isoproterenol, acetaminophen, folic acid, propranolol and caffeine, with peak-to-peak potential separation not less than 170â€¯mV. Then, the SWV technique was explored for the simultaneous determination of quinary mixtures of these analytes, resulting in analytical curves with linear ranges and limits of detection at micromolar concentration levels. The practical viability of the proposed voltammetric sensor was illustrated in the analysis of human body fluid samples. The proposed sensor showed good repeatability and a successful application using urine and serum matrices, with recoveries close to 100%.

Constitutive model development and micro-structural topology optimisation for nafion hydrogel membranes with ionic clustering.

https://www.ncbi.nlm.nih.gov/pubmed/14768907

The deployment of electroactive ionic polymer hydrogel-metal composites in artificial muscle and BioMEMS applications has recently been intensively investigated. In order to analyse their

electromechanical responses to externally applied electrical fields, it is critical to develop a constitutive model linking the macro-mechanical moduli with the micro-mechanical characteristics, and to determine the geometric size and shape of the micro-structural cluster and investigate the effect of cluster morphology on the effective electro-elastic moduli of the polymer hydrogels. As a typical ionic polymer-based hydrogel, the Nafion membrane is studied in this work. Based on the Biot poroelasticity theory, a multi-scale constitutive model which includes both macro and micro characteristics is developed using an asymptotic homogenisation method. The effect of water-volume fraction on the effective elastic moduli of the hydrogel membrane is examined for different equivalent weights. Numerical investigations show that the simulated effective constitutive moduli agree well with experimental data. The presently developed constitutive model is thus validated. In order to determine the micro-structural shape of the polymer skeleton subject to fluid pressure, a representative volume element (RVE) is designed by topology optimisation of the periodic microstructures of the Nafion hydrogels, through the minimisation of the electro-elastic interaction energy between the polymer-based fluorocarbon matrix and the surrounding fluid. This optimal RVE correctly predicts the geometric shapes of the clusters.

Electrically-Induced Actuation of Acrylic-Based Dielectric Elastomers in Excess of 500% Strain.

https://www.ncbi.nlm.nih.gov/pubmed/30036143

Conventional robots are typically actuated by hard actuators, while biological entities consist mostly of soft muscles. Being soft imparts a functionality of compliance, thereby greatly enhancing the range of actuation and the degrees of freedom. Here, we demonstrate a soft electromechanically-active polymer capable of an electrically-induced linear strain beyond 500% that is continuously tunable by voltage. Previous experiments on the same material have demonstrated that by harnessing and bypassing electromechanical instability, soft electroactive polymers may bi-stably switch between an actuated state and an uncharged state of about 323% linear strain. In this paper, we use theory to inspire the possibility of suppressing electromechanical instability using pre-stretch by applying a non-isotropic pre-stretch onto the membrane, so as to achieve an ultra-large actuation strain that is continuously tunable by voltage. This geometry that enables such a large magnitude of actuation is simple and highly amenable to integration in robotic systems. With an electrically-induced strain of at least two orders of magnitude larger than conventional actuators, we expect our demonstration to expand the range of application for soft actuators.

Redox-active polymers based on nonbridged metal-metal bonds. Electrochemical formation of [Os(bpy)(CO)(L)](n) (bpy = 2,2'-bipyridine; L = CO, MeCN) and of their reduced forms: a spectroelectrochemical study.

https://www.ncbi.nlm.nih.gov/pubmed/15500366

IR, UV-vis, and EPR spectroelectrochemistry at variable temperatures and in different solvents were applied to investigate in situ the formation of electroactive molecular chains with a nonbridged Os-Os backbone, in particular, the polymer [Os(0)(bpy)(CO)(2)](n) (bpy = 2,2'-bipyridine), from a mononuclear Os(II) carbonyl precursor, [Os(II)(bpy)(CO)(2)Cl(2)]. The one-electron-reduced form, [Os(II)(bpy(.)(-))(CO)(2)Cl(2)](-), has been characterized spectroscopically at low temperatures. This radical anion is the key intermediate in the electrochemical propagation process responsible for the metal-metal bond formation. Unambiguous spectroscopic evidence has been gained also for the formation of [[Os(0)(bpy(*)(-))(CO)(2)](-)](n), the electron-rich electrocatalyst of CO(2) reduction. The polymer species are fairly well soluble in butyronitrile, which is important for their potential utilization in nanoscience, for example, as conducting molecular wires. We have also shown that complete solubility is accomplished for the monocarbonyl-acetonitrile derivative of the polymer, [Os(0)(bpy)(CO)(MeCN)(2)Cl](n).

Synthesis of diindolocarbazoles by Ullmann reaction: a rapid route to ladder oligo(p-aniline)s.

https://www.ncbi.nlm.nih.gov/pubmed/15355065

[structure: see text] New and facile synthesis of symmetric diindolocarbazoles was developed using the copper-catalyzed Ullmann reaction. The key step is a double-intramolecular cyclization reaction realized on N-alkyl-3,6-dibromo-2,7-bis(2'aminophenyl)carbazole derivatives which offers the desired symmetric ladder oligo(p-aniline)s. Depending upon the nature of the side- and/or end-groups, well-defined thin films and/or semiladder polymers could be obtained. These electroactive ladder oligomers may have great potential in organic electronics.

A sandwich-type amperometric immunosensor fabricated by Au@Pd NDs/Fe2+-CS/PPy NTs and Au NPs/NH2-GS to detect CEA sensitively via two detection methods.

https://www.ncbi.nlm.nih.gov/pubmed/30267981

The quantitative detection of carcinoembryonic antigen (CEA) is significant to assess tumor status and therapeutic efficiency. In this study, a sandwich-type amperometric immunosensor for CEA

detection sensitively was fabricated by novel signal amplification system. The signal amplification system was formed by gold nanoparticles loaded on amino functionalized graphene sheet (Au NPs/NH2-GS) and gold@palladium nanodendrites loaded on ferrous-chitosan functionalized polypyrrole nanotubes (Au@Pd NDs/Fe2+-CS/PPy NTs). Au NPs/NH2-GS as platform enhanced the electron transfer proven by apparent electron transfer rate constant. Au@Pd NDs/Fe2+-CS/PPy NTs nanocomposite as label appeared high catalytic activity to hydrogen peroxide reduction. Thus, the immunosensor showed wide linear concentration range (50â€¯fg/mL to 50â€¯ng/mL) and low detection limit of 17â€¯fg/mL via amperometric i-t curve (i-t). Significantly, the nanocomposite can act as electroactive substance, which provided a good method to detect CEA without additional electroactive substance via square wave voltammetry (SWV). An overlapping linear concentration range (500 fg/mL to 5.0â€¯ng/mL) was obtained compared i-t with SWV. The good reliability was verified mutually by i-t and SWV in actual sample analysis under overlapping linear concentration range. The detection method of without additional electroactive substance has vast potential for future development, due to simple testing condition.

Quartz crystal microbalance: a useful tool for studying thin polymer films and complex biomolecular systems at the solution-surface interface.

https://www.ncbi.nlm.nih.gov/pubmed/12959572

The quartz crystal microbalance (QCM) is a simple, cost effective, high-resolution mass sensing technique, based upon the piezoelectric effect. As a methodology, the QCM evolved a solution measurement capability in largely analytical chemistry and electrochemistry applications due to its sensitive solution-surface interface measurement capability. The technique possesses a wide detection range. At the low mass end, it can detect monolayer surface coverage by small molecules or polymer films. At the upper end, it is capable of detecting much larger masses bound to the surface. These can be complex arrays of biopolymers and biomacromolecules, even whole cells. In addition, the QCM can provide information about the energy dissipating properties of the bound surface mass. Another important and unique feature of the technique is the ability to measure mass and energy dissipation properties of films while simultaneously carrying out electrochemistry on solution species or upon film systems bound to the upper electrode on the oscillating quartz crystal surface. These measurements can describe the course of electropolymerization of a film or can reveal ion or solute transport within a film during changes in the film environment or state, including the oxidation state for an electroactive film driven by the underlying surface potential. The past

decade has witnessed an explosive growth in the application of the QCM technique to the study of a wide range of molecular systems at the solution-surface interface, in particular, biopolymer and biochemical systems. In this report, we start with a brief historical and technical overview. Then we discuss the application of the QCM technique to measurements involving micellar systems, self-assembling monolayers and their phase transition behavior, molecularly imprinted polymers, chemical sensors, films formed using the layer-by-layer assembly technique, and biopolymer films and point out the utility of the electrochemical capabilities of the technique to characterizing film properties, especially electroactive polymer films. We also describe the wide range of surface chemistries and attachment strategies used by investigators to bring about surface attachment and multi-layer interactions of these thin film systems. Next we review the wide range of recent applications of the technique to: studies of complex biochemical and biomimetic systems, the creation of protein and nucleic acid biosensors, studies of attached living cells and whole cell biosensor applications. Finally, we discuss future technical directions and applications of the QCM technique to areas such as drug discovery.

Temperature-induced reversible change in the redox response in phenothiazine-labeled poly(ethoxyethyl glycidyl ether) and its application to the thermal control of the catalytic reaction of glucose oxidase.

https://www.ncbi.nlm.nih.gov/pubmed/15379507

Novel redox-active thermosensitive polymers (phenothiazine-labeled poly(ethoxyethyl glycidyl ether), PT-PEEGE), composed of a polyoxyalkylene backbone, ethoxyethoxymethyl side chains, and an electroactive phenothiazine end group, were prepared by base-catalyzed anionic ring-opening polymerization of ethoxyethyl glycidyl ether monomer in the presence of 10-(2-hydroxyethyl)phenothiazine. Phase separation of a 1.0 mmol dm(-3) (0.33 wt %) PT-PEEGE aqueous solution occurs at 28 degrees C. While the phase separation temperature (Tc) is almost constant in the concentration range above 1.0 mmol dm(-3), it increases at below 1.0 mmol dm(-3). A 10-fold decrease in the oxidation current of PT-PEEGE is observed above Tc and reflects the decrease in the apparent concentration of electroactive PT-PEEGE due to the phase separation. The redox response mainly comes from PT-PEEGE molecules in the dilute phase, resulting from the phase separation, and the half-wave potential and peak separation are independent of the phase separation. This thermally induced change in the redox response is reversible and is applied for the thermal control of the electrocatalytic reaction of glucose oxidase (GOx). The catalytic current in the

presence of PT-PEEGE as an electron mediator decreases at temperatures higher than Tc. This originates from the phase separation of PT-PEEGE, and PT-PEEGE molecules which remained to be soluble participate in the electrocatalytic reactions of GOx as mediators.

Galvanic Redox Potentiometry for Self-Driven in Vivo Measurement of Neurochemical Dynamics at Open-Circuit Potential.

https://www.ncbi.nlm.nih.gov/pubmed/30335971

Understanding the real-time correlation between chemical patterns and neural processes is critical for deciphering brain function. Voltammetry has enabled this task but with a number of challenges for current-based electrolysis in vivo. Herein, we report galvanic redox potentiometry (GRP) potentially as a universal strategy for in vivo monitoring of neurochemicals, with ascorbic acid (AA) as a typical example. The GRP sensor is constructed on a self-driven galvanic cell configuration, where AA is spontaneously oxidized at the indicating single-walled carbon nanotube-modified carbon fiber electrode (SWNT-CFE), while oxygen reduced at the laccase-modified reference CFE (Lac-CFE). At thermodynamic equilibrium, open-circuit potential (OCP) can be a linear indicator of the concentration of AA. The resulting sensor shows a high selectivity to AA dynamics in the presence of coexisting electroactive neurochemicals, which is mainly determined by the driving force for the cell reaction, as suggested by principal investigation. Sensing sensitivity of this OCP-based GRP method is not affected by nonspecific protein adsorption and electrode fouling. Moreover, a micropipette compartment of the reference electrode is designed to suppress mass crossover and prevent disturbance to oxygen reduction through confinement effect. The in vivo application of the GRP sensor is illustrated by measuring the basal level of cortical AA in live rat brain (230 Â± 40 Î¼M) and its dynamics during ischemia/reperfusion. The GRP concept is demonstrated as a prominent method for in vivo, real-time, quantitative analysis of brain neurochemistry.

Regarding the origin of the delayed fluorescence of conjugated polymers.

https://www.ncbi.nlm.nih.gov/pubmed/16396570

In the first part of this work we revisit and reevaluate the experimental data that lead to the assignment of the origin of the delayed fluorescence (DF) to triplet-triplet annihilation for polyfluorene and to geminate pair recombination in the case of the ladder-type polyparaphenylene (MeLPPP); the ambiguity of this classification is unveiled. Next, new data about the DF of MeLPPP under applied electric field are presented. Here, the DF intensity completely recovers once the field

is turned off, which rules out geminate pairs as the origin of the DF and in turn provides clear evidence of the triplet-triplet annihilation picture. Finally, we show and discuss how recombination of space charge layers may also give rise to electric field induced delayed fluorescence, whereby the formation of these space charge layers strongly depends on device configuration and purity of the materials.

Electrochemically Triggered Surface Deposition of Polyelectrolytes.

https://www.ncbi.nlm.nih.gov/pubmed/30278136

An electrochemical approach to surface deposition of polyelectrolytes on self-assembled monolayers is presented. This deposition process can be triggered facilely by a potential bias, which oxidizes ferrocene moieties included in the self-assembled monolayer to ferrocenium, whose charge compensation is fulfilled by polyelectrolytes and associated counterions. This approach is quite general, affording quantitative deposition of both polyanions and polycations with a wide range of chemical identities (synthetic polymers, peptides, and DNA) and molecular weights (103-107 Da as tested). Conventional layer-by-layer polyelectrolyte deposition can be straightforwardly combined with this method to produce electroactive polymer films. Several techniques, including voltammetry, fluorescence spectroscopy, contact angle analysis, electrochemical quartz crystal microbalance, and atomic force microscopy, were employed to characterize the deposition processes. A detailed discussion on the involved deposition mechanisms is also presented.

Preparation and characterization of thick-film Ni/MH battery.

https://www.ncbi.nlm.nih.gov/pubmed/15142577

Using the porous polypropylene (PP) films sputtered with gold and the Ni as current collectors, the electroactive materials (Ni(OH)2 and metal hydride (MH)) of positive and negative electrodes were prepared on the current collector using thick-film technology. Two types of cell configurations were prepared and the characteristics of these batteries were compared. The cycle number for the formation of batteries based on the porous PP film was found to be 2, which was significantly less than that of batteries based on the ceramic substrates. Using the porous PP film as substrate, the number of cycles for the formation of battery increased from 2 to 5 with the increase of the charge/discharge rate from 0.1C/0.025C to 2.0C/0.5C. The silver oxides dendrites formed by the oxidation of silver paste used to adhere the current collectors and the conducting wires in the charge/discharge process caused a short contact between the positive and negative electrodes,

which then caused the battery failure. The cycle life of the battery based on the porous PP film was found to be greater than 400 when the charge/discharge rate was 2.0C/0.5C.

Fabrication of poly(dimethylsiloxane) microfluidic system based on masters directly printed with an office laser printer.

https://www.ncbi.nlm.nih.gov/pubmed/16130797

Applications of poly(dimethylsiloxane) (PDMS)-based microfluidic systems are more popular nowadays. Previous fabrication methods of the masters for PDMS microchannels require complicated steps and/or special device. In this paper, we demonstrated that the toner printed on the transparency film with the office laser printer (1200 dpi) can be used as the positive relief of the masters. The transparency film was printed in two steps in order to obtain the same printing quality for the crossed lines. With the laser-printed master, the depth of the fabricated PDMS microchannels was ca. 10 microm and the smallest width was ca. 60 microm. Surface characteristics of the PDMS/PDMS microchannels were performed with SEM. Their electrokinetic properties were investigated by the aids of the measurement of electroosmotic flow (EOF) and the Ohm's curve. Using the PDMS/PDMS microchip CE systems, electroactive biological molecules and non-electroactive inorganic ions were well separated, respectively. This simple approach could make it easy to carry out the studies of PDMS microfluidic systems in more general labs without special devices.

Electroactive polymeric sensors in hand prostheses: bending response of an ionic polymer metal composite.

https://www.ncbi.nlm.nih.gov/pubmed/16260170

In stark contrast to the inspiring functionality of the natural hand, limitations of current upper limb prostheses stemming from marginal feedback control, challenges of mechanical design, and lack of sensory capacity, are well-established. This paper provides a critical review of current sensory systems and the potential of a selection of electroactive polymers for sensory applications in hand prostheses. Candidate electroactive polymers are reviewed in terms of their relevant advantages and disadvantages, together with their current implementation in related applications. Empirical analysis of one of the most novel electroactive polymers, ionic polymer metal composites (IPMC), was conducted to demonstrate its potential for prosthetic applications. With linear responses within the operating range typical of hand prostheses, bending angles, and bending rates were accurately

measured with 4.4+/-2.5 and 4.8+/-3.5% error, respectively, using the IPMC sensors. With these comparable error rates to traditional resistive bend sensors and a wide range of sensitivities and responses, electroactive polymers offer a promising alternative to more traditional sensory approaches. Their potential role in prosthetics is further heightened by their flexible and formable structure, and their ability to act as both sensors and actuators.

Optical sensors based on hybrid aptamer/conjugated polymer complexes.

https://www.ncbi.nlm.nih.gov/pubmed/14759196

Single-stranded DNA (aptamer) can specifically bind potassium ions or human alpha-thrombin. When binding takes place, the aptamer undergoes a conformational transition from an unfolded to a folded structure. This conformational change of the negatively charged oligonucleotide can be detected by adding a water-soluble, cationic polythiophene derivative, which transduces the new complex formation into an optical (colorimetric or fluorometric) signal without any labeling of the probe or of the target. This simple and rapid methodology has enabled the detection of human thrombin in the femtomole range. This new biophotonic tool can easily be applied to the detection of various other proteins as well as being useful in the high-throughput screening of new drugs.

Layer-by-Layer Assembly and Electrochemical Study of Alizarin Red S-Based Thin Films.

https://www.ncbi.nlm.nih.gov/pubmed/30960149

Electroactive organic dyes incorporated in layer-by-layer (LbL) assemblies are of great interest for a variety of applications. In this paper, Alizarin Red S (ARS), an electroactive anthraquinone dye, is employed to construct LbL (BPEI/ARS)n films with branched poly(ethylene imine) (BPEI) as the complementary polymer. Unconventional LbL methods, including co-adsorption of ARS and poly(4-styrene sulfonate) (PSS) with BPEI to assemble (BPEI/(ARS+PSS))n, as well as pre-complexation of ARS with BPEI and further assembly with PSS to fabricate ((BPEI+ARS)/PSS)n, are designed for investigation and comparison. Film growth patterns, UVâ•»Vis spectra and surface morphology of the three types of LbL assemblies are measured and compared to reveal the formation mechanism of the LbL films. Electrochemical properties including cyclic voltammetry and spectroelectrochemistry of (BPEI/ARS)120, (BPEI/(ARS+PSS))120 and ((BPEI+ARS)/PSS)120 films are studied, and the results show a slight color change due to the redox reaction of ARS. ((BPEI+ARS)/PSS)120 shows the best stability among the three samples. It is concluded that the manner of dye- incorporation has a great effect on the electrochemical

properties of the resultant films.

Fabrication of PVC based membrane using nickel porphyrazine as ionophore in the screening of thiocyanate ion in aqueous and real samples.

https://www.ncbi.nlm.nih.gov/pubmed/15200384

The [Ni[(TAP)(SBn)8]] complex (I), i.e. ([2,3,7,8,12,13,17,18-octakis(benzylthio)-5,10,15,20-tetraazaporphyrin])nickel(II), has been explored as an ionophore for fabrication of the PVC based membrane electrodes used in the screening of thiocyanate anion (SCN-). The membrane having [Ni[(TAP)(SBn)8]] complex (I) as an electroactive material and dioctylphthalate (DOP) as plasticizer in the PVC matrix with the percentage ratio 5 : 158 : 200 (I : DOP : PVC, % w/w) exhibited a linear response in the concentration range 7.0 x 10(-6)-1.0 x 10(-1) M of SCN- with a sub-Nernstian slope 32.5 +/- 0.2 mV/decade of activity and a fast response time of 10 +/- 2 s. The sensor works well in the pH range 3.0 - 9.5 and could be satisfactorily used in presence of 50 % (v/v) methanol, ethanol and acetone, and is selective for SCN- over a large number of anions with slight interference from iodide (I-) and azide (N3-) if present at a level >or = 1.0 x 10(-5) M. Described electrode works well over a period of six months. The sensor can be successfully applied for the screening of SCN- in both aqueous and real samples and also as indicator electrodes in precipitation titrations.

Low Background Cascade Signal Amplification Electrochemical Sensing Platform for Tumor-Related mRNA Quantification by Target-Activated Hybridization Chain Reaction and Electroactive Cargo Release.

https://www.ncbi.nlm.nih.gov/pubmed/30261719

Herein a low background cascade signal amplification electrochemical sensing platform has been proposed for the ultrasensitive detection of mRNA (mRNA) by coupling the target-activated hybridization chain reaction and electroactive cargo release from mesoporous silica nanocontainers (MSNs). In this sensing platform, the 5'-phosphate-terminated DNA (5'-PO4 cDNA) complement to target mRNA is hybridized with the trigger DNA and anchor DNA on the surface of the MSNs, aiming at forming a double-stranded DNA gate molecule and sealing the methylene blue (MB) in the inner pores of the MSNs. In the presence of target mRNA, the 5'-PO4 cDNA is displaced from the MSNs and competitively hybridizes with mRNA, which led to the liberation of the trigger DNA and the opening of the MSNs pore. The liberated trigger DNA can be then immobilized onto the electrode

surface through hybridization with the capture DNA, triggering HCR on the electrode surface. At the same time, the MB released from the MSNs will selectively intercalate into the HCR long dsDNA polymers, giving rise to significant electrochemical response. In addition, due to the Î»-exonuclease (Î»-Exo) cleavage reaction-assisted target recycling, more amounts of trigger DNA will be liberated and trigger HCR, and numerous MB are uncapped and intercalate into the HCR products. As proof of concept, thymidine kinase 1 (TK1) mRNA was used as a model target. Featured with amplification efficiency, label-free capability, and low background signal, the strategy could quantitatively detect TK1 mRNA down to 2.0 aM with a linear calibration range from 0.1 fM to 1 pM. We have also demonstrated the practical application of our proposed sensing platform for detecting TK1 mRNA in real samples, opening up new avenues for highly sensitive quantification of biomarkers in bioanalysis and clinical diagnosis.

Natural polysaccharides as electroactive polymers.

https://www.ncbi.nlm.nih.gov/pubmed/15724215

Electroactive polymers (EAPs), a new class of materials, have the potential to be used for applications like biosensors, environmentally sensitive membranes, artificial muscles, actuators, corrosion protection, electronic shielding, visual displays, solar materials, and components in high-energy batteries. The commercialization of synthetic EAPs, however, has so far been severely limited. Biological polymers offer a degree of functionality not available in most synthetic EAPs. Carbohydrate polymers are produced with great frequency in nature. Starch, cellulose, and chitin are some of the most abundant natural polymers on earth. Biopolymers are a renewable resource and have a wide range of uses in nature, functioning as energy storage, transport, signaling, and structural components. In general, electroactive materials with polysaccharide matrices reach conductance levels comparable with synthetic ion-conducting EAPs. This review gives a brief history of EAPs, including terminology, describes evaluation methods, and reports on the current progress of incorporating polysaccharides as matrices for doped, blended, and grafted electroactive materials.

Artificial kinesthetic systems for telerehabilitation.

https://www.ncbi.nlm.nih.gov/pubmed/15718648

Artificial sensory motor systems are now under development in a truly wearable form using an innovative technology based on electroactive polymers. The integration of electroactive polymeric

materials into wearable garments endorses them with strain sensing and mechanical actuation properties. The methodology underlying the design of haptic garments has necessarily to rely on knowledge of biological perceptual and motor processes which is, however, scattered and fragmented. Notwithstanding, the combined use of new polymeric electroactive materials in the form of fibers and fabrics with emerging concepts of biomimetic nature in sensor data analysis, pseudomuscular actuator control and biomechanical design may not only provide new avenues toward the realization of truly wearable kinesthetic and haptic interfaces, but also clues and instruments to better comprehend human manipulative and gestual functions. In this talk the conception, early stage implementation and preliminary testing of a fabric-based wearable interface endowed with spatially redundant strain sensing and distributed actuation are illustrated with reference to a wearable upper limb artificial kinesthesia system, intended to be used in telerehabilitation of post stroke patient.

Extracellular electron transfer features of Gram-positive bacteria.

https://www.ncbi.nlm.nih.gov/pubmed/31203962

Electroactive microorganisms possess the unique ability to transfer electrons to or from solid phase electron conductors, e.g., electrodes or minerals, through various physiological mechanisms. The processes are commonly known as extracellular electron transfer and broadly harnessed in microbial electrochemical systems, such as microbial biosensors, microbial electrosynthesis, or microbial fuel cells. Apart from a few model microorganisms, the nature of the microbe-electrode conductive interaction is poorly understood for most of the electroactive species. The interaction determines the efficiency and a potential scaling up of bioelectrochemical systems. Gram-positive bacteria generally have a thick electron non-conductive cell wall and are believed to exhibit weak extracellular electron shuttling activity. This review highlights reported research accomplishments on electroactive Gram-positive bacteria. The use of electron-conducting polymers as mediators is considered as one promising strategy to enhance the electron transfer efficiency up to application scale. In view of the recent progress in understanding the molecular aspects of the extracellular electron transfer mechanisms of Enterococcus faecalis, the electron transfer properties of this bacterium are especially focused on. Fundamental knowledge on the nature of microbial extracellular electron transfer and its possibilities can provide insight in interspecies electron transfer and biogeochemical cycling of elements in nature. Additionally, a comprehensive understanding of cell-electrode interactions may help in overcoming insufficient electron transfer and restricted

operational performance of various bioelectrochemical systems and facilitate their practical applications.

Assemblies of dendrimers and proteins on carbon and gold electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/16707279

Dendritic macromolecules of two adjacent (G3.5 and G4) generations have been used to modify gold or carbon electrodes. The structure and stability of deposited films have been explored by quartz crystal microbalance (QCM), Surface Plasma Resonance (SPR) and electrochemistry. Dendrimers have been shown to adsorb spontaneously on electrode materials as compressed macromolecular films. They are able to inhibit (G3.5) or promote (G4) electroactive anionic species such as Fe(CN)(6)(3-/4-) used as a probe system. Mixed protein/dendrimer assemblies have been constructed with proteins differing in charge, nature of the prosthetic groups and sizes such as lysozyme, cytochrome c, polyhemic cytochrome c(3) or glucose oxidase. Generally, the stability of adsorbed films seems to be limited to one dendrimer/protein bilayer. Owing to the satisfactory stability of composite cytochrome c(3)/G3.5 or glucose oxidase/G4 films, biosensing applications are described for metal bioremediation and glucose detection, respectively.

Conductive nanostructured materials based on poly-(3,4-ethylenedioxythiophene) (PEDOT) and starch/Îº-carrageenan for biomedical applications.

https://www.ncbi.nlm.nih.gov/pubmed/29580413

Smart electroactive biomaterials are sought to allow the direct delivery of electrical, electrochemical and electromechanical signals to biological tissues. Specifically, poly-(3,4-ethylenedioxythiophene) (PEDOT) is a polymer of special interest attending to its biocompatibility, tuneable electrical conductivity and processing versatility. In this work, nanostructured PEDOT was synthesized using starch/Îº-carrageenan aerogels as templates. Îº-carrageenan biopolymer acted as doping agent of the conductive polymer to enhance the biocompatibility and the electrical response. The physicochemical, morphological, mechanical and electrical properties of the nanostructured PEDOT and templates were characterized. The incorporation of Îº-carrageenan to the nanostructured materials resulted in an increase in the compressive strength of ca. 40% and a decrease in the electrical impedance of one order-of-magnitude. The synergistic combination of the inherent electrical properties of the PEDOT, the advantageous features of Îº-carrageenan as doping agent and the porous morphology of the aerogel template resulted in electroactive PEDOT nanostructures

with relevant properties for biomedical applications.

Effect of Homeopathic Dilutions of Cuprum Arsenicosum on the Electrical Properties of Poly(Vinylidene Fluoride-Co-Hexafluoropropylene).

https://www.ncbi.nlm.nih.gov/pubmed/29767830

We report the effects of nanoparticles in homeopathic preparations of copper salts on the electrical properties of polymer film. Previous work showed that the incorporation of metal-derived homeopathic medicines increases the dielectric constant and alternating current (AC) conductivity of an electroactive polymer film that is commonly used as a capacitor in the electronic industry.We report here the effect of dilution of one homeopathic medicine, Cuprum arsenicosum (CuAs), at 200C potency on the electrical properties of the polymer film of poly(vinylidene fluoride-co-hexafluoropropylene).

On-line coupling of a microelectrode array equipped poly(dimethylsiloxane) microchip with an integrated graphite electrospray emitter for electrospray ionisation mass spectrometry.

https://www.ncbi.nlm.nih.gov/pubmed/16175254

A novel method for the manufacturing of microchips for on-chip combinations of electrochemistry (EC) and sheathless electrospray ionisation mass spectrometry (ESI-MS) is described. The technique, which does not require access to clean-room facilities, is based on the incorporation of an array of gold microcoil electrodes into a poly(dimethylsiloxane)(PDMS) microflow channel equipped with an integrated graphite based sheathless ESI emitter. Electrochemical measurements, which were employed to determine the electroactive area of the electrodes and to test the microchips, show that the manufacturing process was reproducible and that the important interelectrode distance in the electrochemical cell could to be adequately controlled. The EC-ESI-MS device was evaluated based on the ESI-MS detection of the oxidation products of dopamine. The results demonstrate that the present on-chip approach enables full potentiostatic control of the electrochemical cell and the attainment of very short transfer times between the electrochemical cell and the electrospray emitter. The transfer times were 0.6 and 1.2 s for flow rates of 1.0 and 0.5 microL min(-1), respectively, while the electrochemical conversion efficiency of the electrochemical cell was found to be 30% at a flow rate of 0.5 microL min(-1). To decouple the electrochemical cell from the ESI-MS high voltage and to increase the user-friendliness, the on-line electrochemistry-ESI-MS experiments were performed using a wireless Bluetooth battery-powered

instrument with the chip floating at the potential induced by the ESI high voltage. The described on-chip EC-ESI-MS device can be used for fundamental electrochemical investigations as well as for applications based on the use of electrochemically controlled sample pretreatment, preconcentration and ionisation steps prior to ESI-MS.

Time-temperature superposition for viscoelastic properties of regioregular poly(3-hexylthiophene) films.

https://www.ncbi.nlm.nih.gov/pubmed/15771516

Shear moduli were determined for chemically polymerized and solvent cast regioregular poly(3-hexylthiophene) films, using thickness shear mode acoustic wave resonators. The results are strikingly different to those for electropolymerized regiorandom poly(3-hexylthiophene) films. The time scale of the measurement was varied directly by use of higher harmonics of the acoustic wave resonator and indirectly via temperature. The significant variations in shear modulus with effective time scale can be "normalized"onto a stress master relaxation curve by using the concept of time-temperature superposition; this is the first time this has been demonstrated for electroactive films. The shift factors required to effect this normalization do not follow the classical Williams-Landel-Ferry (WLF) equation developed for long-range backbone motions of bulk polymers. Instead, they follow an Arrhenius-like behavior, commonly used to describe secondary motions of polymer side-chains. The activation enthalpy associated with this is independent of applied potential, is the same as for as cast (undoped) films, and is similar to that for rotation about a carbon-carbon single bond. These all point to the hexyl side-chains as the origins of the observed phenomena, consistent with the "melting point" separating two temperature-dependent phases and with the different molecular packing arrangements that would necessarily apply to regioregular and regiorandom materials.

Enzyme-amplified electrochemical detection of DNA using electrocatalysis of ferrocenyl-tethered dendrimer.

https://www.ncbi.nlm.nih.gov/pubmed/14588003

We have developed a sandwich-type enzyme-linked DNA sensor as a new electrochemical method to detect DNA hybridization. A partially ferrocenyl-tethered poly(amidoamine) dendrimer (Fc-D) was used as an electrocatalyst to enhance the electronic signals of DNA detection as well as a building block to immobilize capture probes. Fc-D was immobilized on a carboxylic acid-terminated

self-assembled monolayer (SAM) by covalent coupling of unreacted amine in Fc-D to the acid. Thiolated capture probe was attached to the remaining amine groups of Fc-D on the SAM via a bifunctional linker. The target DNA was hybridized with the capture probe, and an extension in the DNA of the target was then hybridized with a biotinylated detection probe. Avidin-conjugated alkaline phosphatase was bound to the detection probe and allowed to generate the electroactive label, p-aminophenol, from p-aminophenyl phosphate enzymatically. p-Aminophenol diffuses into the Fc-D layer and is then electrocatalytically oxidized by the electronic mediation of the immobilized Fc-D, which leads to a great enhancement in signal. Consequently, the amount of hybridized target can be estimated using the intensity of electrocatalytic current. This DNA sensor exhibits a detection limit of 20 fmol. Our method was also successfully applied to the sequence-selective discrimination between perfectly matched and single-base mismatched target oligonucleotides.

Application of polymerized multiporous nanofiber of SnO2 for designing a bienzyme glucose biosensor based on HRP/GOx.

https://www.ncbi.nlm.nih.gov/pubmed/30465828

This work reports on a novel glucose biosensor based on co-immobilization of glucose oxidase (GOx) and horseradish peroxidase with polymerized multiporous nanofiber (MPNFs) of SnO2 onto glassy carbon electrode with chitosan. Multiporous nanofibers of SnO2 were synthesized by electrospinning method from the tin precursor which possesses high surface area good electrical conductivity, and the nanofibers were polymerized with polyaniline (PANI). GOx and HRP were then co-immobilized with the nanofibers on the surface of the glassy carbon electrode by using chitosan. The polymerized nanofibers play a significant role in facilitating the direct electron transfer between the electroactive center of the immobilized enzyme and the electrode surface. The morphology of the nanofiber and polymerized nanofiber has been evaluated by field emission scanning electron microscopy (FESEM). Cyclic Voltammetry and amperometry were employed to study and optimize the performance of the fabricated biosensor. The PANI/SnO2-NF/GOx-HRP/Ch/GC biosensor displayed a linear amperometric response towards the glucose concentration range from 5 to 100â€¯Î¼M with a detection limit of 1.8â€¯Î¼M (S/Nâ€¯=â€¯3). Also, the anti-interference study and real sample analysis was investigated. Furthermore, the biosensor reported in this work exhibited excellent stability, reproducibility, and repeatability.

Electrocomposite Developed with Chitosan and Ionic Liquids Using Screen-Printed Carbon

Electrodes Useful to Detect Rutin in Tropical Fruits.

https://www.ncbi.nlm.nih.gov/pubmed/30181437

This work reports the development of a composite of the ionic liquid 1-butyl-3-methylimidazolium tetrafluoroborate ([BMIM]BPâ„) and chitosan (CS) described in previous reports through a new method using cyclic voltammetry with 10 cycles at a scan rate of 50.0 mV s-1. This method is different from usual methods such as casting, deposition, and constant potential, and it allows the development of an electroactive surface toward the oxidation of rutin by stripping voltammetry applied to the detection in tropical fruits such as orange, lemon, and agraz (Vaccinium meridionale Swartz), with results similar to those reported in previous studies. In addition, the surface was characterized by electrochemical impedance spectroscopy (EIS), scanning electron microscopy (SEM), and Raman spectroscopy. The limit of detection was 0.07 Âµmol L-1 and the relative standard deviation (RSD) of 10 measurements using the same modified electrode was 0.86%. Moreover, the stability of the sensor was studied for six days using the same modified electrode, where the variation of the signal using a known concentration of rutin (RT) was found to be less than 5.0%. The method was validated using a urine chemistry control spiked with known amounts of RT and possible interference was studied using ten substances including organic and biological compounds, metal ions, and dyes. The results obtained in this study demonstrated that this electrodeveloped composite was sensitive, selective, and stable.

Advances in Polymeric Materials for Electromechanical Devices.

https://www.ncbi.nlm.nih.gov/pubmed/30357999

Electroactive polymers (EAP) provide lightweight and cost-effective materials that enable the next generation of electromechanical devices. Commercial polymers have historically dominated research in EAP devices due to their availability. However, several drawbacks of these materials have limited their commercial applications, necessitating new materials for the commercial success of future EAP devices. This review highlights recent advances in novel EAPs for ionic polymer-metal composites (IPMC) and dielectric elastomer actuators (DEA). Ion-containing block copolymers and charged segmented condensation polymers demonstrate suitable electromechanical properties competitive with Nafion-based IPMCs. In addition, swelling ionic polymer membranes with free ionic liquid enhances ionic conductivity and promotes electromechanical actuation. Synthetic approaches to increasing permittivity in dielectric elastomers are also explored as a method of producing more efficient DEAs. Incorporating polar functional groups into siloxane and acrylic elastomers through

grafting or blending provides high-dielectric elastomers for use in DEAs with low driving voltages.

Large Piezoelectric Strain in Sub-10 Nanometer Two-Dimensional Polyvinylidene Fluoride Nanoflakes.

https://www.ncbi.nlm.nih.gov/pubmed/30883093

Functional polymers such as polyvinylidene fluoride (PVDF) and its copolymers, which exhibit room-temperature piezoelectricity and ferroelectricity in two-dimensional (2D) limit, are promising candidates to substitute hazardous lead-based piezoceramics for flexible nanoelectronic and electromechanical energy-harvesting applications. However, realization of many polymers including PVDF in ultrathin 2D nanostructures with desired crystal phases and tunable properties remains challenging due to ineffective conventional synthesis methods. Consequently, it has remained elusive to obtain optimized piezoelectric performance of PVDF particularly in sub-10 nm regimes. Taking advantage of its high flexibility and easy processing, we fabricate ultrathin PVDF nanoflakes with thicknessesÂ down to 7 nmÂ by using a hot-pressing method. This thermo-mechanical strategy simultaneously induces robust thermodynamic Î± to electroactive Î²-phase transformation, with Î² fraction as high as 92.8% in sub-10 nm flakes. Subsequently, piezoelectric studies performed by using piezoresponse force microscopy reveal an excellent piezoelectric strain of 0.7% in 7 nm film and the highest piezoelectric coefficient (d33) achieved is -68 pm/V for 50 nm-thick nanoflakes, which is 13% higher than the piezoresponse from 50 nm-thick PZT nanofilms. Our results further suggest thickness modulation as an effective strategy to tune the piezoelectric performance of PVDF and affirm its supremacy over conventional piezoceramics especially at nanoscale. This work aims not only to help understand fundamental piezoelectricity of pure PVDF in sub-10 nm regimes but also provides an opportunity to realize other polymer-based 2D nanocrystals.

Copolymer based multifunctional conducting polymer film for fluorescence sensing of glucose.

https://www.ncbi.nlm.nih.gov/pubmed/29765012

A simple, rapid and effective fluorescence sensing platform has been fabricated using a fluorescent conducting polymer surface. For this purpose, a rhodamine based electroactive monomer (RDC) and a functional group containing monomer (SNS) have been copolymerized to develop a conducting polymer based sensor platform having a fluorescence and enzyme-binding surface on ITO electrode. The proposed fluorescence sensing mechanism for detection of glucose is related to

the consumption of dissolved oxygen at the double layer of the electrode which is fluorescence quenching agent by glucose-GOx reaction. Concentration of glucose was investigated quantitatively from 0.05 to 1 mM via fluorescence signal measurement. This novel approach could be adapted for the production of various rapid and effective fluorescence sensing platforms for glucose.

Enabling portable multiple-line refreshable Braille displays with electroactive elastomers.

https://www.ncbi.nlm.nih.gov/pubmed/30082203

Full-page (multiple-lines), electrically refreshable, portable and affordable Braille displays do not currently exist. There is a need for such an assistive technology, which could be used as the Braille-coded tactile analogue for blind people of the digital tablets used by sighted people. Turning those highly desirable systems into reality requires a radically new technology for Braille dot actuation. Here, we describe standard-sized refreshable Braille dots based on an innovative actuation technology that uses electro-responsive smart materials known as dielectric elastomers. Owing to a significantly reduced lateral size with respect to conventional Braille dot drives, the proposed solution is suitable to array multiple dots in multiple lines, so as to form full-page Braille displays. Furthermore, a significant reduction also of the vertical size makes the design suitable for the development of thin and lightweight displays, thus enabling portability. We present the first prototype samples of these new refreshable Braille dots, showing that the achievable active displacements are adequately close to the standard Braille requirements, although the force has to be further improved. The paper discusses the remaining challenges and describes promising strategies to address them.

DNA biosensor based on chitosan film doped with carbon nanotubes.

https://www.ncbi.nlm.nih.gov/pubmed/16169507

A biosensor based on chitosan doped with carbon nanotube (CNT) was fabricated to detect salmon sperm DNA. Methylene blue (MB) was employed as a DNA indicator. It was found that CNTs can enhance the electroactive surface area threefold (0.28 +/- 0.03 and 0.093 +/- 0.06 cm(2) for chitosan-CNT- and chitosan-modified electrodes, respectively) and can accelerate the rate of electron transfer between the redox-active MB and the electrode. A low detection limit of 0.252 nM fish sperm DNA was achieved, and no interference was found in the presence of 5 microg/ml human serum albumin. The differential pulse voltammetry signal of MB was linear over the fish sperm DNA concentration range of 0.5-20 nM.

Electrochemical olefin epoxidation employing an iron(IV)porphyrin/trisbipyridineruthenium(III) polymer catalyst.

https://www.ncbi.nlm.nih.gov/pubmed/16142936

A porphyrin molecule containing four meso-appended 2,2'-bipyridyl ligands has been prepared. Each bipyridine is attached to the porphyrin core at the 4-position (pseudo-para to one of the pyridine nitrogens). Subsequently, each of the four bipyridines was complexed with a RuL2(2+) moiety and iron coordinated in the porphyrin core. When L = 4-vinyl-4'-methyl-2,2'-bipyridine, reduction of the ruthenium centers resulted in the formation of robust electroactive polymer films which deposited on the electrode surface. In the presence of aqueous acid, these films electrocatalytically epoxidize cyclohexene at positive potentials from the formal iron(IV) oxidation state. Although product analysis has only been conducted for cyclohexene, the catalytic activity extends to a large variety of olefins including ethylene and propylene.

Long-term recording performance and biocompatibility of chronically implanted cylindrically-shaped, polymer-based neural interfaces.

https://www.ncbi.nlm.nih.gov/pubmed/29478038

Stereo-electroencephalography depth electrodes, regularly implanted into drug-resistant patients with focal epilepsy to localize the epileptic focus, have a low channel count (6-12 macro- or microelectrodes), limited spatial resolution (0.5-1 cm) and large contact area of the recording sites (~mm2). Thus, they are not suited for high-density local field potential and multiunit recordings. In this paper, we evaluated the long-term electrophysiological recording performance and histocompatibility of a neural interface consisting of 32 microelectrodes providing a physical shape similar to clinical devices. The cylindrically-shaped depth probes made of polyimide (PI) were chronically implanted for 13 weeks into the brain of rats, while cortical or thalamic activity (local field potentials, single-unit and multi-unit activity) was recorded regularly to monitor the temporal change of several features of the electrophysiological performance. To examine the tissue reaction around the probe, neuron-selective and astroglia-selective immunostaining methods were applied. Stable single-unit and multi-unit activity were recorded for several weeks with the implanted depth probes and a weak or moderate tissue reaction was found around the probe track. Our data on biocompatibility presented here and in vivo experiments in non-human primates provide a strong indication that this type of neural probe can be applied in stereo-electroencephalography recordings of up to 2 weeks in humans targeting the localization of epileptic foci providing an increased spatial

resolution and the ability to monitor local field potentials and neuronal spiking activity.

All-Organic Conductive Biomaterial as an Electroactive Cell Interface.

https://www.ncbi.nlm.nih.gov/pubmed/30234966

Various attractive materials are being used in bioelectronics recently. In this paper, hydroxymethyl-3,4-ethylenedioxythiophene (EDOT-OH) has been in situ integrated and polymerized on the surface of the regenerated silk fibroin (RSF) film to construct a biocompatible electrode. In order to improve the efficiency of in situ polymerization, sodium dodecyl sulfate (SDS) was adopted as surfactant to construct a well-organized and stable poly(hydroxymethyl-3,4-ethylenedioxythiophene) (PEDOT-OH) coating, whereas ammonium persulfate was used as oxidant. The effects of dosages of surfactant and oxidant, initial pH value, and monomer concentration on the polymerization were studied. Under the optimal conditions, the RSF/PEDOT-OH film exhibited a square resistance of 3.28 Ã— 105 Î© corresponding to a conductance of 6.1 Ã— 10-3 S/cm. Scanning electron microscope images indicated that PEDOT-OH was deposited uniformly on the surface of the RSF film with SDS. Furthermore, Fourier transform infrared spectroscopy confirmed that interactions existed between the peptide linkages of silk fibroin (SF) macromolecules and PEDOT-OH. The RSF/PEDOT-OH film displayed favorable electrochemical stability, biocompatibility, and fastness. This study provides a feasible method to endow conductivity to RSF materials in various forms. In addition, the conductive layer and biocompatible silk substrate make the RSF/PEDOT-OH biomaterial highly suitable for potential applications in bioelectric devices, sensors, and tissue engineering.

Synthesis, self-assembly, and characterization of supramolecular polymers from electroactive dendron rodcoil molecules.

https://www.ncbi.nlm.nih.gov/pubmed/15521765

We report here the synthesis and self-assembly of a series of three molecules with dendron rodcoil architecture that contain conjugated segments of oligo(thiophene), oligo(phenylene-vinylene), and oligo(phenylene). Despite their structural differences, all three molecules yield similar self-assembled structures. Electron and atomic force microscopy reveals the self-assembly of the molecules into high aspect ratio ribbon-like nanostructures which at low concentrations induce gelation in nonpolar solvent. Self-assembly results in a blue-shifted absorption spectrum and a red-shifted, quenched fluorescence spectrum, indicating aggregation of the conjugated segments

within the ribbon-like structures. The assembly of these molecules into one-dimensional nanostructures is a route to pi-pi stacked supramolecular polymers for organic electronic functions. In the oligo(thiophene) derivative, self-assembly leads to a 3 orders of magnitude increase in the conductivity of iodine-doped films due to self-assembly. We also found that electric field alignment of these supramolecular assemblies can be used to create arrays of self-assembled nanowires on a device substrate.

Theoretical Calculations for Highly Selective Direct Heteroarylation Polymerization: New Nitrile-Substituted Dithienyl-Diketopyrrolopyrrole-Based Polymers.

https://www.ncbi.nlm.nih.gov/pubmed/30213056

Direct Heteroarylation Polymerization (DHAP) is becoming a valuable alternative to classical polymerization methods being used to synthesize Ï€-conjugated polymers for organic electronics applications. In previous work, we showed that theoretical calculations on activation energy (Ea) of the Câ•»H bonds were helpful to rationalize and predict the selectivity of the DHAP. For readers' convenience, we have gathered in this work all our previous theoretical calculations on Ea and performed new ones. Those theoretical calculations cover now most of the widely utilized electron-rich and electron-poor moieties studied in organic electronics like dithienyl-diketopyrrolopyrrole (DT-DPP) derivatives. Theoretical calculations reported herein show strong modulation of the Ea of Câ•»H bond on DT-DPP when a bromine atom or strong electron withdrawing groups (such as fluorine or nitrile) are added to the thienyl moiety. Based on those theoretical calculations, new cyanated dithienyl-diketopyrrolopyrrole (CNDT-DPP) monomers and copolymers were prepared by DHAP and their electro-optical properties were compared with their non-fluorinated and fluorinated analogues.

Assembly of electroactive layer-by-layer films of myoglobin and ionomer poly(ester sulfonic acid).

https://www.ncbi.nlm.nih.gov/pubmed/12702396

Layer-by-layer films were assembled on solid substrates by alternate adsorption of negatively charged ionomer poly(ester sulfonic acid) or Eastman AQ55 from its aqueous dispersion and positively charged myoglobin (Mb) from its solution at pH 4.5. The film assembly process was monitored by cyclic voltammetry (CV), UV-vis spectroscopy, and quartz crystal microbalance (QCM). [AQ/Mb](n) films grown on pyrolytic graphite (PG) electrodes showed a pair of well-defined

and nearly reversible CV peaks at about -0.20 V vs Ag/AgCl in pH 5.5 buffers, characteristic of the Mb heme Fe(III)/Fe(II) redox couple. Although the amount of Mb adsorbed in each bilayer was essentially the same, the fraction of electroactive Mb decreased dramatically with an increase of bilayer number (n). Soret absorption bands of [AQ/Mb](n) films on glass slides suggest that Mb in the films retains its native state in the medium pH range. Trichloroacetic acid, oxygen, and hydrogen peroxide were electrochemically catalyzed by [AQ/Mb](6) films with significant lowering of reduction overpotential.

Synthesis of conducting polyelectrolyte complexes of polyaniline and poly(2-acrylamido-3-methyl-1-propanesulfonic acid) catalyzed by pH-stable palm tree peroxidase.

https://www.ncbi.nlm.nih.gov/pubmed/15877353

Comparison of the stability of five plant peroxidases (horseradish, royal palm tree leaf, soybean, and cationic and anionic peanut peroxidases) was carried out under acidic conditions favorable for synthesis of polyelectrolyte complexes of polyaniline (PANI). It demonstrates that palm tree peroxidase has the highest stability. Using this peroxidase as a catalyst, the enzymatic synthesis of polyelectrolyte complexes of PANI and poly(2-acrylamido-3-methyl-1-propanesulfonic acid) (PAMPS) was developed. The template polymerization of aniline was carried out in aqueous buffer at pH 2.8. Varying the concentrations of aniline, PAMPS, and hydrogen peroxide as reagents, favorable conditions for production of PANI were determined. UV-vis-NIR absorption and EPR demonstrated that PAMPS and PANI formed the electroactive complex similar to PANI doped traditionally using low molecular weight sulfonic acids. The effect of pH on conformational variability of the complex was evaluated by UV-vis spectroscopy. Atomic force microscopy showed that a size of the particles of the PANI-PAMPS complexes varied between 10 and 25 nm, depending on a concentration of PAMPS in the complex. The dc conductivity of the complexes depends also on the content of PAMPS, the higher conductivity being for the complexes containing the lower content of the polymeric template.

Thin film construction and characterization and gas-sensing performances of a tailored phenylene-thienylene copolymer.

https://www.ncbi.nlm.nih.gov/pubmed/15369361

An alternating copolymer, poly(2,5-dioctyloxy-1,4-phenylene-alt-2,5-thienylene), has been

synthesized and used in this research. The behavior of the floating film at the air-water interface has been investigated by measuring surface pressure versus area Langmuir isotherms and contemporaneously by reflection spectroscopy and Brewster angle microscopy. The floating films were transferred by the Langmuir-SchÃ¤fer (horizontal lifting) method onto various substrates. It is apparent from these analyses that the effective conjugation length is larger than those in other electroactive polymers and that a strong coplanarity and interchain association takes place above all in the floating film on the water surface and in the transferred multilayers. Such films were used as the active layers in resistive chemical gas sensor devices, thus revealing excellent sensitivity toward NO(2), reversibility, and time stability of the response.

Construction of amperometric immunosensors based on the electrogeneration of a permeable biotinylated polypyrrole film.

https://www.ncbi.nlm.nih.gov/pubmed/15538808

The construction of amperometric immunosensors to cholera antitoxin immunoglobulins were shown to have improved sensitivity when the cholera toxin B subunit biorecognition entity was linked to an electrogenerated biotinylated polypyrrole film copolymerized with pyrrole-lactobionamide monomer. The copolymer exhibits greater film permeability than biotinylated polypyrrolic or polyphenolic films for the permeation of electroactive species. Hence, when the presence of the HRP marker of the immunoassay was determined using hydroquinone, the production of electroactive quinone was shown to permeate faster to the electrode, thus providing a faster response time.

New colorimetric and fluorometric chemosensor based on a cationic polythiophene derivative for iodide-specific detection.

https://www.ncbi.nlm.nih.gov/pubmed/12683798

Electrostatic interactions between anions and a new water-soluble, cationic, affinitychromic poly(3-alkoxy-4-methylthiophene) derivative provide a new tool for a selective optical detection method (colorimetric or fluorometric) for iodide ions.

Tailored Biodegradable and Electroactive Poly(Hydroxybutyrate-Co-Hydroxyvalerate) Based Morphologies for Tissue Engineering Applications.

https://www.ncbi.nlm.nih.gov/pubmed/30042300

Polymer-based piezoelectric biomaterials have already proven their relevance for tissue engineering applications. Furthermore, the morphology of the scaffolds plays also an important role in cell proliferation and differentiation. The present work reports on poly(hydroxybutyrate-co-hydroxyvalerate) (PHBV), a biocompatible, biodegradable, and piezoelectric biopolymer that has been processed in different morphologies, including films, fibers, microspheres, and 3D scaffolds. The corresponding magnetically active PHBV-based composites were also produced. The effect of the morphology on physico-chemical, thermal, magnetic, and mechanical properties of pristine and composite samples was evaluated, as well as their cytotoxicity. It was observed that the morphology does not strongly affect the properties of the pristine samples but the introduction of cobalt ferrites induces changes in the degree of crystallinity that could affect the applicability of prepared biomaterials. Young's modulus is dependent of the morphology and also increases with the addition of cobalt ferrites. Both pristine and PHBV/cobalt ferrite composite samples are not cytotoxic, indicating their suitability for tissue engineering applications.

Transport properties and electroanalytical response characteristics of drotaverine ion-selective sensors.

https://www.ncbi.nlm.nih.gov/pubmed/16007441

The construction and electroanalytical response characteristics of poly(vinyl chloride) matrix ion-selective sensors (ISSs) for drotaverine hydrochloride are described. The membranes incorporate ion-association complexes of drotaverine with tetraphenylborate, picrate, tetraiodomercurate, tetraiodobismuthate, Reinecke salt, and heteropolycompounds of Keggin structure-molybdophosphoric acid, tungstophosphoric acid, molybdosiliconic acid and tungstosiliconic acid as electroactive materials for ionometric sensor controls. These ISSs have a linear response to drotaverine hydrochloride over the range 8 x 10(-6) to 5 x 10(-2) mol L(-1) with cationic slopes from 51 to 58 mV per concentration decade. These ISSs have a fast response time (up to 1 min), a low determination limit (down to 4.3 x 10(-6) mol L(-1)), good stability (3-5 weeks), and reasonable selectivity. Permeabilities and ion fluxes through a membrane were calculated for major and interfering ions. Dependences of the transport properties of the membranes on the concentrations of the ion exchanger and near-membrane solution and their electrochemical characteristics are presented. The ISSs were used for direct potentiometry and potentiometric titration (sodium tetraphenylborate) of drotaverine hydrochloride. Results with mean accuracy of

99.1+/-1.0% of nominal were obtained which corresponded well to data obtained by use of high-performance liquid chromatography.

Electrochemical interrogation of conformational changes as a reagentless method for the sequence-specific detection of DNA.

https://www.ncbi.nlm.nih.gov/pubmed/12867594

We report a strategy for the reagentless transduction of DNA hybridization into a readily detectable electrochemical signal by means of a conformational change analogous to the optical molecular beacon approach. The strategy involves an electroactive, ferrocene-tagged DNA stem-loop structure that self-assembles onto a gold electrode by means of facile gold-thiol chemistry. Hybridization induces a large conformational change in this surface-confined DNA structure, which in turn significantly alters the electron-transfer tunneling distance between the electrode and the redoxable label. The resulting change in electron transfer efficiency is readily measured by cyclic voltammetry at target DNA concentrations as low as 10 pM. In contrast to existing optical approaches, an electrochemical DNA (E-DNA) sensor built on this strategy can detect femtomoles of target DNA without employing cumbersome and expensive optics, light sources, or photodetectors. In contrast to previously reported electrochemical approaches, the E-DNA sensor achieves this impressive sensitivity without the use of exogenous reagents and without sacrificing selectivity or reusability. The E-DNA sensor thus offers the promise of convenient, reusable detection of picomolar DNA.

Direct growth of metal-organic frameworks thin film arrays on glassy carbon electrode based on rapid conversion step mediated by copper clusters and hydroxide nanotubes for fabrication of a high performance non-enzymatic glucose sensing platform.

https://www.ncbi.nlm.nih.gov/pubmed/29702380

The direct growth of self-supported metal-organic frameworks (MOFs) thin film can be considered as an effective strategy for fabrication of the advanced modified electrodes in sensors and biosensor applications. However, most of the fabricated MOFs-based sensors suffer from some drawbacks such as time consuming for synthesis of MOF and electrode making, need of a binder or an additive layer, need of expensive equipment and use of hazardous solvents. Here, a novel free-standing MOFs-based modified electrode was fabricated by the rapid direct growth of MOFs on the surface of the glassy carbon electrode (GCE). In this method, direct growth of MOFs was occurred by the formation of vertically aligned arrays of Cu clusters and Cu(OH)2 nanotubes, which can act as both

mediator and positioning fixing factor for the rapid formation of self-supported MOFs on GCE surface. The effect of both chemically and electrochemically formed Cu(OH)2 nanotubes on the morphological and electrochemical performance of the prepared MOFs were investigated. Due to the unique properties of the prepared MOFs thin film electrode such as uniform and vertically aligned structure, excellent stability, high electroactive surface area, and good availability to analyte and electrolyte diffusion, it was directly used as the electrode material for non-enzymatic electrocatalytic oxidation of glucose. Moreover, the potential utility of this sensing platform for the analytical determination of glucose concentration was evaluated by the amperometry technique. The results proved that the self-supported MOFs thin film on GCE is a promising electrode material for fabricating and designing non-enzymatic glucose sensors.

PVC membrane ion-selective electrodes for the determination of Hyoscyamine in pure solution and in pharmaceutical preparations under batch and flow modes.

https://www.ncbi.nlm.nih.gov/pubmed/15935604

New PVC membrane electrodes selective for the determination of hyoscyamine ion (Hy(+)) based on hyoscyamine tetraphenylborate (Hy-TPB) or hyoscyamine phosphotungstate (Hy-PT) ion-exchangers as electroactive materials are described. The electrodes show a linear response for Hy(+) over the concentration range of 1.00 x 10(-5) to 1.26 x 10(-2) mol L(-1) and 1.00 x 10(-4) to 1.00 x 10(-2) mol L(-1) in case of Hy-TPB electrode applying batch and flow injection analysis (FIA), respectively, and 1.00 x 10(-5) to 4.52 x 10(-3) mol L(-1) and 6.31 x 10(-5) to 1.00 x 10(-2) mol L(-1) in case of Hy-PT electrode for batch and FIA, respectively. The lower detection limits are 3.90 x 10(-6) and 4.51 x 10(-6) at 25 degrees C for Hy-TPB and Hy-PT electrodes, respectively. The electrodes posses near Nernstian slopes of 56.5 and 57.8 mV/decade for Hy-TPB and Hy-PT electrodes, respectively, and a fast potential response of < or =20 s which is almost constant over a pH range of 3-10. Selectivity coefficient data for some common inorganic cations, sugars, amino acids and the components, other than hyoscyamine, of the mixed drugs investigated show negligible interference. The electrodes have been applied to the potentiometric determination of hyoscyamine in pure solution and in pharmaceutical preparations under batch and FIA conditions and as end point indicator electrode for the determination of hyoscyanine using potentiometric titration. For the concentrations (1.08 x 10(-5) mol L(-1) to 3.16 x 10(-3) mol L(-1)) an average recovery of 99.95% with relative standard deviation of 0.63% has been achieved. The effect of temperature on the electrodes was also studied.

Oligoaniline-based conductive biomaterials for tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/29625254

The science and engineering of biomaterials have improved the human life expectancy. Tissue engineering is one of the nascent strategies with an aim to fulfill this target. Tissue engineering scaffolds are one of the most significant aspects of the recent tissue repair strategies; hence, it is imperative to design biomimetic substrates with suitable features. Conductive substrates can ameliorate the cellular activity through enhancement of cellular signaling. Biocompatible polymers with conductivity can mimic the cells' niche in an appropriate manner. Bioconductive polymers based on aniline oligomers can potentially actualize this purpose because of their unique and tailoring properties. The aniline oligomers can be positioned within the molecular structure of other polymers, thus painter acting with the side groups of the main polymer or acting as a comonomer in their backbone. The conductivity of oligoaniline-based conductive biomaterials can be tailored to mimic the electrical and mechanical properties of targeted tissues/organs. These bioconductive substrates can be designed with high mechanical strength for hard tissues such as the bone and with high elasticity to be used for the cardiac tissue or can be synthesized in the form of injectable hydrogels, particles, and nanofibers for noninvasive implantation; these structures can be used for applications such as drug/gene delivery and extracellular biomimetic structures. It is expected that with progress in the fields of biomaterials and tissue engineering, more innovative constructs will be proposed in the near future. This review discusses the recent advancements in the use of oligoaniline-based conductive biomaterials for tissue engineering and regenerative medicine applications.

Electroactive Textile Actuators for Breathability Control and Thermal Regulation Devices.

https://www.ncbi.nlm.nih.gov/pubmed/31323744

Smart fabrics offer the potential for a new generation of soft robotics and wearable technologies through the fusion of smart materials, textiles and electrical circuitries. Conductive and stretchable textiles have inherent compliance and low resistance that are suitable for driving artificial muscle actuators and are potentially safer electrode materials for soft actuation technologies. We demonstrate how soft electroactive actuating structures can be designed and fabricated from conducting textiles. We first quantitatively analyse a range of stretchable conductive textiles for dielectric elastomer actuators (DEAs). We found that conductive-knit textiles are more suitable for unidirectional DEA applications due to the largest difference (150%) in principle strain axes,

whereas isotropic textiles are more suited to bidirectional DEA applications due to the smallest (11.1%) principle strain difference. Finally, we demonstrate controllable breathability through a planar e-textile DEA-driven skin and show thermal regulation in a wearable prototype that exploits soft actuation and kirigami.

Low-voltage polymer-based scanning cantilever for in vivo optical coherence tomography.

https://www.ncbi.nlm.nih.gov/pubmed/15648635

Novel hand-held optical coherence tomography (OCT) probes with polymer cantilevers have been developed for clinical oral and skin imaging. An electroactive ionic polymer-metal composite cantilever was used to generate 3-mm transverse scanning movement of an optical fiber with applied 2-V linear alternating voltage at 1 Hz. Low driving voltage ensures safety. Two different optical designs achieve both forward and sidewise scanning and make it possible to image everywhere within the human oral cavity. In vivo OCT imaging of the human tongue is demonstrated.

96X Screen-Printed Gold Electrode Platform to Evaluate Electroactive Polymers as Marine Antifouling Coatings.

https://www.ncbi.nlm.nih.gov/pubmed/29611700

Several alternatives are currently investigated to prevent and control the natural process of colonization of any seawater submerged surfaces by marine organisms. Since few years we develop an approach based on addressable electroactive coatings containing conducting polymers or polymers with lateral redox groups. In this article we describe the use of a screen-printed plate formed by 96 three-electrode electrochemical cells to assess the potential of these electroactive coatings to prevent the adhesion of marine bacteria. This novel platform is intended to control and record the redox properties of the electroactive coating in each well during the bioassay (15 h) and to allow screening its antiadhesion activity with enough replicates to support significant conclusions. Validation of this platform was carried out with poly(ethylenedioxythiophene) (PEDOT) as electroactive coating obtained by electropolymerization of EDOT monomer in artificial seawater electrolyte on the working electrode of each electrochemical cell of the 96-well microplate.

Development of Citrate-based Dual-Imaging Enabled Biodegradable Electroactive Polymers.

https://www.ncbi.nlm.nih.gov/pubmed/31588204

Increasing occurrences of degenerative diseases, defective tissues and severe cancers heighten the importance of advanced biomedical treatments, which in turn enhance the need for improved biomaterials with versatile theranostic functionalities yet using minimal design complexity. Leveraging the advantages of citrate chemistry, we developed a multifunctional citrate-based biomaterial platform with both imaging and therapeutic capabilities utilizing a facile and efficient one-pot synthesis. The resulting aniline tetramer doped biodegradable photoluminescent polymers (BPLPATs) not only possess programmable degradation profiles (<1 to >6 months) and mechanical strengths (~20 MPa to > 400 MPa), but also present a combination of intrinsic fluorescence, photoacoustic (PA) and electrical conductivity properties. BPLPAT nanoparticles are able to label cells for fluorescence imaging and perform deep tissue detection with PA imaging. Coupled with significant photothermal performance, BPLPAT nanoparticles demonstrate great potential for thermal treatment and in vivo real-time detection of cancers. Our results on BPLPAT scaffolds demonstrate three-dimensional (3D) high-spatial-resolution deep tissue PA imaging (23 mm), as well as promote growth and differentiation of PC-12 nerve cells. We envision that the biodegradable dual-imaging-enabled electroactive citrate-based biomaterial platform will expand the currently available theranostic material systems and open new avenues for diversified biomedical and biological applications via the demonstrated multi-functionality.

Processing of PVDF-based electroactive/ferroelectric films: importance of PMMA and cooling rate from the melt state on the crystallization of PVDF beta-crystals.

https://www.ncbi.nlm.nih.gov/pubmed/29785441

Poly(vinylidene difluoride) (PVDF) displays attractive ferroelectric/piezoelectric properties and its polar Î²-crystals are specifically targeted for achieving electroactive applications. However, their direct crystallization from the melt state represents a challenging task that has never been addressed using melt-state processes. The use of poly(methyl methacrylate) (PMMA) is herein investigated to promote the PVDF polar Î²-phase using melt-blending and extrusion-calendering technologies. The presence of the Î²-phase is here confirmed by ATR-FTIR and WAXS experiments with blends at a PMMA content as low as 5 wt%. The key role of PMMA for the Î²-phase crystallization from the melt state was unambiguously highlighted with the help of Flash DSC experiments in non-isothermal cooling mode from the melt state. PMMA is able to efficiently shift the Î±-to-Î² crystal transition to lower cooling rates (>100-200 Â°C s-1), making the achievement of the

PVDF polar Î²-phase for these blends compatible with conventional processing tools. A crystal phase diagram is proposed for the PVDF/PMMA blends to highlight the dual effects of both PMMA and cooling rate on the PVDF crystallization during melt-processing. Ferroelectric properties were even observed for the blends containing PMMA up to 10 wt% with the highest remanent polarization obtained at 5 wt% PMMA. After 10 wt% PMMA, a progressive transition from ferroelectric to pseudo-linear dielectric behavior is observed more likely due to the presence of PMMA in the interlamellar amorphous phase of the polar PVDF spherulites as shown by SAXS experiments. In this work, we successfully demonstrated that PMMA plays a key role in the crystallization of PVDF polar crystals from the melt state, enabling large-scale and continuous extrusion processing of PVDF-based materials with attractive dielectric properties for sensing and harvesting applications.

Azo group(s) in selected macrocyclic compounds.

https://www.ncbi.nlm.nih.gov/pubmed/29568230

Azobenzene derivatives due to their photo- and electroactive properties are an important group of compounds finding applications in diverse fields. Due to the possibility of controlling the trans-cis isomerization, azo-bearing structures are ideal building blocks for development of e.g. nanomaterials, smart polymers, molecular containers, photoswitches, and sensors. Important role play also macrocyclic compounds well known for their interesting binding properties. In this article selected macrocyclic compounds bearing azo group(s) are comprehensively described. Here, the relationship between compounds' structure and their properties (as e.g. ability to guest complexation, supramolecular structure formation, switching and motion) is reviewed.

Electrochemical Impedance Spectroscopy as a Tool for Electrochemical Rate Constant Estimation.

https://www.ncbi.nlm.nih.gov/pubmed/30371654

Electrochemical impedance spectroscopy (EIS) was used for advanced characterization of organic electroactive compounds along with cyclic voltammetry (CV). In the case of fast reversible electrochemical processes, current is predominantly affected by the rate of diffusion, which is the slowest and limiting stage. EIS is a powerful technique that allows separate analysis of stages of charge transfer that have different AC frequency response. The capability of the method was used to extract the value of charge transfer resistance, which characterizes the rate of charge exchange on the electrode-solution interface. The application of this technique is broad, from biochemistry up

to organic electronics. In this work, we are presenting the method of analysis of organic compounds for optoelectronic applications.

PEDOT:PSS-based Multilayer Bacterial-Composite Films for Bioelectronics.

https://www.ncbi.nlm.nih.gov/pubmed/30327574

Microbial electrochemical systems provide an environmentally-friendly means of energy conversion between chemical and electrical forms, with applications in wastewater treatment, bioelectronics, and biosensing. However, a major challenge to further development, miniaturization, and deployment of bioelectronics and biosensors is the limited thickness of biofilms, necessitating large anodes to achieve sufficient signal-to-noise ratios. Here we demonstrate a method for embedding an electroactive bacterium, Shewanella oneidensis MR-1, inside a conductive three-dimensional poly(3,4-ethylenedioxythiophene):poly(styrenesulfonate) (PEDOT:PSS) matrix electropolymerized on a carbon felt substrate, which we call a multilayer conductive bacterial-composite film (MCBF). By mixing the bacteria with the PEDOT:PSS precursor in a flow-through method, we maintain over 90% viability of S. oneidensis during encapsulation. Microscopic analysis of the MCBFs reveal a tightly interleaved structure of bacteria and conductive PEDOT:PSS up to 80â€‰Âµm thick. Electrochemical experiments indicate S. oneidensis in MCBFs can perform both direct and riboflavin-mediated electron transfer to PEDOT:PSS. When used in bioelectrochemical reactors, the MCBFs produce 20 times more steady-state current than native biofilms grown on unmodified carbon felt. This versatile approach to control the thickness of bacterial composite films and increase their current output has immediate applications in microbial electrochemical systems, including field-deployable environmental sensing and direct integration of microorganisms into miniaturized organic electronics.

Electroactive polymer-based devices for e-textiles in biomedicine.

https://www.ncbi.nlm.nih.gov/pubmed/16167684

This paper describes the early conception and latest developments of electroactive polymer (EAP)-based sensors, actuators, electronic components, and power sources, implemented as wearable devices for smart electronic textiles (e-textiles). Such textiles, functioning as multifunctional wearable human interfaces, are today considered relevant promoters of progress and useful tools in several biomedical fields, such as biomonitoring, rehabilitation, and telemedicine. After a brief outline on ongoing research and the first products on e-textiles under commercial

development, this paper presents the most highly performing EAP-based devices developed by our lab and other research groups for sensing, actuation, electronics, and energy generation/storage, with reference to their already demonstrated or potential applicability to electronic textiles.

Raman and IR Spectroelectrochemical Methods as Tools to Analyze Conjugated Organic Compounds.

https://www.ncbi.nlm.nih.gov/pubmed/30371655

In the presented work, two spectroelectrochemical techniques are discussed as tools for the analysis of the structural changes occurring in the molecule on the vibrational level of energy. Raman and IR spectroelectrochemistry can be used for advanced characterization of the structural changes in the organic electroactive compounds. Here, the step-by-step analysis by means of Raman and IR spectroelectrochemistry is shown. Raman and IR spectroelectrochemical techniques provide complementary information about structural changes occurring during an electrochemical process, i.e. allows for the investigation of redox processes and their products. The examples of IR and Raman spectroelectrochemical analysis are presented, in which the products of the redox reactions, both in solution and solid state, are identified.

Label-free photoelectrochemical immunosensing platform for detection of carcinoembryonic antigen through photoactive conducting poly(5-formylindole) nanocomposite.

https://www.ncbi.nlm.nih.gov/pubmed/29859398

Poly(5-formylindole)/electrochemically reduced graphene oxide (P5FIn/erGO) nanocomposite is firstly used to construct a label-free photoelectrochemical (PEC) immunosensor to detect carcinoembryonic antigen (CEA). As photoactive material and electroactive mediator, the prepared P5FIn/erGO nanocomposite exhibits high photocurrent intensity under visible-light irradiation due to the synergistic effect of P5FIn and erGO. The anti-CEA is connected to the P5FIn/erGO modified electrode surface, and gold nanoparticles (AuNP) is used as cross-linking in the process. The linear decrease of photocurrent is caused by the specific recognition of anti-CEA and CEA. This PEC immunosensor shows a wide linear response to CEA ranging from 0.0005 to 50â€¯ngâ€¯mL-1 with a low detection limit of 0.14â€¯pgâ€¯mL-1. The proposed immunosensor has good stability, reproducibility and high specificity. The satisfied results are also obtained when this immunosensor is used to detect CEA in actual human serum samples analysis, thus opening up a new promising PEC analysis platform based on conducting polymers.

Electroactive polymers for tissue regeneration: Developments and perspectives.

https://www.ncbi.nlm.nih.gov/pubmed/29983457

Human body motion can generate a biological electric field and a current, creating a voltage gradient of -10 to -90 mV across cell membranes. In turn, this gradient triggers cells to transmit signals that alter cell proliferation and differentiation. Several cell types, counting osteoblasts, neurons and cardiomyocytes, are relatively sensitive to electrical signal stimulation. Employment of electrical signals in modulating cell proliferation and differentiation inspires us to use the electroactive polymers to achieve electrical stimulation for repairing impaired tissues. Electroactive polymers have found numerous applications in biomedicine due to their capability in effectively delivering electrical signals to the seeded cells, such as biosensing, tissue regeneration, drug delivery, and biomedical implants. Here we will summarize the electrical characteristics of electroactive polymers, which enables them to electrically influence cellular function and behavior, including conducting polymers, piezoelectric polymers, and polyelectrolyte gels. We will also discuss the biological response to these electroactive polymers under electrical stimulation. In particular, we focus this review on their applications in regenerating different tissues, including bone, nerve, heart muscle, cartilage and skin. Additionally, we discuss the challenges in tissue regeneration applications of electroactive polymers. We conclude that electroactive polymers have a great potential as regenerative biomaterials, due to their ability to stimulate desirable outcomes in various electrically responsive cells.

Electrochemically Enhanced Drug Delivery Using Polypyrrole Films.

https://www.ncbi.nlm.nih.gov/pubmed/29966387

The delivery of drugs in a controllable fashion is a topic of intense research activity in both academia and industry because of its impact in healthcare. Implantable electronic interfaces for the body have great potential for positive economic, health, and societal impacts; however, the implantation of such interfaces results in inflammatory responses due to a mechanical mismatch between the inorganic substrate and soft tissue, and also results in the potential for microbial infection during complex surgical procedures. Here, we report the use of conducting polypyrrole (PPY)-based coatings loaded with clinically relevant drugs (either an anti-inflammatory, dexamethasone phosphate (DMP), or an antibiotic, meropenem (MER)). The films were characterized and were shown to enhance the delivery of the drugs upon the application of an electrochemical stimulus in vitro, by circa (ca.) 10â•»30% relative to the passive release from non-stimulated samples. Interestingly, the loading

and release of the drugs was correlated with the physical descriptors of the drugs. In the long term, such materials have the potential for application to the surfaces of medical devices to diminish adverse reactions to their implantation in vivo.

Carboxylic acid-functionalized conductive polypyrrole as a bioactive platform for cell adhesion.

https://www.ncbi.nlm.nih.gov/pubmed/16768385

Electroactive polymers such as polypyrrole (PPy) are highly attractive for a number of biomedical applications, including their use as coatings for electrodes or neural probes and as scaffolds to induce tissue regeneration. Surface modification of these materials with biological moieties is desired to enhance the biomaterial-tissue interface and to promote desired tissue responses. Here, we present the synthesis and physicochemical characterization of poly(1-(2-carboxyethyl)pyrrole) (PPyCOOH), a PPy derivative that contains a chemical group that can be easily modified with biological moieties at the N-position of the polymer backbone. FTIR, XPS, and fluorescence microscopy were used to demonstrate the successful incorporation of carboxylic acid (-COOH) functionality into PPy materials, and a four-point probe analysis was used to demonstrate electrical conductivity in the semiconductor range. Human umbilical vascular endothelial cells (HUVECs) cultured on PPyCOOH films surface-modified with the cell-adhesive Arg-Gly-Asp (RGD) motif demonstrated improved attachment and spreading. Thus, PPyCOOH could be useful in developing PPy composites that contain a variety of biological molecules as bioactive conducting platforms for specific biomedical purposes.

Electroactive poly(vinylidene fluoride)-based structures for advanced applications.

https://www.ncbi.nlm.nih.gov/pubmed/29543796

Poly(vinylidene fluoride) (PVDF) and its copolymers are the polymers with the highest dielectric constants and electroactive responses, including piezoelectric, pyroelectric and ferroelectric effects. This semicrystalline polymer can crystallize in five different forms, each related to a different chain conformation. Of these different phases, the Î² phase is the one with the highest dipolar moment and the highest piezoelectric response; therefore, it is the most interesting for a diverse range of applications. Thus, a variety of processing methods have been developed to induce the formation of the polymer Î² phase. In addition, PVDF has the advantage of being easily processable, flexible and low-cost. In this protocol, we present a number of reproducible and effective methods to produce

Î²-PVDF-based morphologies/structures in the form of dense films, porous films, 3D scaffolds, patterned structures, fibers and spheres. These structures can be fabricated by different processing techniques, including doctor blade, spin coating, printing technologies, non-solvent-induced phase separation (NIPS), temperature-induced phase separation (TIPS), solvent-casting particulate leaching, solvent-casting using a 3D nylon template, freeze extraction with a 3D poly(vinyl alcohol) (PVA) template, replica molding, and electrospinning or electrospray, with the fabrication method depending on the desired characteristics of the structure. The developed electroactive structures have shown potential to be used in a wide range of applications, including the formation of sensors and actuators, in biomedicine, for energy generation and storage, and as filtration membranes.

Positively-charged hierarchical PEDOT interface with enhanced electrode kinetics for NADH-based biosensors.

https://www.ncbi.nlm.nih.gov/pubmed/30173009

Poly(ethylenedioxythiophene) (PEDOT) has attracted considerable attention as an advanced electrode material for electrochemical sensors and biosensors, due to its unique electrical and physicochemical properties. Here, we demonstrate the facile preparation of a positively-charged and hierarchical micro-structured PEDOT electrochemical interface with enhanced electrode kinetics for the electrooxidation of NADH. Processable PEDOT colloidal microparticles (PEDOT CMs) were synthesised by template-assisted polymerisation and were then utilised as building blocks for the fabrication of hierarchically-structured electrodes with a larger accessible electroactive surface (2.8 times larger than that of the benchmark PEDOT:PSS) and inter-particle space, thus improving electrode kinetics. The intrinsic positive charge of the PEDOT CMs further facilitated the detection of negatively-charged molecules by electrostatic accumulation. Due to the synergistic effect, these hierarchically-structured PEDOT CMs electrodes exhibited improved NADH electrooxidation at lower potentials and enhanced electrocatalytic activity compared to the compact structure of conventional PEDOT:PSS electrodes. The PEDOT CMs electrodes detected NADH over the range of 20-240â€¯Î¼M, with a sensitivity of 0.0156â€¯Î¼A/Î¼M and a limit of detection of 5.3â€¯Î¼M. Moreover, the PEDOT CMs electrode exhibited a larger peak separation from the interferent ascorbic acid, and improved stability. This enhanced analytical performance for NADH provides a sound basis for further work coupling to a range of NAD-dependent dehydrogenases for applications in biosensing, bio-fuel cells and biocatalysis.

Improving in Situ Electrode Calibration with Principal Component Regression for Fast-Scan Cyclic Voltammetry.

https://www.ncbi.nlm.nih.gov/pubmed/30335966

Fast-scan cyclic voltammetry with a carbon-fiber microelectrode is an increasingly popular technique for in vivo measurements of electroactive neurotransmitters, most notably dopamine. Calibration of these electrodes is essential for many uses, but it is complicated by the many factors that affect an electrode's sensitivity when it is implanted in neural tissue. Experienced practitioners of fast-scan cyclic voltammetry are well aware that an electrode's sensitivity to dopamine depends on both the size and shape of the electrode's background waveform. In vitro electrode calibration is still the standard method, although a strategy for in situ calibration based on the size of the electrode's background waveform has previously been published. We reasoned that the accuracy and transferability of in situ calibration could be improved by using principalÂ component regression to capture information contained in the shape of the background waveform. We use leave-one-out cross-validation to estimate the ability of this strategy to predict unknown electrodes and to compare its performance with that of the total-background-current strategy. The principal-component-regression strategy has significantly greater predictive performance than the total-background-current strategy, and the resulting calibration models can be transferred across independent laboratories. Importantly, multivariate quality-control statistics establish the applicability of the strategy to in vivo data. Adoption of the principal-component-regression strategy forÂ in situ calibration will improve the interpretation of in vivo fast-scan cyclic voltammetry data.

Conductive Shape Memory Microfiber Membranes with Core-Shell Structures and Electroactive Performance.

https://www.ncbi.nlm.nih.gov/pubmed/30248257

Conductive shape memory polymers as a class of functional materials play a significant role in sensors and actuators. A high conductivity and a high response speed are needed in practical applications. In this work, a conductive shape memory polylactic acid (PLA) microfiber membrane was synthesized by combining electrospinning with chemical vapor polymerization. The shape memory PLA was electrospun into microfibers with different diameters, and a conductive polypyrrole (PPy) coating was applied to the PLA microfiber membranes using vapor polymerization. The conductivity of the microfiber membrane was investigated as a function of different experimental parameters: $FeCl_3$ concentration, PPy evaporation time, and PPy temperature. The maximum

conductivity of the membrane prepared in a sub-zero environment is 0.5 S/cm, which can sustain a heat-generating electric current sufficient to trigger the electro-actuated behaviors of the membrane within 2 s at 30 V. Thermographic imaging was used to assess the uniformity of the temperature distribution during the shape recovery process. The low surface temperature is compatible with potential applications in many fields.

Molecular Approach to Conjugated Polymers with Biomimetic Properties.

https://www.ncbi.nlm.nih.gov/pubmed/29897228

The field of bioelectronics involves the fascinating interplay between biology and human-made electronics. Applications such as tissue engineering, biosensing, drug delivery, and wearable electronics require biomimetic materials that can translate the physiological and chemical processes of biological systems, such as organs, tissues. and cells, into electrical signals and vice versa. However, the difference in the physical nature of soft biological elements and rigid electronic materials calls for new conductive or electroactive materials with added biomimetic properties that can bridge the gap. Soft electronics that utilize organic materials, such as conjugated polymers, can bring many important features to bioelectronics. Among the many advantages of conjugated polymers, the ability to modulate the biocompatibility, solubility, functionality, and mechanical properties through side chain engineering can alleviate the issues of mechanical mismatch and provide better interface between the electronics and biological elements. Additionally, conjugated polymers, being both ionically and electrically conductive through reversible doping processes provide means for direct sensing and stimulation of biological processes in cells, tissues, and organs. In this Account, we focus on our recent progress in molecular engineering of conjugated polymers with tunable biomimetic properties, such as biocompatibility, responsiveness, stretchability, self-healing, and adhesion. Our approach is general and versatile, which is based on functionalization of conjugated polymers with long side chains, commonly polymeric or biomolecules. Applications for such materials are wide-ranging, where we have demonstrated conductive, stimuli-responsive antifouling, and cell adhesive biointerfaces that can respond to external stimuli such as temperature, salt concentration, and redox reactions, the processes that in turn modify and reversibly switch the surface properties. Furthermore, utilizing the advantageous chemical, physical, mechanical and functional properties of the grafts, we progressed into grafting of the long side chains onto conjugated polymers in solution, with the vision of synthesizing solution-processable conjugated graft copolymers with biomimetic functionalities. Examples of the

developed materials to date include rubbery and adhesive photoluminescent plastics, biomolecule-functionalized electrospun biosensors, thermally and dually responsive photoluminescent conjugated polymers, and tunable self-healing, adhesive, and stretchable strain sensors, advanced functional biocidal polymers, and filtration membranes. As outlined in these examples, the applications of these biomimetic, conjugated polymers are still in the development stage toward truly printable, organic bioelectronic devices. However, in this Account, we advocate that molecular engineering of conjugated polymers is an attractive approach to a versatile class of organic electronics with both ionic and electrical conductivity as well as mechanical properties required for next-generation bioelectronics.

Biosafety assessment of conducting nanostructured materials by using co-cultures of neurons and astrocytes.

https://www.ncbi.nlm.nih.gov/pubmed/30031109

Neural electrode implants are made mostly of noble materials. We have synthesized a nanostructured material combining the good electrochemical properties of iridium oxide (IrOx) and carbon-nanotubes (CNT) and the properties of poly(3,4-ethylenedioxythiophene) (PEDOT). IrOx-CNT-PEDOT charge storage capacity was lower than that of IrOx and IrOx-CNT, but higher than that of other PEDOT-containing hybrids and Pt. Cyclic voltammetry, SEM, XPS and micro-Raman spectroscopy suggest that PEDOT encapsulates IrOx and CNT. In our search for a cell culture platform that could optimize modelling the in vivo environment, we determined cell viability, neuron and astrocyte functionality and the response of astrocytes to an inflammatory insult by using primary cultures of neurons, of astrocytes and co-cultures of both. The materials tested (based on IrOx, CNT and PEDOT, as well as Pt as a reference) allowed adhesion and proliferation of astrocytes and full compatibility for neurons grown in co-cultures. Functionality assays show that uptake of glutamate in neuron-astrocyte co-culture was significantly higher than the sum of the uptake in astrocytes and neurons. In co-cultures on IrOx, IrOx-CNT and IrOx-CNT-PEDOT, glutamate was released by a depolarizing stimulus and induced a significant increase in intracellular calcium, supporting the expression of functional NMDA/glutamate receptors. LPS-induced inflammatory response in astrocytes showed a decreased response in NOS2 and COX2 mRNA expression for IrOx-CNT-PEDOT. Results indicate that neuron-astrocyte co-cultures are a reliable model for assessing the biocompatibility and safety of nanostructured materials, evidencing also that hybrid IrOx-CNT-PEDOT nanocomposite materials may offer larger resistance to inflammatory

insults.

Conjugated Polymers in Bioelectronics.

https://www.ncbi.nlm.nih.gov/pubmed/29874033

The emerging field of organic bioelectronics bridges the electronic world of organic-semiconductor-based devices with the soft, predominantly ionic world of biology. This crosstalk can occur in both directions. For example, a biochemical reaction may change the doping state of an organic material, generating an electronic readout. Conversely, an electronic signal from a device may stimulate a biological event. Cutting-edge research in this field results in the development of a broad variety of meaningful applications, from biosensors and drug delivery systems to health monitoring devices and brain-machine interfaces. Conjugated polymers share similarities in chemical "nature" with biological molecules and can be engineered on various forms, including hydrogels that have Young's moduli similar to those of soft tissues and are ionically conducting. The structure of organic materials can be tuned through synthetic chemistry, and their biological properties can be controlled using a variety of functionalization strategies. Finally, organic electronic materials can be integrated with a variety of mechanical supports, giving rise to devices with form factors that enable integration with biological systems. While these developments are innovative and promising, it is important to note that the field is still in its infancy, with many unknowns and immense scope for exploration and highly collaborative research. The first part of this Account details the unique properties that render conjugated polymers excellent biointerfacing materials. We then offer an overview of the most common conjugated polymers that have been used as active layers in various organic bioelectronics devices, highlighting the importance of developing new materials. These materials are the most popular ethylenedioxythiophene derivatives as well as conjugated polyelectrolytes and ion-free organic semiconductors functionalized for the biological interface. We then discuss several applications and operation principles of state-of-the-art bioelectronics devices. These devices include electrodes applied to sense/trigger electrophysiological activity of cells as well as electrolyte-gated field-effect and electrochemical transistors used for sensing of biochemical markers. Another prime application example of conjugated polymers is cell actuators. External modulation of the redox state of the underlying conjugated polymer films controls the adhesion behavior and viability of cells. These smart surfaces can be also designed in the form of three-dimensional architectures because of the processability of conjugated polymers. As such, cell-loaded scaffolds based on electroactive polymers enable

integrated sensing or stimulation within the engineered tissue itself. A last application example is organic neuromorphic devices, an alternative computing architecture that takes inspiration from biology and, in particular, from the way the brain works. Leveraging ion redistribution inside a conjugated polymer upon application of an electrical field and its coupling with electronic charges, conjugated polymers can be engineered to act as artificial neurons or synapses with complex, history-dependent behavior. We conclude this Account by highlighting main factors that need to be considered for the design of a conjugated polymer for applications in bioelectronics-although there can be various figures of merit given the broad range of applications, as emphasized in this Account.

Using the Surface Features of Plant Matter to Create All-Polymer Pseudocapacitors with High Areal Capacitance.

https://www.ncbi.nlm.nih.gov/pubmed/30335944

Controlling mesoscale organization in thick films of electroactive polymers is crucial for studying and optimizing charge and ion transport in these disordered materials. Conventional approaches focus on directing long-range polymer aggregation and/or crystallization during film formation by using interfaces, flow and/or shear forces. Here, we describe an alternative method that takes advantage of naturally textured biological substrates and vapor-coating to structure thick-conjugated polymer films. Reactive vapor-coating is a technique that enables in situ synthesis of doped conjugated polymers inside a reduced-pressure reactor. Reactive vapor deposition conformally coats the surface of plant matter, such as leaves and flower petals, with conducting polymer films while leaving these living substrates undamaged. Importantly, the intricate surface features of plant matter are faultlessly reproduced in the coating, effectively creating thick, high-surface-area, electrochemically active conducting polymer electrodes on plant matter. A microstructured, 10 Î¼m thick film of p-doped poly(3,4-ethylenedioxythiophene) on a pilea involucrata leaf acts as an all-polymer pseudocapacitor with a higher areal capacitance (142 mF/cm2) than an analogous film on a planar plastic substrate lacking microstructure (50 mF/cm2). Taken together, reactive vapor deposition and microstructured plant matter present a unique combination of processing technique and substrate than can yield a diverse library of controllably microstructured electronic polymer films.

Intrinsically Conductive Polymer Nanocomposites for Cellular Applications.

https://www.ncbi.nlm.nih.gov/pubmed/30357622

Intrinsically conductive polymer nanocomposites have a remarkable potential for cellular applications such as biosensors, drug delivery systems, cell culture systems and tissue engineering biomaterials. Intrinsically conductive polymers transmit electrical stimuli between cells, and induce regeneration of electroactive tissues such as muscle, nerve, bone and heart. However, biocompatibility and processability are common issues for intrinsically conductive polymers. Conductive polymer composites are gaining importance for tissue engineering applications due to their excellent mechanical, electrical, optical and chemical functionalities. Here, we summarize the different types of intrinsically conductive polymers containing electroactive nanocomposite systems. Cellular applications of conductive polymer nanocomposites are also discussed focusing mainly on poly(aniline), poly(pyrrole), poly(3,4-ethylene dioxythiophene) and poly(thiophene).

Electroactive graphene composite scaffolds for cardiac tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/30325093

Contractile behavior of cardiomyocytes relies on directed signal propagation through the electroconductive networks that exist within the native myocardium. Due to their unique electrical properties, electroactive materials, such as graphene, have recently emerged as promising candidate materials for cardiac tissue engineering applications. In this work, the potential of three-dimensional (3D) nanofibrous graphene and poly(caprolactone) (PCL + G) composite scaffold for cardiac tissue engineering has been explored for the first time. The addition of graphene into PCL led to an increased volume conductivity of scaffolds with an even distribution of graphene particles throughout the matrix. Graphene particles provided local conductive sites within the PCL matrix, which enabled application of external electrical stimulation throughout the scaffold using a custom point stimulation device. When mouse embryonic stem cell derived cardiomyocytes (mES-CM) were seeded on PCL + G scaffolds, cells adhered well, contracted spontaneously, and exhibited classical cardiomyocyte phenotype confirming the biocompatibility of electroactive PCL + G scaffolds. Further functional characterization demonstrated that graphene especially affected Ca2+ handling properties of mES-CM compared to that of cardiomyocytes cultured in 2D culture, highlighting the potential of PCL + G for in vitro cardiac tissue engineering. Â© 2018 Wiley Periodicals, Inc. J. Biomed. Mater. Res. Part A: 106A: 2923-2933, 2018.

Electrochemically mediated polymerization for highly sensitive detection of protein kinase

activity.

https://www.ncbi.nlm.nih.gov/pubmed/29597099

Protein kinases play a pivotal role in cellular regulation and signal transduction, the detection of protein kinase activity and inhibition is therefore of great importance to clinical diagnosis and drug discovery. In this work, a novel electrochemical platform using the electrochemically mediated polymerization as an efficient and cost-effective signal amplification strategy is described for the highly sensitive detection of protein kinase activity. This platform involves 1) the phosphorylation of substrate peptide by protein kinase, 2) the attachment of alkyl halide to the phosphorylated sites via the carboxylate-Zr4+-phosphate chemistry, and 3) the in situ grafting of electroactive polymers from the phosphorylated sites through the electrochemically mediated atom transfer radical polymerization (eATRP) at a negative potential, in the presence of the surface-attached alkyl halide as the initiator and the electroactive tag-conjugated acrylate as the monomer, respectively. Due to the electrochemically mediated polymerization, a large number of electroactive tags can be linked to each phosphorylated site, thereby greatly improving the detection sensitivity. This platform has been successfully applied to detect the activity of cAMP-dependent protein kinase (PKA) with a detection limit down to 1.63 mU mL-1. Results also demonstrate that it is highly selective and can be used for the screening of protein kinase inhibitors. The potential application of our platform for protein kinase activity detection in complex biological samples has been further verified using normal human serum and HepG2 cell lysate. Moreover, our platform is operationally simple, highly efficient and cost-effective, thus holding great potential in protein kinase detection and inhibitor screening.

Occlusion phenomenon of redox probe by protein as a way of voltammetric detection of non-electroactive C-reactive protein.

https://www.ncbi.nlm.nih.gov/pubmed/29908448

Simple, selective and sensitive analytical devices are of a great importance for medical application. Herein, we developed highly selective immunosensor for electrochemical detection of C-reactive protein (CRP) in blood sample. Branched polyethylenimine functionalized with ferrocene residues (PEI-Fc) was the main element of the recognition layer, which allowed: (i) covalent binding of an antibody in its most favorable orientation and (ii) voltammetric detection of the C-reactive protein. Anchoring of PEI-Fc to the electrode surface through the electrodeposition process leads to the formation of thin, stable and reproducible layers, which is extremely important in the case of electrochemical immunosensing. The proposed analytical device is characterized by high selectivity

and sensitivity and can be successfully used in the concentration range of CRP from 1 to 5Â·104 ngâ€¯mL-1. The determined limit of detection was circa 0.5 and 2.5â€¯ngâ€¯mL-1 for voltammetric and impedance analysis, respectively. The developed analytical device has also been successfully applied for the analysis of CRP level in rat blood samples.

Enhanced methanogenic co-degradation of propionate and butyrate by anaerobic microbiome enriched on conductive carbon fibers.

https://www.ncbi.nlm.nih.gov/pubmed/29982046

Recent studies have shown that the addition of conductive materials can promote direct interspecies electron transfer (DIET) between bacteria and methanoarchaea. This study demonstrated that carbon fibers could significantly stimulate methanogenic conversion of propionate and butyrate as co-substrate, while only butyrate was completely degraded in the unamended control bioreactor. In the carbon fibers-amended bioreactor, specific methane production (mL-CH4/gâ€¯CODInitial) and methanogenesis rate (d-1) increased by around 2.4 and 6.7 times, respectively. Various electroactive bacteria were abundant in the carbon fibers-amended bioreactor, whereas different known fermentative bacteria were abundant in the control. Moreover, carbon fibers substantially increased the abundance of Methanosaeta species. These results suggest that electroactive bacteria could be involved in DIET with Methanosaeta species enabling co-degradation of propionate and butyrate. Additionally, electrical conductivities of the biomass were comparable in both configurations, indicating that carbon fibers were the primary route for DIET.

A flexible polyaniline-based bioelectronic patch.

https://www.ncbi.nlm.nih.gov/pubmed/29363686

Bioelectronic materials based on conjugated polymers are being developed in the hope to interface with electroresponsive tissues. We have recently demonstrated that a polyaniline chitosan patch can efficiently electro-couple with cardiac tissue modulating its electrophysiology. As a promising bioelectronic material that can be tailored to different types of devices, we investigate here the impact of varying the synthesis conditions and time of the in situ polymerization of aniline (An) on the sheet resistance of the bioelectronic patch. The sheet resistance increases significantly for samples that have either the lowest molar ratio of oxidant to monomer or the highest molar ratio of dopant to monomer, while the polymerization time does not have a significant effect on the electrical properties. Conductive atomic force microscopy reveals that the patch with the lowest sheet

resistance has a connected network of the conductive phase. In contrast, patches with higher sheet resistances exhibit conductive areas of lower current signals or isolated conductive islands of high current signals. Having identified the formulation that results in patches with optimal electrical properties, we used it to fabricate patches that were implanted in rats for two weeks. It is shown that the patch retains an electroactive nature, and only mild inflammation is observed with fibrous tissue encapsulating the patch.

Low-voltage-driven soft actuators.

https://www.ncbi.nlm.nih.gov/pubmed/29623967

Soft actuators based on electroactive polymers (EAPs) are the core constituents of future soft robots owing to their fascinating properties such as lightweight, compactness, easy fabrication into various forms, and low cost. Ionic EAP actuators are particularly attractive owing to the low driving voltages (<3 V) as compared to those of electronic EAP actuators (usually kilovolts). This paper presents a brief overview of the recent progress in a range of EAP actuators by focusing on low voltage operation, in addition to the challenges and future strategies for their wide applicability in artificial muscles and various innovative soft robot technologies.

Properties and Applications of the Î² Phase Poly(vinylidene fluoride).

https://www.ncbi.nlm.nih.gov/pubmed/30966263

Poly(vinylidene fluoride), PVDF, as one of important polymeric materials with extensively scientific interests and technological applications, shows five crystalline polymorphs with Î±, Î², Î³, Î´ and Îµ phases obtained by different processing methods. Among them, Î² phase PVDF presents outstanding electrical characteristics including piezo-, pyro-and ferroelectric properties. These electroactive properties are increasingly important in applications such as energy storage, spin valve devices, biomedicine, sensors and smart scaffolds. This article discusses the basic knowledge and character methods for PVDF fabrication and provides an overview of recent advances on the phase modification and recent applications of the Î² phase PVDF are reported. This study may provide an insight for the development and utilization for Î² phase PVDF nanofilms in future electronics.

Fluorinated Polymers as Smart Materials for Advanced Biomedical Applications.

https://www.ncbi.nlm.nih.gov/pubmed/30966197

Fluorinated polymers constitute a unique class of materials that exhibit a combination of suitable properties for a wide range of applications, which mainly arise from their outstanding chemical resistance, thermal stability, low friction coefficients and electrical properties. Furthermore, those presenting stimuli-responsive properties have found widespread industrial and commercial applications, based on their ability to change in a controlled fashion one or more of their physicochemical properties, in response to single or multiple external stimuli such as light, temperature, electrical and magnetic fields, pH and/or biological signals. In particular, some fluorinated polymers have been intensively investigated and applied due to their piezoelectric, pyroelectric and ferroelectric properties in biomedical applications including controlled drug delivery systems, tissue engineering, microfluidic and artificial muscle actuators, among others. This review summarizes the main characteristics, microstructures and biomedical applications of electroactive fluorinated polymers.

New Spin on Organic Radical Batteries-An Isoindoline Nitroxide-Based High-Voltage Cathode Material.

https://www.ncbi.nlm.nih.gov/pubmed/29411960

Organic electrode materials are a highly promising and environmentally benign class of battery materials with radical polymers being at the forefront of this research. Herein, we report the first example of the 1,1,3,3-tetramethylisoindolin-2-yloxyl class of nitroxides as an organic electrode material and the synthesis and application of a novel styrenic nitroxide polymer, poly(5-vinyl-1,1,3,3-tetramethylisoindolin-2-yloxyl) (PVTMIO). The polymer was synthesized from the precursor monomer, 2-methoxy-5-vinyl-1,1,3,3-tetramethylisoindoline, and subsequent oxidative deprotection yielded the electroactive radical species. Cyclic voltammetry revealed a high oxidation potential of 3.7 V versus Li, placing it among the top of the nitroxide class of electrode materials. The suitability of PVTMIO for utilization in a high-voltage organic radical battery was confirmed with a discharge capacity of 104.7 mAh g-1, high rate performance, and stability under cycling conditions (90% capacity retention after 100 cycles), making it one of the highest reported organic p-dopable cathode materials.

Protein micropatterning based on electrochemically switched immobilization of bioligand on electropolymerized film of a dually electroactive monomer.

https://www.ncbi.nlm.nih.gov/pubmed/17109049

We demonstrate a protein micropatterning method based on electropolymerization of a monomer with two electroactive units, hydroquinone monoester and disulfide, which enables electrochemical ON-OFF switching for immobilization of bioligands on electrodes modified with the electropolymerized film.

Photorefractive polymers sensitized by two-photon absorption.

https://www.ncbi.nlm.nih.gov/pubmed/18007702

We demonstrate the recording of holograms and their nondestructive readout in a photorefractive polymer, using two-photon absorption. Sensitivity is provided by the excitation of the electroactive chromophore with femtosecond pulses, followed by charge injection into the photoconducting poly(N-vinylcarbazole) matrix. The holograms can be fully erased with a pulsed laser source but are insensitive to cw laser beams with the same wavelength. Studies of the field and intensity dependence of the diffraction efficiency indicate that the holograms are formed through the photorefractive effect.

Potentiometric batch and flow injection analysis of betaine hydrochloride.

https://www.ncbi.nlm.nih.gov/pubmed/17822229

Novel PVC membrane electrodes for the determination of betaine ion based on the formation of betaine-tetraphenylborate (Be-TPB) and betaine-phosphotungstate (Be-PT) ion-exchangers as electroactive materials are described. The sensors show a fast, stable, near Nernstian response for 6.92 x 10(-6) to 7.94 x 10(-3) M and 1.0 x 10(-4) to 1.0 x 10(-2) M betaine hydrochloride (Be.Cl) in case of Be-TPB electrode applying batch and flow injection analysis (FIA), respectively, and 2.95 x 10(-5) to 2.26 x 10(-3) M and 3.16 x 10(-5) to 1.0 x 10(-2) M in case of Be-PT electrode for batch and FIA electrodes, respectively, at 25 degrees C over the pH range of 3.5-10 with a cationic slope of 60.2 and 59.1 mV decade(-1) and a fast potential response of < or =15 s. The lower detection limits are 7.94 x 10(-6) and 3.18 x 10(-5) M Be.Cl for Be-TPB and Be-PT electrodes, respectively. Selectivity coefficient data for some common inorganic cations, sugars, amino acids and the components other than betaine, of the mixed drug investigated show negligible interference. The electrodes have been applied to the direct potentiometric determination of betaine hydrochloride in water and in a pharmaceutical preparation under batch and FIA conditions. Potentiometric titrations of Be.Cl with NaTPB and PTA as titrants were monitored with the developed betaine electrodes as an end point indicator electrode. The determination of Be.Cl shows an average recovery of 100.8%

with mean relative standard deviation of 0.61%. The effect of temperature on the electrodes was also studied.

Alternated quinoid/aromatic units in terthiophenes building blocks for electroactive narrow band gap polymers. Extended spectroscopic, solid state, electrochemical, and theoretical study.

https://www.ncbi.nlm.nih.gov/pubmed/16853114

We report here the synthesis of three novel pi-conjugated heterocyclic mixed trimers that contain two electron-donating 3,4-ethylenedioxy-2-thienyl (EDOT) units covalently attached to a central proquinoid electron-accepting thienopyrazine moiety (two of these narrow-HOMO-LUMO gap D-A-D compounds also bear hexyl side chains attached either to the outermost alpha positions of the EDOT end rings or to the beta positions of the pyrazine fused ring). The modification of the terthiophene structure upon EDO, pyrazine, and hexyl substitutions has been treated in detail with spectroscopic and theoretical arguments. Solid-state properties reveal the occurrence of short intramolecular contacts between heteroatoms of adjacent rings. The analysis of the structure of the pi-conjugated backbone of each molecule is consistent with a partial quinoid-like pattern which partially reverts to be subtly more aromatic depending on the topology of the positive inductive effect of the hexyl chains. This quinoidization is a consequence of the appearance of a D(EDOT)-->A(PyT)<--D(EDOT) intramolecular charge transfer which further polarizes the structure. The same chemical concepts have been applied to address their electrochemical behavior. The three mixed trimers exhibit amphoteric properties due to the combination of electron acceptor and donor groups. Given their relative low HOMO-LUMO energy gap, these trimers promise to be good candidates for obtaining polymers with significant low energy gap combining electroactivity.

A new composite consisting of electrosynthesized conducting polymers, graphene sheets and biosynthesized gold nanoparticles for biosensing acute lymphoblastic leukemia.

https://www.ncbi.nlm.nih.gov/pubmed/29367018

In this work we report the synthesis of a stable composite with excellent electrical properties, on the surface of a biosensor. Conductive polymers offer both high electrical conductivity and mechanical strength. Many reports have focused on synthesizing conductive polymers with the aid of high-cost enzymes. In the current work we introduce a novel electrochemical, one-step, facile and cost effective procedure for synthesizing poly (catechol), without using expensive enzymes. The poly

(catechol) conductivity was enhanced by modification with graphene sheets and biosynthesized gold nanoparticles. Four different robust methods, DPV, EIS, CV and chronoamperometry, were used to monitor the biosensor modifications. The peak currents of the catechol (an electroactive probe) were linearly related to the logarithm of the concentrations of target DNA in the range 100.0â€¯Î¼M to 10.0â€¯pM, with a detection limit of 1.0â€¯pM for the DNA strand. The current work investigates a new, stable composite consisting of conductive polymers and nanoparticles, which was applied to the detection of acute lymphoblastic leukemia.

Electrochemical detection of short sequences related to the hepatitis B virus using MB on chitosan-modified CPE.

https://www.ncbi.nlm.nih.gov/pubmed/17084111

A novel electrochemical DNA biosensor based on methylene blue (MB) and chitosan-modified carbon paste electrode (CCPE) for short DNA sequences and polymerase chain reaction (PCR) amplified real samples related to the hepatitis B virus (HBV) hybridization detection is presented. Differential pulse voltammetry (DPV) was used to investigate the surface coverage and hybridization event. The decrease in the peak current of MB, an electroactive label, was observed upon hybridization of probe with the target. Numerous factors affecting the target hybridization and indicator binding reaction are optimized to maximize the sensitivity.

Highly sensitive and selective method to detect dopamine in the presence of ascorbic acid by a new polymeric composite film.

https://www.ncbi.nlm.nih.gov/pubmed/17720131

A new approach was applied to modify gold electrode with a unique polymer composite for selectively detecting dopamine (DA), a neurotransmitter, in the presence of an electroactive species of ascorbic acid (AA). After self-assembly of 11-mercaptoundecanoic acid (MUA) monolayer on gold surface, polyethylene glycol (PEG) was used to perform electrochemical esterification with MUA. In general, AA is the main interference of DA detection in a biological system. The resulting composite layer showed high sensitivity to detect DA but selectively blocked the interference from AA. Furthermore, for the first time, an interesting mechanism was demonstrated from our experimental results, namely, that the catalytic effect of AA on DA is limited by DA concentration when AA/DA>1. The modified electrode showed good reproducibility (+/-2% relative standard deviation), a low detection limit (10 nM), a fast response time (<2s), high sensitivity (86 nA/microM), a wide dynamic

range of detection (20 microM), and great selectivity (without AA interference). The discovery is very promising for applications of detection of DA in a physiological environment where a high concentration of AA always exists.

pH-sensing properties of poly(aniline) ultrathin films self-assembled on indium-tin oxide.

https://www.ncbi.nlm.nih.gov/pubmed/17297939

The structural and functional properties of ultrathin (<5 nm) poly(aniline) (PANI) films deposited on indium-tin oxide (ITO) have been investigated using electrochemical and attenuated total reflection (ATR) spectroscopy methods. Layer-by-layer (LbL) self-assembly was used to form films composed of one and two bilayers of PANI and poly(acrylic acid) (PAA), as well as single PANI layers of approximately monolayer thickness. PANI deposited on an ITO electrode is electroactive at neutral pH, both with and without codeposition of an acid dopant such as PAA. In the absence of PAA, it is hypothesized that the acidic surface groups on ITO can function as the counterion. The pH response of PANI single layer, (PANI/PAA)(1), and (PANI/PAA)(2) films was examined using both potentiometry and ATR spectroscopy. Near-Nernstian potentiometric responses over pH 3-9 were observed for all three types of films, consistent with the weak acid-base behavior expected of polymers assembled in a LbL film. The ATR spectral sensitivity to pH increases as the number of layers in the film increases, with the highest sensitivity achieved by monitoring the absorbance at 800 nm (predominately due to the emeraldine salt form) of (PANI/PAA)(2) films. Codeposition of PANI and PAA appears to produce a wide distribution of strengths of acidic and basic sites in the film and thus a large linear dynamic range, up to six pH units. The water contact angle of (PANI/PAA)(2) is approximately 16 degrees, which is considerably more hydrophilic than either the PANI single layer or (PANI/PAA)(1) films (approximately 40 degrees). This film is shown to be a suitable substrate for deposition of a planar supported phospholipid bilayer. The supported membrane is highly impermeable to protons, which makes this architecture useful for monitoring transmembrane charge transport.

Measurement of apparent diffusion coefficients within ultrathin nafion Langmuir-Schaefer films: comparison of a novel scanning electrochemical microscopy approach with cyclic voltammetry.

https://www.ncbi.nlm.nih.gov/pubmed/17129006

The use of scanning electrochemical microscopy (SECM) to evaluate the apparent diffusion

coefficient, Dapp, of redox-active species in ultrathin Nafion films is described. In this technique, an ultramicroelectrode (UME) tip, positioned close to a film on a macroscopic electrode, is used to oxidize (or reduce) a species in bulk solution, causing the tip-generated oxidant (reductant) to diffuse to the film/solution interface. The oxidation (reduction) of film-confined species regenerates the reductant (oxidant) in solution, leading to feedback to the UME. A numerical model is developed that allows Dapp to be determined. For these studies, ultrathin films of Nafion were prepared using the Langmuir-Schaefer (LS) technique and loaded with an electroactive species, either the ferrocene derivative ferrocenyltrimethylammonium cation, FA+, or tris(2,2'-bipyridyl)ruthenium(II), Ru(bpy)32+. The morphology and the thickness of the Nafion LS films (1.5 +/- 0.2 nm per layer deposited) were evaluated using atomic force microscopy (AFM). For comparison with the SECM measurements, cyclic voltammetry (CV) was employed to evaluate the concentration of electroactive species within the Nafion LS films and to determine Dapp. The latter was found to be essentially invariant with film thickness, but the value for Ru(bpy)32+ was 1 order of magnitude larger than for FA+. CV and SECM measurements yield different values of Dapp, and the underlying reasons are discussed. In general, the Dapp values for these films are considerably smaller than for recast Nafion films, which can be attributed to the compactness of Nafion LS films. Nonetheless, the ultrathin nature of the films leads to fast response times, and we thus expect that these modified electrodes could find applications in sensing, electroanalysis, and electrocatalysis.

Bioinspired actuation of the eyeballs of an android robotic face: concept and preliminary investigations.

https://www.ncbi.nlm.nih.gov/pubmed/17671329

This paper describes the concept and preliminary investigations related to the development of simple bioinspired actuation mechanisms for the eyeballs of an android robotic face. Two design solutions for a one-degree-of-freedom mechanism are proposed and analytically studied according to linear models. Both of them are based on new contractile actuators made of electroactive polymers, employed as pseudomuscular devices. The actuators consist of dielectric elastomers and are capable of electrically driven linear contractions. The arrangement and the functionality of the actuators were conceived to mimic those of rectus-type human ocular muscles. Both the presented solutions rely on a couple of agonist-antagonist actuators, in order to enable bidirectional rotations of the eyeball around an axis. The two configurations basically differ in the presence/absence of pulleys, guiding tendon-like wires which connect the actuators to the eyeball. The influence on the

system performances of both rest length and elastic modulus of the actuators was studied for both configurations. Geometrical constraints allow the configuration with pulleys to perform more than the other, despite a potential intrinsic superior efficacy of the latter. The paper describes also the assembly of a simple prototype version of the system and presents the results of preliminary tests. These permitted us to assess the feasibility of the proposed concept and suggested possible improvements.

The effect of polypyrrole with incorporated neurotrophin-3 on the promotion of neurite outgrowth from auditory neurons.

https://www.ncbi.nlm.nih.gov/pubmed/17007922

This research aims to improve the nerve-electrode interface of the cochlear implant using polymer technology to encourage neuron survival, elongation and adhesion to the electrodes. Polypyrrole (Ppy) doped with p-toluene sulphonate (pTS) is an electroactive polymer into which neurotrophin-3 (NT3) can be incorporated. Ppy/pTS+/-NT3 was synthesised over gold electrodes and used as a surface for auditory neuron explant culture. Neurite outgrowth from explants grown on Ppy/pTS was equivalent to tissue culture plastic but improved with the incorporation of NT3 (Ppy/pTS/NT3). Electrical stimulation of Ppy/pTS/NT3 with a biphasic current pulse, as used in cochlear implants, significantly improved neurite outgrowth from explants. Using (125)I-NT3, it was shown that low levels of NT3 passively diffused from Ppy/pTS/NT3 during normal incubation and that electrical stimulation enhanced the release of biologically active NT3 in quantities adequate for neuron survival. Furthermore, Ppy/pTS/NT3 and its constituents were not toxic to auditory neurons and the Ppy/pTS/NT3 coating on gold electrodes did not alter impedance. If applied to the cochlear implant, Ppy/pTS/NT3 will provide a biocompatible, low-impedance substrate for storage and release of NT3 to help protect auditory neurons from degradation after sensorineural hearing loss and encourage neurite outgrowth towards the electrodes.

Fabrication of a low background signal glucose biosensor with 3D network materials as the electrocatalyst.

https://www.ncbi.nlm.nih.gov/pubmed/30571945

Glucose oxidase (GOx) based biosensor is an effective method to determine glucose level. However, the biosensors embedded with high electroactive species suffered from high background signal levels, which leading to relative low sensitivity for glucose sensing. In this work, a novel 3D

network materials based glucose biosensor with low background signal was constructed, which demonstrated high sensitivity and selectivity towards glucose assay. Here, the combination of ionic liquid modified graphene sheets (GS-IL) and Au nanorods (Au NRs) acted as high electroactive catalyst, and thiol-containing silica sol-gel served as a nonconductive matrix to self-assembly of GS-IL and Au NRs to form the three-dimensional (3D) network materials. Meanwhile, the doping amount of the sol-gel had significant influences on electrochemical performance of the 3D network materials based biosensor. As a result, optimized 3.75% doping 3D network materials were selected to construct the glucose biosensor, which exhibited low background signal and high sensitivity. This biosensor was successfully applied in monitoring the glucose levels of serum and brain microdialysate samples.

Galvanic cell without liquid junction for potentiometric determination of copper.

https://www.ncbi.nlm.nih.gov/pubmed/17586116

This paper describes potentiometric measurements in an integrated galvanic cell with both indicator and reference electrodes. Both electrodes are conducting polymer-based. The copper-sensitive indicator electrode is made by using poly(3,4-ethylenedioxythiophene) (PEDOT) doped with 2-(o-arsenophenylazo)-1,8-dihydroxynaphthalene-3,6-disulphonic sodium salt (Arsenazo-I) as the electroactive substance in the film, while the reference electrode is based on PEDOT doped by 2-morpholineoethanesulfonic acid (MES). It is shown that the galvanic cell can be used for determination of copper both in non-aqueous media (where all PVC-based membranes failed) and in the presence of chloride ions, which disturb the signal of conventional copper ion-selective electrodes with solid-state membranes. It is further shown that the titration of copper ions can be successfully monitored using the described electrochemical cell.

Electrically Responsive, Nanopatterned Surfaces for Triggered Delivery of Biologically Active Molecules into Cells.

https://www.ncbi.nlm.nih.gov/pubmed/30565453

Polyelectrolyte multilayers (PEMs) assembled layer-by-layer have emerged as functional polymer films that are both stable and capable of containing drug molecules for controlled release applications. Most of these applications concentrate on sustained release, where the concentration of the released molecules remains rather constant with time. However, high-efficiency delivery requires obtaining high local concentrations at the vicinity of the cells, which is achieved by triggered

release. Here, we show that a nanopatterned PEM platform demonstrates superior properties with respect to drug retention and triggered delivery. A chemically modified block copolymer film was used as a template for the selective deposition of poly(ethylene imine) and a charged derivative of the electroactive poly(3,4-ethylenedioxythiophene) together with a drug molecule. This nanopatterned PEM shows the following advantages: (1) high drug loading; (2) enhanced retention of the bioactive molecule; (3) release triggered by an electrochemical stimulus; (4) high efficacy of drug delivery to cells adsorbed on the surface compared to the delivery efficacy of a similar concentration of drug to cells suspended in a solution.

Contraction process of an electroactive actuator based on a one microsecond atomistic molecular dynamics simulation.

https://www.ncbi.nlm.nih.gov/pubmed/17200928

The contraction process of an electroactive actuator constituted by calix[4]arene units and quaterthiophene segments has been investigated at the microscopic level by using atomistic molecular dynamics simulations in dichloromethane solution using explicit solvent molecules. Results derived from a 1 mus trajectory of the oxidized and deprotonated actuator indicate that the contraction occurs through a non-concerted mechanism in which each actuating units present in the system behave independently. The efficiency of the contraction process can be reduced by the presence of secondary conformational transitions in the calix[4]arene scaffolds. Accordingly, the drastic reduction of the molecular length expected during the contraction process can be limited by such transitions, which involve the rotational isomerism of a phenolate ring. However, such type of conformational transitions does not compromise the actuator power due to its intrinsic capacity to adopt compact molecular arrangements. On the other hand, the rate of the contraction process is influenced by the presence of solvent molecules, which have been found to reduce it by a factor of about 1000.

Simultaneous measurements of ascorbate and glutamate in vivo in the rat brain using carbon fiber nanocomposite sensors and microbiosensor arrays.

https://www.ncbi.nlm.nih.gov/pubmed/29413864

Nanocomposite sensors consisting of carbon fiber microelectrodes modified with NafionÂ® and carbon nanotubes, and ceramic-based microelectrode biosensor arrays were used to measure ascorbate and glutamate in the brain with high spatial, temporal and chemical resolution.

Nanocomposite sensors displayed electrocatalytic properties towards ascorbate oxidation, translated into a negative shift from +0.20V to -0.05V vs. Ag/AgCl, as well as a significant increase (10-fold) of electroactive surface area. The estimated average basal concentration of ascorbate in vivo in the CA1, CA3 and dentate gyrus (DG) sub regions of the hippocampus were 276Â±60Î¼M (n=10), 183Â±30Î¼M (n=10) and 133Â±42Î¼M (n=10), respectively. The glutamate microbiosensor arrays showed a high sensitivity of 5.3Â±0.8pAÎ¼M-1 (n=18), and LOD of 204Â±32nM (n=10), and t50% response time of 0.9Â±0.02s (n=6) and high selectivity against major interferents. The simultaneous and real-time measurements of glutamate and ascorbate in the hippocampus of anesthetized rats following local stimulus with KCl or glutamate revealed a dynamic interaction between the two neurochemicals.

Electrical detection of deoxyribonucleic acid hybridization based on carbon-nanotubes/nano zirconium dioxide/chitosan-modified electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/17386614

A novel and sensitive electrochemical DNA biosensor based on nanoparticles ZrO(2) and multi-walled carbon nanotubes (MWNTs) for DNA immobilization and enhanced hybridization detection is described. The MWNTs/nano ZrO(2)/chitosan-modified glassy carbon electrode (GCE) was fabricated and oligonucleotides were immobilized to the GCE. The hybridization reaction on the electrode was monitored by differential pulse voltammetry (DPV) analysis using electroactive daunomycin as an indicator. Compared with previous DNA sensors with oligonucleotides directly incorporated on carbon electrodes, this carbon nanotube-based assay with its large surface area and good charge-transport characteristics increased DNA attachment quantity and complementary DNA detection sensitivity. The response signal increases linearly with the increase of the logarithm of the target DNA concentration in the range of 1.49 x 10(-10) to 9.32 x 10(-8) mol L(-1) with the detection limit of 7.5 x 10(-11) mol L(-1) (S/N=3). The linear regression equation is I=32.62+3.037 logC(DNA) (mol L(-1)) with a correlation coefficient value of 0.9842. This is the first application of carbon nanotubes combined with nano ZrO(2) to the fabrication of an electrochemical DNA biosensor with a favorable performance for the rapid detection of specific hybridization.

Ultrathin conjugated polymer network films of carbazole functionalized poly(p-phenylenes) via electropolymerization.

https://www.ncbi.nlm.nih.gov/pubmed/17521182

Ultrathin films of a cross-linked and chemically distinct conjugated poly(p-phenylene) network via electropolymerization are described. The amphiphilic network precursor was synthesized by incorporating the alkoxy carbazole group (-O(CH2)5Cb) to a poly(p-phenylene) (C6PPPOH) backbone. In order to investigate the combined thin film electrochemical and photophysical properties of poly(p-phenylene)s and polycarbazole conjugated polymers, C6PPPC5Cb was deposited on substrates using the Langmuir Blodgett Kuhn (LBK) method. The monolayer isotherm of the polymer, C6PPPC5Cb, showed a liquid expanded region slightly different from the parent polymer C6PPPOH. Multilayers (up to 30 layers) were transferred to different substrates such as quartz, gold coated LaSFN9 and ITO substrates for analysis. For conversion to a conjugated polymer network (CPN) film, the electroactive carbazole group was electropolymerized using cyclic voltammetry (CV) resulting in polycarbazole linking units. The differences in the film properties and corresponding changes in the electrochemical behavior indicate the importance of film thickness and electron/ion transport process in cross linked network films. From the electrochemical studies, the scan rate was found to have a considerable effect on electropolymerization with higher oxidation and reduction peak values found for the rigid network polymer compared to the uncrosslinked polymers.

Simultaneous voltammetric immunodetection of alpha-fetoprotein and glypican-3 using a glassy carbon electrode modified with magnetite-conjugated dendrimers.

https://www.ncbi.nlm.nih.gov/pubmed/30904972

The authors describe an electrochemical immunoassay for simultaneous determination of alpha-fetoprotein (AFP) and glypican-3 (GPC-3) which are important biomarkers for early detection of hepatocellular carcinoma (HCC). Magnetite (Fe3O4) nanoparticles (NPs) were decorated with hyperbranched amino functionalized dendrimers. The modified NPs were coupled to the antibodies against AFP and GPC-3. The electrochemical behaviour of the Fe3O4 NPs and dendrimer-modified NPs were studied. A glassy carbon electrode was then modified with the NP-conjugated antibodies and biomolecular interactions were studied by using cyclic voltammetry and electrochemical impedance spectroscopy. Dual differential pulse voltammetric sensing was performed by utilizing the redox probes; Prussian blue for AFP and toluidine blue for GPC-3. The biomarkers can be detected best at voltages of 0.25Â mV and - 0.54Â mV (vs Ag/AgCl) for AFP and GPC-3, respectively. The low working potentials makes the method more selective over other electroactive species present in real human serum samples. Response is linear in 0.02 to 10Â ngÂ mL-1 concentration ranges of

both AFP and GPC-3; and the respective detection limits are 50 and 70Â pgÂ mL-1. The method was validated by analysing spiked human serum samples. In our perception, the method is of great clinical significance as combination of GPC-3 and AFP increases the sensitivity of detection of HCC. Graphical abstract Schematic presentation of polyamidoamine (PAMAM) dendrimers modified magnetite (Fe3O4) nanoparticles as electrochemical sensing platform using redox dyes Prussian blue and toluidine blue for simultaneous detection of alpha-fetoprotein (AFP) and glypican-3 (GPC-3), respectively by differential pulse voltammetry.

Electrochemical characterization of Geobacter sulfurreducens cells immobilized on graphite paper electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/17929324

Bacteria able to transfer electrons to conductive surfaces are of interest as catalysts in microbial fuel cells, as well as in bioprocessing, bioremediation, and corrosion. New procedures for immobilization of Geobacter sulfurreducens on graphite electrodes are described that allow routine, repeatable electrochemical analysis of cell-electrode interactions. Immediately after immobilizing G. sulfurreducens on electrodes, electrical current was obtained without addition of exogenous electron shuttles or electroactive polymers. Voltammetry and impedance analysis of pectin-immobilized bacteria transferring electrons to electrode surfaces could also be performed. Cyclic voltammetry of immobilized cells revealed voltage-dependent catalytic current similar to what is commonly observed with adsorbed enzymes, with catalytic waves centered at -0.15 V (vs. SHE). Electrodes maintained at +0.25 V (vs. SHE) initially produced 0.52 A/m(2) in the presence of acetate as the electron donor. Electrical Impedance Spectroscopy of coatings was also consistent with a catalytic mechanism, controlled by charge transfer rate. When electrodes were maintained at an oxidizing potential for 24 h, electron transfer to electrodes increased to 1.75 A/m(2). These observations of electron transfer by pectin-entrapped G. sulfurreducens appear to reflect native mechanisms used for respiration. The ability of washed G. sulfurreducens cells to immediately produce electrical current was consistent with the external surface of this bacterium possessing a pathway linking oxidative metabolism to extracellular electron transfer. This electrochemical activity of pectin-immobilized bacteria illustrates a strategy for preparation of catalytic electrodes and study of Geobacter under defined conditions.

[Research progresses on electroactive and electrically conductive polymers for tissue

engineering scaffolds].

https://www.ncbi.nlm.nih.gov/pubmed/17260480

Electroactive and/or electrically conductive polymers have shown potential applications in the culture of excitable cells and as the electroactive scaffolds for neuronal or cardiac tissue engineering. The biocompatibility of the conductive polymer can be improved by covalently grafting or blending with oligo- or polypeptides. The new progresses in this area on two types of conductive polymers, polypyrrole and polyaniline (PANi) are reviewed in this paper. The studies of oligopeptide-modified PANi and electrospun PANi/gelatin nanofibers are highlighted.

Natural gum-assisted phthalocyanine immobilization in electroactive nanocomposites: physicochemical characterization and sensing applications.

https://www.ncbi.nlm.nih.gov/pubmed/17939712

Natural gums have been traditionally applied in cosmetics and the food industry, mainly as emulsification agents. Due to their biodegradability and excellent mechanical properties, new technological applications have been proposed involving their use with conventional polymers forming blends and composites. In this study, we take advantage of the polyelectrolyte character exhibited by the natural gum ChichA (Sterculia striata), extracted in the Northeastern region of Brazil, to produce electroactive nanocomposites. The nanocomposites were fabricated in the form of ultrathin films by combining a metallic phthalocyanine (nickel tetrasulfonated phthalocyanine, NiTsPc) and the ChichA gum in a tetralayer architecture, in conjunction with conventional polyelectrolytes. The presence of the gum led to an efficient adsorption of the phthalocyanine and enhanced the electrochemical response of the films. Upon combining the electrochemical and UV-vis absorption data, energy diagrams of the ChichA/NiTsPc-based system were obtained. Furthermore, modified electrodes based on gum/phthalocyanine films were able to detect dopamine at concentrations as low as 10-5 M.

A novel glucose biosensor based on immobilization of glucose oxidase into multiwall carbon nanotubes-polyelectrolyte-loaded electrospun nanofibrous membrane.

https://www.ncbi.nlm.nih.gov/pubmed/17905578

Nanofibrous glucose electrodes were fabricated by the immobilization of glucose oxidase (GOx) into an electrospun composite membrane consisting of polymethylmethacrylate (PMMA) dispersed with multiwall carbon nanotubes (MWCNTs) wrapped by a cationic polymer

(poly(diallyldimethylammonium chloride) (PDDA)) and this nanofibrous electrode (NFE) is abbreviated as PMMA-MWCNT(PDDA)/GOx-NFE. The NFE was characterized for morphology and electroactivity by using electron microscopy and cyclic voltammetry, respectively. Field emission transmission electron microscopy (FETEM) image reveals the dispersion of MWCNT(PDDA) within the matrix of PMMA. Cyclic voltammetry informs that NFE is suitable for performing surface-confined electrochemical reactions. PMMA-MWCNT(PDDA)/GOx-NFE exhibits excellent electrocatalytic activity towards hydrogen peroxide (H(2)O(2)) with a pronounced oxidation current at +100 mV. Glucose is amperometrically detected at +100 mV (vs. Ag/AgCl) in 0.1M phosphate buffer solution (PBS, pH 7). The linear response for glucose detection is in the range of 20 microM to 15 mM with a detection limit of 1 microM and a shorter response time of approximately 4 s. The superior performance of PMMA-MWCNT(PDDA)/GOx-NFE is due to the wrapping of PDDA over MWCNTs that binds GOx through electrostatic interactions. As a result, an effective electron mediation is achieved. A layer of nafion is made over PMMA-MWCNT(PDDA)/GOx-NFE that significantly suppressed the electrochemical interference from ascorbic acid or uric acid. In all, PMMA-MWCNT(PDDA)/GOx-nafion-NFE has exhibited excellent properties for the sensitive determination of glucose like high selectivity, good reproducibility, remarkable stability and without interference from other co-existing electroactive species.

Antimicrobial Photodynamic Polymeric Films Bearing Biscarbazol Triphenylamine End-Capped Dendrimeric Zn(II) Porphyrin.

https://www.ncbi.nlm.nih.gov/pubmed/31310503

A novel biscarbazol triphenylamine end-capped dendrimeric zinc(II) porphyrin (DP 5) was synthesized by click chemistry. This compound is a cruciform dendrimer that bears a nucleus of zinc(II) tetrapyrrolic macrocycle substituted at the meso positions by four identical substituents. These are formed by a tetrafluorophenyl group that possesses a triazole unit in the para position. This nitrogenous heterocyclic is connected to a 4,4'-di(N-carbazolyl)triphenylamine group by means of a phenylenevinylene bridge, which allows the conjugation between the nucleus and this external electropolymerizable carbazoyl group. In this structure, dendrimeric arms act as light-harvesting antennas, increasing the absorption of blue light, and as electroactive moieties. The electrochemical oxidation of the carbazole groups contained in the terminal arms of the DP 5 was used to obtain novel, stable, and reproducible fully ï€-conjugated photoactive polymeric films (FDP 5). First, the spectroscopic characteristics and photodynamic properties of DP 5 were compared with its

constitutional components derived of porphyrin P 6 and carbazole D 7 moieties in solution. The fluorescence emissions of the dendrimeric units in DP 5 were more strongly quenched by the tetrapyrrolic macrocycle, indicating photoinduced energy transfer. In addition, FDP 5 film showed the Soret and Q absorption bands and red fluorescence emission of the corresponding zinc(II) porphyrin. Also, FDP 5 film was highly stable to photobleaching, and it was able to produce singlet molecular oxygen in both N,N-dimethylformamide (DMF) and water. Therefore, the porphyrin units embedded in the polymeric matrix of FDP 5 film mainly retain the photochemical properties. Photodynamic inactivation mediated by FDP 5 film was investigated in Staphylococcus aureus and Escherichia coli. When a cell suspension was deposited on the surface, complete eradication of S. aureus and a 99% reduction in E. coli survival were found after 15 and 30 min of irradiation, respectively. Also, FDP 5 film was highly effective to eliminate individual bacteria attached to the surface. In addition, photodynamic inactivation (PDI) sensitized by FDP 5 film produced >99.99% bacterial killing in biofilms formed on the surface after 60 min irradiation. The results indicate that FDP 5 film represents an interesting and versatile photodynamic active material to eradicate bacteria as planktonic cells, individual attached microbes, or biofilms.

Hysteresis in a carbon nanotube based electroactive polymer microfiber actuator: numerical modeling.

https://www.ncbi.nlm.nih.gov/pubmed/18047099

Hysteretic behavior is an important consideration for smart electroactive polymer actuators in a wide variety of nano/micro-scale applications. We prepared an electroactive polymer actuator in the form of a microfiber, based on single-wall carbon nanotubes and polyaniline, and investigated the hysteretic characteristics of the actuator under electrical potential switching in a basic electrolyte solution. For actuation experiments, we measured the variation of the length of the carbon-nanotube-based electroactive polymer actuator, using an Aurora Scientific Inc. 300B Series muscle lever arm system, while electrical potentials ranging from 0.2 V to 0.65 V were applied. Based on the classical Preisach hysteresis model, we presented and validated a numerical model that described the hysteretic behavior of the carbon-nanotube-based electroactive polymer actuator. Inverse hysteretic behavior was also simulated using the model to demonstrate its capability to predict an input from a desired output. This numerical model of hysteresis could be an effective approach to micro-scale control of carbon-nanotube-based electroactive polymer actuators in potential applications.

Loading/release behavior of (chitosan/DNA)n layer-by-layer films toward negatively charged anthraquinone and its application in electrochemical detection of natural DNA damage.

https://www.ncbi.nlm.nih.gov/pubmed/17768042

In the present work, positively charged chitosan (CS) and negatively charged DNA were alternately adsorbed on the surface of pyrolytic graphite (PG) electrodes, forming (CS/DNA)(n) layer-by-layer films. Cyclic voltammetry (CV) results showed that negatively charged electroactive probe, 9,10-anthraquinone-2,6-disulfonate (AQDS), could be loaded into the (CS/DNA)(n) films from its solution (1 mM at pH 7.0, containing 0.1 M NaCl), designated as (CS/DNA)(n)-AQDS, and then released from the films in blank buffers. The loading/release behavior of (CS/DNA)(n) films toward AQDS was found to be obviously different between double-stranded (dsDNA) and single-stranded DNA (ssDNA). The release rate of AQDS from (CS/dsDNA)(n) films was much slower than that from the ssDNA counterparts mainly because AQDS could be intercalated into the double helix structure of dsDNA despite the repulsion between likely charged AQDS and DNA. The loading/release behavior of (CS/DNA)(n) films toward AQDS in recognition of dsDNA and ssDNA was then successfully applied to electrochemically detect the damage of natural DNA caused by Fenton reaction. To further understand the essence of the interactions involved in the AQDS loading/release process for (CS/DNA)(n) films, comparison experiments were performed, in which either positively charged intercalator brilliant cresyl blue (BCB) was used to replace AQDS as the redox probe, or poly(diallyldimethylammonium) (PDDA) with relatively high positive charge density was used to replace CS as the constituent of layer-by-layer films with DNA. The loading/release behavior of DNA films toward electroactive intercalator may open new possibilities for dsDNA/ssDNA recognition and of DNA damage detection by electrochemistry.

Effect of surfactant on water-soluble conjugated polymer used in biosensor.

https://www.ncbi.nlm.nih.gov/pubmed/17918987

The effect of nonionic surfactants on the cationic conjugated polymer (CCP), poly{9,9-bis[6-(N,N-trimethylammonium)hexyl]fluorene-co 1,4-phenylene} iodide 1, has been investigated. It is shown that the CCP in various solvents exists in three phases: isolated polymer chains, polymer aggregate, and variable size clusters (partially dissolved polymer). It is shown that nonionic surfactants enhance the photoluminescence (PL) quantum yield of the CCP in water by breakup of polymer aggregates, which eliminates the nonemissive interchain quenching with aggregates and increases surface-to-volume ratio of the CCP. Furthermore, the surfactants reduce

quenching by incorporation of the CCP into aggregates or binary micelles. Surfactant also reduces the polar interaction strength between CCP and water and enhances CCP quenching by the counterions (iodine) by ion pairing effect. The dynamics of the interactions are complex and reveal that the surfactant induces rapid increase in the PL which imply that the main force that causes the aggregation is weak and may be due to hydrophobic interaction of the CCP in water rather than a solid, particulate-like state. Time-resolved fluorescence measurements at the exciton energy (420 nm) confirm that the CCP in water and in some organic solvents is a multiphase system in which three exponential decay terms are needed to fit the decay profile of the CCP. The change in the decay lifetime explains clearly the effect of surfactant and solvent polarity on the three CCP phases. The average lifetime of the CCP does not increase with surfactant, but the number of isolated polymer chains increases which leads to higher PL quantum yield. The association between the polymer and a quencher, single-strand deoxyribonucleic acid (ssDNA), was investigated. It indicated that CCP:ssDNA forms a weak electrostatic complex that does not alter the absorption spectra of the CCP but induces a strong CCP fluorescence quenching with association constant KS = 5 x 10(7) M(-1). At low ssDNA concentrations, the surfactant reduces quenching in the complex possibly by preventing charge-transfer processes. This may be due to an increase in the distance between the CCP and ssDNA through incorporation of the CCP into aggregates (micelles). However, at high ssDNA concentration, the quenching increases sharply which may be assigned to the increase in the electrostatic force destroying the micelles' structure around the CCP, leading to contact quenching as well as DNA induced CCP aggregation, which in turn leads to CCP-CCP quenching.

Controlling the electrochemically active area of carbon fiber microelectrodes by the electrodeposition and selective removal of an insulating photoresist.

https://www.ncbi.nlm.nih.gov/pubmed/16841943

A new and simple method permits control of the electrochemically active area of a carbon fiber microelectrode. An electrophoretic photoresist insulates the 10-microm-diameter carbon fiber microelectrodes. Photolysis of the photoresist followed by immersion of the exposed area into a developing solution reveals electroactive carbon fiber surface. The electroactive surface area exposed can be controlled with a good degree of reproducibility.

Loading behavior of {chitosan/hyaluronic acid}n layer-by-layer assembly films toward myoglobin: an electrochemical study.

https://www.ncbi.nlm.nih.gov/pubmed/17125331

When {CS/HA}n layer-by-layer films assembled by oppositely charged chitosan (CS) and hyaluronic acid (HA) were immersed in myoglobin (Mb) solution at pH 5.0, Mb was gradually loaded into the {CS/HA}n films, designated as {CS/HA}n-Mb. The cyclic voltammetric (CV) peak pair of Mb FeIII/FeII redox couple for {CS/HA}n-Mb films on pyrolytic graphite (PG) electrodes was used to investigate the loading behavior of {CS/HA}n films toward Mb. The various influencing factors, such as the number of bilayers (n), the pH of Mb loading solution, and the ionic strength of solution, were investigated by different electrochemical methods and other techniques. The results showed that the main driving force for the bulk loading of Mb was most probably the electrostatic interaction between oppositely charged Mb in solution and HA in the films, while other interactions such as hydrogen bonding and hydrophobic interaction may also play an important role. Other polyelectrolyte multilayer (PEM) films with different components were compared with {CS/HA}n films in permeability and Mb loading, and electroactive probes with different size and surface charge were compared in their incorporation into PEM films. The results suggest that due to the unique structure of CS and HA, {CS/HA}n films with relatively low charge density are packed more loosely and more easily swelled by water, and have better permeability, which may lead to the higher loading amount and shorter loading time for Mb. The protein-loaded PEM films provide a new route to immobilize redox proteins on electrodes and realize the direct electrochemistry of the proteins.

Stability-indicating electrochemical methods for the determination of meclophenoxate hydrochloride and pyritinol dihydrochloride using ion-selective membrane electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/17202801

The construction and electrochemical response characteristics of polyvinyl chloride (PVC) membrane sensors for the determination of meclophenoxate hydrochloride (I) and pyritinol dihydrochloride (II) in presence of their degradation products are described. The sensors are based on the use of the ion-association complexes of (I) and (II) cation with sodium tetraphenyl borate and ammonium reineckate counteranions as ion-exchange sites in the PVC matrix. In addition beta-cyclodextrin (beta-CD) membranes were used in the determination of I and II. These ion pairs and beta-CD were then incorporated as electroactive species with ortho nitrophenyl octyl ether (oNPOE) as a plasticizer. Three PVC sensors were fabricated for each drug, i.e. meclophenoxate tetraphenyl borate (meclo-TPB), meclophenoxate reineckate (meclo-RNC) and meclophenoxate beta-cyclodextrin (meclo-beta-CD), and the same was done for pyritinol (pyrit-TPB), (pyrit-RNC) and

(pyrit-beta-CD). They showed near Nernestian responses for meclophenoxate over the concentration range 10(-5)-10(-2) with slopes of 52.73, 51.64 and 54.05 per concentration decade with average recoveries of 99.92+/-1.077, 99.96+/-0.502 and 100.03+/-0.763 for meclo-TPB, meclo-RNC and meclo-beta-CD respectively. Pyritinol also showed near Nernestian responses over the concentration range of 3.162 x 10(-6) - 3.162 x 10(-4) for pyrit-TPB and pyrit-RNC, and 10(-6) - 3.162 x 10(-4) for pyrit-beta-CD with slopes of 30.60, 31.10 and 32.89 per concentration decade and average recoveries of 99.99+/-0.827, 100.00+/-0.775 and 99.99+/-0.680 for pyrit-TPB, pyrit-RNC and pyrit-beta-CD respectively. The sensors were used successfully for the determination of I and II in laboratory prepared mixtures with their degradation products, in pharmaceutical dosage forms and in plasma.

Zirconium ion selective electrode based on bis(diphenylphosphino) ferrocene incorporated in a poly(vinyl chloride) matrix.

https://www.ncbi.nlm.nih.gov/pubmed/17386619

A novel potentiometric zirconium--PVC matrix membrane sensor incorporating bis(diphenylphosphino) ferrocene as an electroactive material and tris(2-ethylhexyl)phosphate as solvent mediator is described. In mixed acetate buffer solution of pH 4.8, the sensor displays a rapid and linear response for zirconium ion over the concentration range 1.0 x 10(-1) to 1.0 x 10(-7) mol L(-1) with a good slope of 59.7+/-0.3 mV per decade and detection limit 1.8 x 10(-8) mol L(-1). The best performance was obtained with membrane composition 33% PVC, 65% TEHP, 1% NaTPB and 1% ionophore. The proposed electrode revealed excellent selectivity for zirconium ion over a wide variety of alkali, alkaline earth, transition and heavy metal ions and could be used in a pH range of 4.15-7.8. The electrode was applied for at least 1 month without any considerable divergence in the potential responses. The practical utility of the electrode has been demonstrated by its use as an indicator electrode in the potentiometric titration of zirconium ions with sodium fluoride and in determination of zirconium ion in some alloy, tape and waste water samples.

Detection and modelling of DNA hybridization by EIS measurements. Mention of a polythiophene matrix suitable for electrochemically controlled gene delivery.

https://www.ncbi.nlm.nih.gov/pubmed/17010598

A conducting polymer sensor for direct label-free DNA detection based on a polythiophene bearing an electroactive linker group is investigated. DNA hybridization is studied by electrochemical

impedance spectroscopy (EIS) and quartz crystal microbalance (QCM) techniques. Modelling of DNA hybridization by EIS measurements exhibits the contribution of nucleic acid to a superficial p-doping process. A 675-mer single-stranded DNA is produced using asymmetric PCR from a DNA sequence of a transposable element mariner and hybridized to the previously immobilized probe. Electrochemical stimulus leads to the release "on demand" of DNA fragments and the amount delivery permits to do PCR amplification.

Enhanced electrochemical performance at screen-printed carbon electrodes by a new pretreating procedure.

https://www.ncbi.nlm.nih.gov/pubmed/17386824

A new method for the pretreatment of screen-printed carbon electrodes (SPCEs) by two successive steps was proposed. In step one, fresh SPCEs were soaked into NaOH with high concentration (e.g. 3 M) for tens to hundreds of minutes, and the resulted electrodes were called as SPCE-I. In step two, SPCE-I were pre-anodized in low concentration of NaOH, which were designated as SPCE-II. The pretreated electrodes showed remarkable enhancement in heterogeneous electron transfer rate constant (k0) increased from 1.6x10(-4) cms(-1) at the fresh SPCE to 1.1x10(-2) cms(-1) at SPCE-I for Fe(CN)6(3-/4-) couple. The peak to peak separation (deltaE(p)) in cyclic voltammetry was reduced from ca. 480 to 84 mV, indicating that the electrochemical reversibility was greatly promoted, possibly due to the removing of polymers/oil binder from the electrode surfaces. The electroactive area (A(ea)) of the electrode was increased by a factor of 17 after pretreatment in step one. Further analysis by the electrochemical impedance method showed that the electron transfer resistance (R(ct)) decreased from ca. 2100 to 1.4 ohms. These pretreated electrodes, especially SPCE-II, exhibited excellent electrocatalytic behavior for the redox of dopamine (DA). Interference from ascorbic acid (AA) in the detection of DA at SPCE-II could be effectively eliminated due to the anodic peak separation (190 mV) between DA and AA, which resulted from the functionalization of the electrode surface in the pretreatment of step two. Under optimum conditions, current responses to DA were linearly changed in two concentration intervals, one was from 3.0x10(-7) to 9.8x10(-6) M, and the other was from 9.8x10(-6) to 3.3x10(-4) M. The detection limit for DA was down to 1.0x10(-7) M.

Stimuli-enabled switch-like paracetamol electrochemical sensor based on thermosensitive polymer and MWCNTs-GQDs composite nanomaterial.

https://www.ncbi.nlm.nih.gov/pubmed/30938724

A temperature-controlled switchable electrochemical sensor was constructed based on a composite film consisting of thermosensitive block polymer poly(styrene-b-(N-isopropylacrylamide)-b-styrene) (PS-PNIPAm-PS), carboxylated multi-walled carbon nanotubes (MWCNTs-COOH) and amino-functionalized graphene quantum dots (N-GQDs). The prepared sensor showed good temperature sensitivity and reversibility in sensing paracetamol. In the low temperature environment, the polymer stretched to bury the electroactive sites of the carbon nanocomposite, and the paracetamol could not pass through the polymer to achieve electronic exchange, representing the "closed" state. Conversely, in the high temperature environment, the polymer shrank to expose the electroactive sites and enlarge background currents, the paracetamol was able to undergo the redox reaction normally and generate the response current, representing the "on" state. In addition, the sensor had a wide detection range (0.1 to 7.0 Î¼M and 7.0 to 103.0 Î¼M) and a low LOD of 66 nM for paracetamol. This switch-like sensor provided a novel idea for the application of thermosensitive polymers.

Probing the periphery of dendrimers by heterogeneous electron transfer.

https://www.ncbi.nlm.nih.gov/pubmed/17392968

The accessibility of the electroactive periphery was studied and compared for dendrimers and linear analogs by heterogeneous electron transfer using microelectrodes.

Perchlorate interchange during the redox process of PPy/PVS films in an acetonitrile medium. a voltammetric and EDX study.

https://www.ncbi.nlm.nih.gov/pubmed/16866458

Polypyrrole/poly(vinyl sulfonate) (PPy/PVS) films in acetonitrile containing 0.1 M LiClO4 were studied by cyclic voltammetry. Consecutive voltammograms pointed to a continuous increase in the charge involved in the process, suggesting a rise in the number of the electroactive participants involved in the redox process. However, voltammograms obtained for the PPy/ClO4 films in analogous conditions pointed to a steady-state behavior from the very early cycles. Theoretical studies based on the Nernst and Butler-Volmer equations indicated that perchlorate ions are involved during the oxidation/reduction process of the PPy/PVS films when the steady state is reached. This result was confirmed by "ex situ" energy-dispersive X-ray analysis of the films. In this regard, the electrochemical behavior of PPy/PVS polymers was similar to that of PPy/ClO4 films

when a high number of cycles were carried out. The exchange of ClO4- during the redox reaction of the PPy/PVS films made it necessary to incorporate Li+ cations inside the polymer during the initial voltammetric cycles to compensate for the negative charges of PVS polyanions. Li+ cations are mainly stabilized inside the polymer by the ion pairs formed with the sulfonated groups of the PVS. An increase and shift of the voltammetric cycles indicated a restructuring of the polymeric chains with consecutive scans.

Multidimensional electrochemical imaging in materials science.

https://www.ncbi.nlm.nih.gov/pubmed/17602213

In the past 20 years the characterization of electroactive surfaces and electrode reactions by scanning probe techniques has advanced significantly, benefiting from instrumental and methodological developments in the field. Electrochemical and electrical analysis instruments are attractive tools for identifying regions of different electrochemical properties and chemical reactivity and contribute to the advancement of molecular electronics. Besides their function as a surface analytical device, they have proved to be unique tools for local synthesis of polymers, metal depots, clusters, etc. This review will focus primarily on progress made by use of scanning electrochemical microscopy (SECM), conductive AFM (C-AFM), electrochemical scanning tunneling microscopy (EC-STM), and surface potential measurements, for example Kelvin probe force microscopy (KFM), for multidimensional imaging of potential-dependent processes on metals and electrified surfaces modified with polymers and self assembled monolayers.

Magnetic Fe2O3-polystyrene/PPy core/shell particles: bioreactivity and self-assembly.

https://www.ncbi.nlm.nih.gov/pubmed/17900197

This paper describes the synthesis of new magnetic, reactive polystyrene/polypyrrole core/shell latex particles. The core consists of a polystyrene microsphere containing gamma-Fe2O3 superparamagnetic nanoparticles (PSmag), and the shell is made of reactive N-carboxylic acid-functionalized polypyrrole (PPyCOOH). These PSmag-PPyCOOH latex particles, average diameter 220 nm, were prepared by copolymerization of pyrrole (Py) and the active carboxyl-functionalized pyrrole (PyCOOH) in the presence of PSmag particles. PNVP was used as a steric stabilizer. The functionalized polypyrrole-coated PSmag particles were characterized in terms of their particle size, surface morphology, chemical composition, and electrochemical and magnetic properties using transmission electron microscopy (TEM), X-ray photoelectron spectroscopy (XPS),

cyclic voltammetry, and SQUID magnetometry. Activation of the particle surface carboxyl groups was achieved using 1-ethyl-3-(3-dimethylaminopropyl)-carbodiimide (EDC) and N-hydroxysuccinimide (NHS), which helps transform the carboxyl groups into activated ester groups (NSE). The activated particles, PSmag-PPyNSE, were further evaluated as bioadsorbents of biotin used as a model biomolecule. It was shown that biotin was immobilized at the surface of the PSmag-PPyNSE particles by forming interfacial amide groups. The assemblies of PSmag-PPyCOOH particles on glass plates were further investigated. When no magnetic field is applied, the particles assemble into 3D colloidal crystals. In contrast, under a magnetic field, one-particle-thick chains gathered in hedgehog-like architectures are obtained. Furthermore, PSmag-PPyCOOH coated ITO electrodes were shown to be electroactive and electrochemically stable, thus offering potentialities for creating novel high-specific-area materials for biosensing devices where the conducting polymer component would act as the transducer through its conductive properties.

Rapid proton-coupled electron-transfer of hydroquinone through phenylenevinylene bridges.

https://www.ncbi.nlm.nih.gov/pubmed/17209656

We describe the synthesis of two oligo(phenylene vinylene)s (OPVs) with a hydroquinone moiety and a thiol anchor group: 4-(2',5'-dihydroxystyryl)benzyl thioacetate and 4-[4'-(2' ',5' '-dihydroxystyryl)styryl]benzyl thioacetate. Monolayers on gold of these molecules were examined by electrochemical techniques to determine the electron transfer kinetics of the hydroquinone functionality (H2Q) through these delocalized tethers ("molecular wires") as a function of pH. Between pH 4 and 9, rate constants were ca. 100-fold faster than for the same H2Q functionality confined to the surface via alkane tethers. Also, in this same pH range rate constants were independent of the length of the OPV bridge. These new electroactive molecules in which the hydroquinone functionality is wired to the gold surface by means of OPV tethers should be useful platforms for constructing bioelectronic devices such as biosensors, biofuel cells, and biophotovoltaic cells with a fast response time.

PEDOT Coated Thick Film Electrodes for In Situ Detection of Cell Adhesion in Cell Cultures.

https://www.ncbi.nlm.nih.gov/pubmed/30400265

Low temperature cofired ceramics (LTCC) provide a technology for the 3-dimensional integration of sensor arrays into bioreactors covering dimensions of several hundred micrometers. Since optical

control in such assemblies is not possible, the in situ detection of cell adhesion on impedance electrodes with high spatial resolution would deliver crucial information. A current limitation is the increasing impedance of microelectrodes with decreasing diameter. This study evaluates the suitability of thick film gold electrodes, pristine and coated with electropolymerized poly(3,4-ethylenedioxythiophene) (PEDOT), for the detection of cell adhesion on the electrode surface. The impedance as criterion for cell attachment is measured with a recording system for electroactive cells with the aim of improving usability. Two cell cultures with different adhesion characteristic are used for adhesion assessment on planar test chips. The impedance increase measured on individual PEDOT coated electrodes due to tight contact of cells reaches a factor of 6.8 in cultures of well-adherent HepG2 cells. Less adhered NG108-15 cells produce a maximum impedance increase by a factor of 2.6. Since the electrode impedance is significantly reduced by PEDOT coating, a reduction of the electrode diameter to values below 100 Âµm and spatially resolved detection is possible. The results encourage further studies using PEDOT coated thick film electrodes as bio-electronic-interfaces. We presume that such miniaturized electrodes are suitable for 3-dimensional recordings in electroactive cell cultures, providing information of local cell adhesion at the same time.

Novel electrochemical sensing platform based on a nanocomposite of PVA/PVP/RGO applied to IgG anti- Toxoplasma gondii antibodies quantitation.

https://www.ncbi.nlm.nih.gov/pubmed/30625604

This article describes the development of a new electrochemical platform composed by a polymer mixture and graphene oxide (GO). The working electrode of a screen-printed carbon electrode (SPCE) was modified with nanocomposite constituted by poly-vinyl alcohol (PVA), poly-vinylpyrrolidone (PVP) and GO, which was electrochemically reduced to obtain PVA/PVP/RGO/SPCE. The interactions and morphology of the PVA/PVP/GO nanocomposite were investigated by SEM, FTIR and UV-Vis. SEM images indicated an excellent dispersion of the GO sheets in the polymer matrix. Besides, FTIR and visible UV studies revealed strong interactions between polymer mixture and GO sheets. According to electrochemical studies, the new platform increased the electroactive surface area by a factor of 20.46 compared to the unmodified SPCE. Also, the PVA/PVP/RGO/SPCE had a fast electron kinetics transfer process with a value of ks =â€¯9.6â€¯s-1. The modified electrode was applied to the determination of IgG anti-T. gondii antibodies for the serological diagnosis of toxoplasmosis. The IgG anti-T. gondii antibodies

quantification showed a detection limit of 0.012â€¯Uâ€¯mL-1, and the coefficients of variation intra-day and inter-day assays were lower than 4.5% and 6.2%, respectively. The electrochemical platform proved to be a sensitive and easily applicable tool applied to the serological diagnosis of toxoplasmosis. Therefore, the developed nanocomposite represents an excellent alternative for the electrochemical biosensor fabrication.

Three-Dimensional Conductive Scaffolds as Neural Prostheses Based on Carbon Nanotubes and Polypyrrole.

https://www.ncbi.nlm.nih.gov/pubmed/30475577

Three-dimensional scaffolds for cellular organization need to enjoy a series of specific properties. On the one hand, the morphology, shape and porosity are critical parameters and eventually related with the mechanical properties. On the other hand, electrical conductivity is an important assetÂ when dealing with electroactive cells, so it is a desirable property even if the conductivity values are not particularly high. Here, we construct three-dimensional (3D) porous and conductive composites, where C8-D1A astrocytic cells were incubated to study their biocompatibility. The manufactured scaffolds are composed exclusively of carbon nanotubes (CNTs), a most promising material to interface with neuronal tissue, and polypyrrole (PPy), a conjugated polymer demonstrated to reduce gliosis, improve adaptability, and increase charge-transfer efficiency in brain-machine interfaces. We developed a new and easy strategy, based on the vapor phase polymerization (VPP) technique, where the monomer vapor is polymerized inside a sucrose sacrificial template containing CNT and an oxidizing agent. After removing the sucrose template, a 3D porous scaffold was obtained and its physical, chemical, and electrical properties were evaluated. The obtained scaffold showed very low density, high and homogeneous porosity, electrical conductivity, and Young's Modulus similar to the in vivo tissue. Its high biocompatibility was demonstrated even after 6 days of incubation, thus paving the way for the development of new conductive 3D scaffolds potentially useful in the field of electroactive tissues.

Captavidin as a regenerable biorecognition element on boron-doped diamond for biotin sensing.

https://www.ncbi.nlm.nih.gov/pubmed/30876631

Captavidin, a nitrated avidin with moderate affinity with biotin, irreversibly adsorbs on carboxymethylcellulose to form a regenerable biorecognition element for biotin. This layer was

retained and stabilized on a boron-doped diamond electrode by a Nafion film for repeated impedance analyses of biotin down to below 1Â nM. The labeless electrochemical sensing scheme was then demonstrated for the analysis of biotin in blood plasma. The incorporation of captavidin confers detection specificity and regenerability, whereas the Nafion and carboxymethylcellulose layers circumvent the diffusion of endogenous electroactive species. The biosensing layer is simply regenerated by applying oxidation ofÂ +2Â V for 1Â min instead of its submersion in carbonate buffer for 10Â min.

Enhancing extracellular electron transfer efficiency and bioelectricity production by vapor polymerization Poly (3,4-ethylenedioxythiophene)/MnO2 hybrid anode.

https://www.ncbi.nlm.nih.gov/pubmed/30529692

Electron transfer efficiency in electroactive biofilm is the limiting factor for bioelectricity output of bioelectrochemical system. Here, carbon felt (CF) is coated with manganese dioxide (MnO2) which acts as electron mediator in electroactive biofilm. A wrapping layer of conducting Poly 3,4-ethylenedioxythiophene is developed to protect the MnO2 and enhance electron transfer efficiency of MnO2 mediator. The hybrid bioanode (PEDOT/MnO2/CF bioanode) delivered the highest electron transfer efficiency (6.3â€¯Ã—â€¯10-9â€¯molâ€¯cm-2â€¯s-1/2) and the highest capacitance of 4.78â€¯F, much higher than bare CF bioanode (1.50â€¯Â±â€¯0.04â€¯Ã—â€¯10-9â€¯molâ€¯cm-2â€¯s-1/2 and 0.42â€¯F). As a result, microbial fuel cells could produce a maximum power density of 1534â€¯Â±â€¯13â€¯mWâ€¯m-2, approximately 57.7% higher than that with the bare carbon felt anode (972â€¯Â±â€¯21â€¯mWâ€¯m-2). Possible mechanisms are proposed to help understanding the different function of the PEDOT and MnO2 on the anodic layer. This study introduces an effective method for the fabrication of high performance anode.

Membrane electrodes for determination of some beta-blocker drugs.

https://www.ncbi.nlm.nih.gov/pubmed/17760336

Five poly(vinyl chloride) (PVC) matrix membrane electrodes responsive to the beta-blockers atenolol (AT), bisoprolol fumarate (BI), timolol maleate (TI), and levobunolol HCl (LV) were developed and characterized. A precipitation-based technique with ammonium reineckate anion as an electroactive material in PVC matrix with AT, BI, TI, and LV cations was used for fabrication of Electrodes 1-4, respectively. Electrode 5 fabrication was based on precipitation of LV cation with tungstophosphate

anion as an electroactive material. Fast and stable Nernstian responses at 1 x 10(-2)-1 x 10(-7) M for different beta-blockers over the pH range of 2-8 were found for these electrodes, which were evaluated according to International Union of Pure and Applied Chemistry recommendations. The method was successively applied for the determination of beta-blockers in their pharmaceutical formulations. Validation of the method according to quality assurance standards showed the suitability of the proposed electrodes for use in the quality control assessment of these drugs. The recoveries for the determination of the beta-blocker drugs by the 5 proposed selective electrodes were 100.1 +/- 0.7, 99.9 +/- 0.8, 100.0 +/-1.1, 100.5 +/- 1.1, and 100.6 +/- 0.7% for Sensors 1-5, respectively. Statistical comparison between the results obtained by this method and the official method of the drugs was performed and no significant difference was found.

A probeless and label-free electrochemical immunosensor for cystatin C detection based on ferrocene functionalized-graphene platform.

https://www.ncbi.nlm.nih.gov/pubmed/31103930

A novel electrochemical sensor with inherent redox activity mediated by ferrocene for Cystatin C (CysC), an early kidney failure biomarker, is described. The current response was mediated by graphene oxide-ferrocene nanofilm with redox-activity coming from electroactive species surface-confined. Anti-CysC antibodies were immobilized by their Fc portions on the drop-casting polyethyleneimine (PEI) film for improving the sensitivity and reproducibility. Stepwise modifications of the nanostructured surface were characterized by electrochemical techniques, FT-IR and AFM. FT-IR confirmed the formation of the Fc-GO nanocomposite and PEI deposition on the electrode surface. The AFM micrographs confirmed a nanometric film of Fc-GO and PEI. The sensor platform showed a response from 0.1 to 1000â€¯ng/mL and lower limit of detection (LOD) of 0.03â€¯ng/mL of CysC, with good accuracy, specificity and it was successfully applied for CysC detection. Advantages of this immunosensor include rapid testing with minimal steps by the simple use of an intrinsic redox probe, working in a reduction potential, which avoids potential interferences. This proposal attempts to circumvent amperometric detection limitations and provides a promising candidate for future point-of-care diagnostics without redox probe additional solutions for measurements.

Synthesis and characterization of electroactive and biodegradable ABA block copolymer of polylactide and aniline pentamer.

https://www.ncbi.nlm.nih.gov/pubmed/17218007

A triblock copolymer PLA-b-AP-b-PLA (PAP) of polylactide (PLA) and aniline pentamer (AP) with the unique properties of being both electroactive and biodegradable is synthesized by coupling an electroactive carboxyl-capped AP with two biodegradable bi-hydroxyl-capped PLAs via a condensation reaction. Three different molecule weight PAP copolymers are prepared. The PAP copolymers exhibit excellent electroactivity similar to the AP and polyaniline, which may stimulate cell proliferation and differentiation. The electrical conductivity of the PAP2 copolymer film (approximately 5x10(-6)S/cm) is in the semiconducting region. Transmission electron microscopic results suggest that there is microphase separation of the two block segments in the copolymer, which might contribute to the observed conductivity. The biodegradation and biocompatibility experiments in vitro prove the copolymer is biodegradable and biocompatible. Moreover, these new block copolymer shows good solubility in common organic solvents, leading to the system with excellent processibility. These biodegradable PAP copolymers with electroactive function thus possess the properties that would be potentially used as scaffold materials for neuronal or cardiovascular tissue engineering.

Overoxidized polypyrrole film directed single-walled carbon nanotubes immobilization on glassy carbon electrode and its sensing applications.

https://www.ncbi.nlm.nih.gov/pubmed/17350819

In this paper, the films of overoxidized polypyrrole (PPyox) directed single-walled carbon nanotubes (SWNTs) have been electrochemically coated onto glassy carbon electrode (GCE). Electroactive monomer pyrrole was added into the solution containing sodium dodecyl sulfate (SDS) and SWNTs. Then, electropolymerization was proceeded at the surface of GCE, and a novel kind of conducting polymer/carbon nanotubes (CNTs) composite film with the orientation of CNTs were obtained correspondingly. Finally, this obtained polypyrrole (PPy)/SWNTs film modified GCE was oxidized at a potential of +1.8 V. It can be found that this proposed PPyox/SWNTs composite film modified GCE exhibited excellent electrocatalytic properties for some species such as nitrite, ascorbic acid (AA), dopamine (DA) and uric acid (UA), and could be used as a new sensor for practical applications. Compared with previous CNTs modified electrodes, SWNTs were oriented towards the outside of modified layer by PPyox and SDS, which made the film easily conductive. Moreover, this proposed film modified electrode was more stable, selective and applicable.

Significantly Enhanced Electromechanical Performance of PDMS Crosslinked PVDF Hybrids.

https://www.ncbi.nlm.nih.gov/pubmed/30960639

Poly(vinylidene fluoride)-based ferroelectric polymers have large and tunable dielectric permittivity (Îµr), but rather high Young's modulus (Y), which limits its electromechanical response when used as actuators. In this work, a silicone oligomer involving amino groups is employed to crosslink a non-crystallized poly(vinylidene fluoride-chlorotrifluoroethylene) matrix bearing double bonds (P(VDF-CTFE-DB)) via addition reaction. Thanks to the flexible silicone molecules, the modulus of the hybrids is reduced over 30% when compared with the pristine matrix. Most interestingly, the Îµr of the hybrids is improved to nearly 100% higher than that of the matrix when the silicone content reaches 30 wt %. This may be due to the dilution effect of silicone molecules, which favors macromolecular chain rearrangement and dipole orientation of the hybrids under an applied electric field. As a result, electric-field activated displacements of the above hybrid increases to 0.73 mm from 0.48 mm of the matrix under 60 MV/m. The maximum electric field-induced thickness strain increases from 1% of the matrix to nearly 3% of the crosslinked hybrid. This work may provide a facile strategy to fabricate PVDF-based hybrids with enhanced electromechanical performance under low activating voltage.

Functional histidine/nickel hexacyanoferrate nanotube assembly for biosensor applications.

https://www.ncbi.nlm.nih.gov/pubmed/17482259

By exploring the properties of histidine, functional histidine/nickel hexacyanoferrate nanotube assembly was prepared using nanopore alumina template via a sequential deposition strategy and demonstrated for improved biosensing. The vertically oriented nanotube assembly has a nanotube density approximately 8x10(8)cm(-2) and can be stably attached to the glassy carbon electrode surface. The nanotube assembly formed provides an ordered well-defined three-dimensional (3D) structure with good electron transfer efficiency and a large specific surface area with abundant electroactive sites. Gold nanoparticles were then absorbed onto nanotube surfaces through amino group provided by histidine, and were used for further absorption of glucose oxidase into the 3D matrix. The histidine and gold nanoparticles on the nanotube surface provide a favorable microenvironment to keep the bioactivity of the enzymes with a low apparent Michaelis-Menten constant (K(Mapp)) of 2.15 mM, and the ordered orientation of the nanotube assembly facilitated enzyme-substrate contact. The biosensor was sensitive and selective toward glucose with a linear range covered from 2 microM to 20 mM of glucose. The biosensor was used to determine glucose

concentration in real blood samples with satisfactory results.

Nanodimensional organostannoxane molecular assemblies.

https://www.ncbi.nlm.nih.gov/pubmed/17439190

Organooxotin cages, clusters, and coordination polymers containing [Sn 2(mu-O)], [Sn 2(mu-OH)], [Sn 2(mu-O) 2], [Sn 2(mu-OH) 2], and [Sn 3(mu 3-O)(mu-OR) 3] building blocks have been assembled by the reactions of organotin precursors with phosphonic, phosphinic, carboxylic, or sulfonic acids. Various synthetic methodologies including Sn-C bond cleavage reactions and solventless procedures have been utilized to generate several nanodimensional organostannoxane assemblies. The synthesis, structure, and structural interrelationship of these diverse organostannoxane compounds are discussed. The synthetic knowledge gained to prepare specific organostannoxane structural forms in high yields has been utilized for the construction of dendrimer-like molecules. These contain a central stannoxane core and a functional periphery. The functional periphery can be readily modulated to assemble photoactive, electroactive, or multisite coordinating molecules. The synthesis, structure, and potential uses of these compounds are discussed.

Hybrid Materials Based on Poly-3-amine-7-methylamine-2-methylphenazine and Magnetite Nanoparticles Immobilized on Single-Walled Carbon Nanotubes.

https://www.ncbi.nlm.nih.gov/pubmed/30966578

Polymer-metal-carbon hybrid nanomaterials based on thermostable electroactive poly-3-amine-7-methylamine-2-methylphenazine (PAMMP), single walled carbon nanotubes (SWCNT), and magnetite (Feâ‚ƒOâ„) nanoparticles were synthesized for the first time. Hybrid Feâ‚ƒOâ„/SWCNT/PAMMP nanomaterial synthesis was carried out via in situ chemical oxidative polymerization of 3-amine-7-methylamine-2-methylphenazine hydrochloride in the presence of metal-carbon Feâ‚ƒOâ„/SWCNT nanocomposites. Feâ‚ƒOâ„/SWCNT nanocomposites were obtained by the immobilization of magnetite nanoparticles on the SWCNT surface in the course of Feâ‚ƒOâ„ nanoparticles synthesis in alkaline medium. The developed nanocomposite materials were characterized by FTIR spectroscopy, X-ray diffraction (XRD), transmission electron microscopy (TEM), field emission (FE-SEM) scanning electron microscopy, atomic absorption spectrometry (AAS), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), and magnetometry. The chemical structure and phase composition, magnetic and electrical properties,

and thermal stability of the obtained multifunctional nanomaterials, depending on synthesis conditions, were investigated.

Wireless Coupling of Conducting Polymer Actuators with Light Emission.

https://www.ncbi.nlm.nih.gov/pubmed/30840350

Combining the actuation of conducting polymers with additional functionalities is an interesting fundamental scientific challenge and increases their application potential. Herein we demonstrate the possibility of direct integration of a miniaturized light emitting diode (LED) in a polypyrrole (PPy) matrix in order to achieve simultaneous wireless actuation and light emission. A light emitting diode is used as a part of an electroactive surface on which electrochemical polymerization allows direct incorporation of the electronic device into the polymer. The resulting free-standing polymer/LED hybrid can be addressed by bipolar electrochemistry to trigger simultaneously oxidation and reduction reactions at its opposite extremities, leading to a controlled deformation and an electron flow through the integrated LED. Such a dual response in the form of actuation and light emission opens up interesting perspectives in the field of microrobotics.

Dispirofluorene-indenofluorene derivatives as new building blocks for blue organic electroluminescent devices and electroactive polymers.

https://www.ncbi.nlm.nih.gov/pubmed/18022969

A series of new dispiro[fluorene-9',6,9'',12-indeno[1,2b]fluorenes] (DSF-IFs) has been synthesised. These new building blocks for blue-light-emitting devices and electroactive polymers combine indenofluorene (IF) and spirobifluorene (SBF) properties. We report here our synthetic investigations towards these new structures and their thermal, structural, photophysical and electrochemical properties. These properties have been compared to those of IF and SBF. We also report the anodic oxidation of DSF-IFs that leads to the formation of non-soluble transparent three-dimensional polymers. The structural and electrochemical behaviour of these polymers has been studied. The first application of these building blocks as new blue-light-emitting materials in organic light-emitting diodes (OLED) is also reported.

Degradable conductive self-healing hydrogels based on dextran-graft-tetraaniline and N-carboxyethyl chitosan as injectable carriers for myoblast cell therapy and muscle regeneration.

https://www.ncbi.nlm.nih.gov/pubmed/30528606

Injectable conductive hydrogels have great potential as tissue engineering scaffolds and delivery vehicles for electrical signal sensitive cell therapy. In this work, we present the synthesis of a series of injectable electroactive degradable hydrogels with rapid self-healing ability and their potential application as cell delivery vehicles for skeletal muscle regeneration. Self-healable conductive injectable hydrogels based on dextran-graft-aniline tetramer-graft-4-formylbenzoic acid and N-carboxyethyl chitosan were synthesized at physiological conditions. The dynamic Schiff base bonds between the formylbenzoic acid and amine group from N-carboxyethyl chitosan endowed the hydrogels with rapid self-healing ability, which was verified by rheological test. Equilibrated swelling ratio, morphology, mechanical strength, electrochemistry and conductivity of the injectable hydrogels were fully investigated. The self-healable conductive hydrogels showed an in vivo injectability and a linear-like degradation behavior. Two different kinds of cells (C2C12 myoblasts and human umbilical vein endothelial cells (HUVEC)) were encapsulated in the hydrogels by self-healing effect. The L929 fibroblast cell culture results indicated the biocompatibility of the hydrogels. Moreover, the C2C12 myoblast cells were released from the conductive hydrogels with a linear-like profile. The in vivo skeletal muscle regeneration was also studied in a volumetric muscle loss injury model. All these data indicated that these biodegradable self-healing conductive hydrogels are potential candidates as cell delivery vehicles and scaffolds for skeletal muscle repair. STATEMENT OF SIGNIFICANCE: Injectable hydrogels with self-healing and electrical conductivity properties are excellent candidates as tissue-engineered scaffolds for myoblast cell therapy and skeletal muscle regeneration. The self-healing property of these hydrogels can prolong their lifespan. However, most of the reported conductive hydrogels are not degradable or do not have the self-healing ability. Herein, we synthesized antibacterial conductive self-healing hydrogels as a cell delivery carrier for cardiac cell therapy based on chitosan-grafted-tetraaniline hydrogels synthesized in our previous work. However, an acid solution was used to dissolve the polymers in that study, which may induce toxicity to cells. In this work, we synthesized a series of injectable electroactive biodegradable hydrogels with rapid self-healing ability composed of N-carboxyethyl chitosan (CECS) and dextran-graft-aniline oligomers, and these hydrogel precusor can dissolve in PBS solution of pH 7.4; we further demonstrated their potential application as cell delivery vehicles for skeletal muscle regeneration.

Composite Aerogels of Carbon Nanocellulose Fibers and Mixed-Valent Manganese Oxides as

Renewable Supercapacitor Electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/30960113

Bio-waste derived nanocelluloses show excellent mechanical flexibility and self-aggregated capability, which enable them to be good supporting substrates for the synthesis of electroactive materials. Herein, we present a facile route for fabricating composite aerogels consisting of carbonized nanocellulose fibers (CNF) and mixed-valent manganese oxide (MnOx), toward supercapacitor applications. Mixed solutions of nanocellulose and manganese acetate with different ratios were prepared and freeze-dried into hybrid aerogels. The hybrid aerogels were then transformed into CNF/MnOx composites by a calcination process. The CNF membranes served as porous carbon nano-reservoirs for MnOx and electrolyte. The CNF/MnOx composites also kept a 3D porous aerogel structure with hierarchical pores, which enabled stable transport of both electrolyte ions and electrons to the electrode surface, leading to low a charge-transfer impedance and good electrochemical kinetics. The CNF/MnOx-based symmetric supercapacitor showed a satisfied energy density and power density of 37.5 Wh kg-1 and 2.75 kW kg-1, respectively. All the above results demonstrate the feasibility of using sustainable nanocellulose as a nanoscale carbon substrate for the synthesis of hybrid composite electrodes toward renewable supercapacitor applications.

Electroactive materials with tunable response based on block copolymer self-assembly.

https://www.ncbi.nlm.nih.gov/pubmed/30723198

Ferroelectric polymers represent one of the key building blocks for the preparation of flexible electronic devices. However, their lack of functionality and ability to simply tune their ferroelectric response significantly diminishes the number of fields in which they can be applied. Here we report an effective way to introduce functionality in the structure of ferroelectric polymers while preserving ferroelectricity and to further tune the ferroelectric response by incorporating functional insulating polymer chains at the chain ends of ferroelectric polymer in the form of block copolymers. The block copolymer self-assembly into lamellar nanodomains allows confined crystallization of the ferroelectric polymer without hindering the crystallinity or chain conformation. The simple adjustment of block polarity leads to a significantly different switching behavior, from ferroelectric to antiferroelectric-like and linear dielectric. Given the simplicity and wide flexibility in designing molecular structure of incorporated blocks, this approach shows the vast potential for application in numerous fields.

Solvent-Free Procedure for the Preparation under Controlled Atmosphere Conditions of Phase-Segregated Thermoplastic Polymer Electrolytes.

https://www.ncbi.nlm.nih.gov/pubmed/30960390

A solvent-free method that allows thermoplastic solid electrolytes based on poly(ethylene oxide) PEO to be obtained under controlled atmosphere conditions is presented. This method comprises two steps, the first one being the melt compounding of PEO with a filler, able to physically crosslink the polymer and its pelletizing, and the second the pellets' swelling with an electroactive liquid phase. This method is an adaptation of the step described in previous publications of the preparation of thermoplastic electrolytes by a single melt compounding. In comparison to the single step extrusion methodology, this new method permits employing electroactive species that are very sensitive to atmospheric conditions. The two-step method can also be designed to produce controlled phase-segregated morphologies in the electrolyte, namely polymer-poor and polymer-rich phases, with the aim of increasing ionic conductivity over that of homogeneous electrolytes. An evaluation of the characteristics of the electrolytes prepared by single and two-step procedures is done by comparing membranes prepared by both methods using PEO as a polymeric scaffold and a solution of the room-temperature ionic liquid 1-ethyl-3-methylimidazolium bis(trifluoromethanesulfonyl) imide (EMI TFSI) and the bis(trifluoromethanesulfonyl) imide lithium salt (Li TFSI) as liquid phase. The electrolytes prepared by both methods have been characterized by Fourier transform infrared spectroscopy and optic microscopy profilometry, differential scanning calorimetry, self-creep experiments, and dielectric spectroscopy. In this way, the phase separation, rheology, and ionic conductivity are studied and compared. It is striking how the electrolytes prepared with this new method maintain their solid-like behavior even at 90 Â°C. Compared to the single step method, the two-step method produces electrolytes with a phase-separated morphology, which results in higher ionic conductivity.

Recycled Carbon Fiber-Supported Polyaniline/Manganese Dioxide Prepared via One-Step Electrodeposition for Flexible Supercapacitor Integrated Electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/30961077

The exploration of multifunctional electrode materials has been a hotspot for the development of high-performance supercapacitors. We have used carbon fiber plates recovered from construction waste to prepare high-quality flexible carbon fiber materials by pyrolysis of epoxy resin. The as-prepared recycled carbon fiber has a diameter of 8 Î¼m and is the perfect substrate material for

flexible electrode materials. Furthermore, polyaniline and manganese dioxide are uniformly deposited on the recycled carbon fiber by one-step electrodeposition to form an active film. The recycled carbon fiber/polyaniline/MnOâ,, composite shows an excellent specific capacitance of 475.1 FÂ·g-1 and capacitance retention of 86.1% after 5000 GCD cycles at 1 AÂ·g-1 in 1 M Naâ,,SOâ,„ electrolyte. The composites optimized for electrodeposition time have more electroactive sites, faster ions and electron transfer, structural stability and higher conductivity, endowing the composites promising application prospect.

Conducting Polymers, Hydrogels and Their Composites: Preparation, Properties and Bioapplications.

https://www.ncbi.nlm.nih.gov/pubmed/30960334

This review is focused on current state-of-the-art research on electroactive-based materials and their synthesis, as well as their physicochemical and biological properties. Special attention is paid to pristine intrinsically conducting polymers (ICPs) and their composites with other organic and inorganic components, well-defined micro- and nanostructures, and enhanced surface areas compared with those of conventionally prepared ICPs. Hydrogels, due to their defined porous structures and being filled with aqueous solution, offer the ability to increase the amount of immobilized chemical, biological or biochemical molecules. When other components are incorporated into ICPs, the materials form composites; in this particular case, they form conductive composites. The design and synthesis of conductive composites result in the inheritance of the advantages of each component and offer new features because of the synergistic effects between the components. The resulting structures of ICPs, conducting polymer hydrogels and their composites, as well as the unusual physicochemical properties, biocompatibility and multi-functionality of these materials, facilitate their bioapplications. The synergistic effects between constituents have made these materials particularly attractive as sensing elements for biological agents, and they also enable the immobilization of bioreceptors such as enzymes, antigen-antibodies, and nucleic acids onto their surfaces for the detection of an array of biological agents. Currently, these materials have unlimited applicability in biomedicine. In this review, we have limited discussion to three areas in which it seems that the use of ICPs and materials, including their different forms, are particularly interesting, namely, biosensors, delivery of drugs and tissue engineering.

Optimizing the Energy Harvesting Cycle of a Dissipative Dielectric Elastomer Generator for Performance Improvement.

https://www.ncbi.nlm.nih.gov/pubmed/30961266

This paper optimizes the energy harvesting cycle of dissipative dielectric elastomer generators (DEGs) to explore possible approaches for improving the energy harvesting performance. By utilizing the developed theoretical framework, the dissipative performance of the DEG with a constant voltage cycle is analyzed, which shows good agreement with the existing experimental data. On this basis, we design a novel energy harvesting cycle and a corresponding energy harvesting circuit in which a transfer capacitor is utilized to store the charge transferred from the DEG. Then, the energy conversion performance of the DEG with the novel energy harvesting cycle is investigated. The results indicate that both the energy density and conversion efficiency are improved by choosing a high voltage during the discharging process and that as the R-C time constant increases, the enhancement effect of the voltage increases and then approaches to the saturation. In addition, there is an optimal transfer capacitor that can maximize energy density or conversion efficiency, and the optimal transfer capacitor increases with the increase in the R-C time constant. These results and methods are expected to guide the optimal design and assessment of DEGs.

Restoration of eyelid closure in facial paralysis using artificial muscle: preliminary cadaveric analysis.

https://www.ncbi.nlm.nih.gov/pubmed/17828051

Electroactive polymer artificial muscle is an emerging technology that has the potential to be used in rehabilitating facial movement in patients with paralysis. These electroactive polymers act like human muscles by expanding and contracting based on variable voltage input levels. The authors seek to establish a reproducible eyelid blink with artificial muscle. The aim of this proof of concept study is to determine whether eyelid closure can be created with a novel eyelid sling model.

Electrical energy storage with engineered biological systems.

https://www.ncbi.nlm.nih.gov/pubmed/31073327

The availability of renewable energy technologies is increasing dramatically across the globe thanks to their growing maturity. However, large scale electrical energy storage and retrieval will almost certainly be a required in order to raise the penetration of renewable sources into the grid. No

present energy storage technology has the perfect combination of high power and energy density, low financial and environmental cost, lack of site restrictions, long cycle and calendar lifespan, easy materials availability, and fast response time. Engineered electroactive microbes could address many of the limitations of current energy storage technologies by enabling rewired carbon fixation, a process that spatially separates reactions that are normally carried out together in a photosynthetic cell and replaces the least efficient with non-biological equivalents. If successful, this could allow storage of renewable electricity through electrochemical or enzymatic fixation of carbon dioxide and subsequent storage as carbon-based energy storage molecules including hydrocarbons and non-volatile polymers at high efficiency. In this article we compile performance data on biological and non-biological component choices for rewired carbon fixation systems and identify pressing research and engineering challenges.

Efficient functionalization of carbon nanotubes with porphyrin dendrons via click chemistry.

https://www.ncbi.nlm.nih.gov/pubmed/19919163

The attempt to decorate carbon nanotubes with organic molecules as a powerful means to form new functional materials has attracted broad attention in the scientific community. Here, we report the functionalization of single-walled carbon nanotubes (SWNTs) with zinc porphyrins (ZnP) using very mild conditions to afford a series of SWNTs-ZnP (1 and 2) electron donor-acceptor conjugates. Owing to the presence of either one or two ZnP, introduced via "click chemistry", different absorption cross sections were realized. Important in this context is that the covalent linkages between SWNT and ZnP were corroborated by monitoring the diagnostic signature of the nitrogen atoms as part of the formed triazole ring by X-ray photoelectron spectroscopy (XPS). The resulting SWNTs-ZnP 1 and 2 were fully characterized. This characterization was complemented by a full-fledged investigation of their electrochemical and photophysical properties. In particular, appreciably strong electronic coupling between the photo- and electroactive constituents (i.e., SWNT and ZnP) led to rapid excited-state deactivation of ZnP via charge transfer to the nanotubes. Here, the different absorption cross sections throughout the visible part of the solar spectrum turned out to be valuable in enhancing the overall light-harvesting features. Upon photoexcitation, for both SWNTs-ZnP 1 and 2, radical ion pair states (i.e., reduced SWNT and oxidized ZnP) are formed. The charge-separated states decay to regenerate the singlet ground state with lifetimes of 820 and 200 ps for 1 and 2, respectively.

Enantioselectivity of potentiometric sensors with application of different mechanisms of chiral discrimination.

https://www.ncbi.nlm.nih.gov/pubmed/18006067

In the recent years, numerous successful applications of various chiral selectors in high performance separation methods have generated an increasing interest in the application of some of these compounds as electroactive species in potentiometric sensors. The objective of this work was to examine the enantioselectivy of several different sensors employing substituted cyclodextrins, example antibiotic teicoplanin and electrodeposited conductive polymers for various chiral analytes. Varying degrees of enantioselectivity were found for the ion-selective electrodes examined, depending on the chiral selector used and the target analyte.

Facile Fabrication of Surface-Imprinted Macroporous Films for Chemosensing of Human Chorionic Gonadotropin Hormone.

https://www.ncbi.nlm.nih.gov/pubmed/30714713

We present an improved approach for the preparation of highly selective and homogeneous molecular cavities in molecularly imprinted polymers (MIPs) via the combination of surface imprinting and semi-covalent imprinting. Toward that, first, a colloidal crystal mold was prepared via the Langmuir-BlodgettÂ (LB) technique. Then, human chorionic gonadotropin (hCG) template protein was immobilized on the colloidal crystal mold. Later, hCG derivatization with electroactive functional monomers via amide chemistry was performed. In a final step, optimized potentiostatic polymerization of 2,3'-bithiophene enabled depositing an MIP film as the macroporous structure. This synergistic strategy resulted in the formation of molecularly imprinted cavities exclusively on the internal surface of the macropores, which were accessible after dissolution of silica molds. The recognition of hCG by the macroporous MIP film was transduced with the help of electric transducers, namely, extended-gate field-effect transistors (EG-FET) and capacitive impedimetry (CI). These readout strategies offered the ability to create chemosensors for the label-free determination of the hCG hormone. Other than the simple confirmation of pregnancy, hCG assay is a common tool for the diagnosis and follow-up of ectopic pregnancy or trophoblast tumors. Concentration measurements with these EG-FET and CI-based devices allowed real-time measurements of hCG in the range of 0.8-50Â and 0.17-2.0 fM, respectively, in 10 mM carbonate buffer (pH = 10). Moreover, the selectivity of chemosensors with respect to protein interferences was very high.

Facile Fabrication of Triphenylamine-Based Redox-Active Nanocomposites by a Sol-Gel Method: Enhanced Electrochromic Response Capability and Stability Performance.

https://www.ncbi.nlm.nih.gov/pubmed/31038774

In this research, a new design of organic-inorganic hybrid networks involving covalently bonding, novel, electron-donating triphenylamine (TPA)-containing electroactive molecules to inorganic metal oxides is successfully developed by using a facile sol-gel process. These anodically electrochromic TPA-containing materials exhibit multicolor electrochromic behaviors at various oxidation states. By introducing zirconium oxide into electrochromic materials, not only can an excellent optical transparency in the visible light region at a neutral state be achieved given the nature of the large energy bandgap, but the electrochromic switching can also be driven by a lower oxidation potential with an enhanced response capability (shorter coloring times and bleaching times). Moreover, the hybrid films show outstanding electrochemical stability and high reversibility under long-term operations owing to their good adhesion to the electrode. Consequently, the electrochromic devices derived from these novel hybrid electroactive materials reveal a huge potential for electrochromic applications.

Universal method for direct bioconjugation of electrode surfaces by fast enzymatic polymerization.

https://www.ncbi.nlm.nih.gov/pubmed/30592993

We report HRP-catalyzed polymerization of Tannic acid (TA) and application of the poly (Tannic acid) (p(TA)) as a versatile platform for covalent immobilization of biomolecules on various electrode surfaces based on electrochemical oxidation of the p(TA) and subsequent oxidative coupling reactions with the biomolecules. We also used this method for capturing cancer cells through a linker molecule, folic acid (FA). Furthermore, we have demonstrated that enhanced electrocatalytic activity of the p(TA)-modified surface could be used for simultaneous electrochemical determination of biologically important electroactive molecules such as ascorbic acid (AA), dopamine (DA), and uric acid (UA). This HRP-catalyzed polymerization of TA and p(TA)-mediated surface modification method can provide a simple and new framework to construct multifunctional platforms for covalent attachment of biomolecules and development of sensitive electrochemical sensing devices.

Optimized fabrication of newly cholesterol biosensor based on nanocellulose.

https://www.ncbi.nlm.nih.gov/pubmed/30611809

A novel and sensitive electrochemical cholesterol biosensor was developed based on immobilization cholesterol oxidase (ChOx) on the polyaniline/crystalline nanocellulose/ionic liquid modified Screen-Printed Electrode (PANi/CNC/IL/SPE). A thin layer of ionic liquid (IL) was spin coated on the modified electrode to enhance the electron transferring. Crystalline nanocellulose was prepared from Semantan bamboo (Gigantochloa scortechinii) via acid hydrolysis and it was used to synthesize a nanocomposite of PANi/CNC via in situ oxidative polymerization process. FESEM and TEM images showed high porosity of the nanostructure with no phase separation, revealing the homogenous polymerization of the monomer on the surface of the crystalline cellulose. Research surface methodology (RSM) was carried out to optimize the parameters and conditions leading to maximize the performance and sensitivity of biosensors. The PANi/CNC/IL/GLU/ChOx-modified electrode showed a high sensitivity value of 35.19â€¯Î¼Aâ€¯mM/cm-2 at optimized conditions. The proposed biosensor exhibited a dynamic linear range of 1â€¯Î¼M to 12â€¯mM (R2â€¯=â€¯0.99083) with the low Limit of Detection of 0.48â€¯Î¼M for cholesterol determination. An acceptable reproducibility (RSDs â‰¤3.76%) and repeatability (RSDs â‰¤3.31%) with the minimal interference from the coexisting electroactive compounds such as ascorbic acid, uric acid and glucose was observed for proposed biosensor.

Implantable Systems for Stress Urinary Incontinence.

https://www.ncbi.nlm.nih.gov/pubmed/29022114

Stress urinary incontinence (SUI), the involuntary urine leakage due to failure of the urethral closure mechanism, is a global health challenge with substantial human suffering and socioeconomic costs. Approximately 167 million male and female patients are predicted to suffer from SUI in 2018, worldwide. A wide range of surgical interventions are available for the treatment of SUI. Severe cases, however, usually require the implantation of artificial urinary sphincter devices. This review comparatively presents and analyzes the working principles, as well as the challenges, associated with the current implantable SUI systems in clinical use. These include slings, urethral bulking agents, artificial urinary sphincters, and adjustable continence devices. It further reports on recent research progress and state-of-the-art in the field of SUI implants, including an original approach proposed by the authors with a pressure feedback sensory mechanism. The new emerging field of artificial muscle devices, including electroactive polymers, provides a promising innovative solution for replacing the weakened urethral sphincter in SUI patients.

Dopamine-Incorporated Dual Bioactive Electroactive Shape Memory Polyurethane Elastomers with Physiological Shape Recovery Temperature, High Stretchability, and Enhanced C2C12 Myogenic Differentiation.

https://www.ncbi.nlm.nih.gov/pubmed/28812353

Soft tissue engineering needs elastic biomaterials not only mimicking the elasticity of soft tissue but also possessing multiple bioactivity to promote cell adhesion, proliferation, and differentiation, which still remain ongoing challenges. Herein, we synthesized a series of dopamine-incorporated dual bioactive electroactive shape memory polyurethane elastomers by combining the properties of elastomeric poly(citric acid-co-polycaprolactone) (CA-PCL) polyurethane elastomer, bioactive dopamine (DA), and electroactive aniline hexamer (AH). The chemical structures, electroactivity, conductivity, thermal properties, hydrophilicity and hydration ability, mechanical properties, and degradability of the polyurethane elastomers were systematically characterized. The elastomers showed excellent shape fixity ratio and shape recovery ability under physiological conditions. The elastomers' elongation and stress were tailored by the AH content, whereas the hydrophilicity and hydration ability of the elastomers were adjusted by the content of DA and AH, as well as the doping state of AH. The viability and proliferation results of C2C12 cells seeded on the elastomers showed their excellent cytocompatibility. Additionally, by analyzing the protein and gene level, the promotion effect on myogenic differentiation of C2C12 cells by these elastomers compared to that by control groups (PCL80â€‰000, CA-PCL elastomer, and CA-PCL elastomer with the DA segment) was demonstrated. Furthermore, the results from subcutaneous implantation confirmed the elastomers' mild host response in vivo. These results represent that these dopamine-incorporated dual bioactive electroactive shape memory polyurethane elastomers are promising candidates for soft tissue regeneration that is sensitive to electrical signals.

Comparative Analysis of Fluorinated Anions for Polypyrrole Linear Actuator Electrolytes.

https://www.ncbi.nlm.nih.gov/pubmed/31083347

Either as salts or room temperature ionic liquids, fluorinated anion-based electrolytes have been a common choice for ionic electroactive polymer actuators, both linear and bending. In the present work, propylene carbonate solutions of four electrolytes of the three hugely popular anions-triflouromethanesulfonate, bis(trifluoromethane)sulfonimide, and hexafluorophosphate were compared and evaluated in polypyrrole linear actuators. The actuation direction, the characteristics-performance relations influence the behavior of the actuators. Isotonic

Electro-chemo-mechanical deformation (ECMD) measurements were performed to study the response of the PPy/DBS samples. The highest strain for pristine PPy/DBS linear actuators was found in range of 21% for LiTFSI, while TBAPF6 had the least cation involvement, suggesting the potential for application in durable and controllable actuators. Interesting cation effects on the actuation of the same anions (CF3SO3-) were also observed.

Hybrid polymer biomaterials for bone tissue regeneration.

https://www.ncbi.nlm.nih.gov/pubmed/30377934

Native tissues possess unparalleled physiochemical and biological functions, which can be attributed to their hybrid polymer composition and intrinsic bioactivity. However, there are also various concerns or limitations over the use of natural materials derived from animals or cadavers, including the potential immunogenicity, pathogen transmission, batch to batch consistence and mismatch in properties for various applications. Therefore, there is an increasing interest in developing degradable hybrid polymer biomaterials with controlled properties for highly efficient biomedical applications. There have been efforts to mimic the extracellular protein structure such as nanofibrous and composite scaffolds, to functionalize scaffold surface for improved cellular interaction, to incorporate controlled biomolecule release capacity to impart biological signaling, and to vary physical properties of scaffolds to regulate cellular behavior. In this review, we highlight the design and synthesis of degradable hybrid polymer biomaterials and focus on recent developments in osteoconductive, elastomeric, photoluminescent and electroactive hybrid polymers. The review further exemplifies their applications for bone tissue regeneration.

Electrochemical quartz crystal microbalance study of covalent tethering of carboxylated thiol to polyaniline for electrocatalyzed oxidation of ascorbic acid in neutral aqueous solution.

https://www.ncbi.nlm.nih.gov/pubmed/19812825

The electrochemical quartz crystal microbalance (EQCM) was used to study the electrosyntheses and electrochemical properties of two kinds of polyaniline (PANI)-thiol composite films in aqueous solutions, which were prepared by covalent binding of a thiol to the oxidized forms of PANI (PANI(post)-thiol, protocol A), and electropolymerization of aniline in the presence of a thiol (PANI(poly)-thiol, protocol B), respectively. The thiols involved were mercaptosuccinic acid (MSA), thioglycolic acid (TGA) and beta-mercaptoethanol (ME). The PANI(post)-thiol binding processes were monitored in situ with the EQCM, giving molar binding ratios (r, thiol vs. aniline unit of the

polymer) of ca. 0.50 at saturation for these thiols. Both PANI(post)-thiol and PANI(poly)-thiol composite films from the carboxylated thiols showed a controllable electroactivity of the PANI moiety in neutral even weakly alkaline phosphate buffer solutions (PBS), with maximum electroactivity roughly at r = 0.11 for PANI(post)-MSA or at r = 0.21 for PANI(post)-TGA. The PANI-thiol interaction was also supported by experiments of scanning electron microscopy, electrochemical surface plasmon resonance, Fourier transform infrared spectroscopy and ultraviolet-visible spectroscopy, and the interaction mechanism is briefly discussed. The PANI(post)-thiol and PANI(poly)-thiol composite films from the carboxylated thiols effectively electrocatalyzed the oxidation of ascorbic acid in pH = 7.3 PBS, and the PANI(post)-thiol exhibited electrocatalytic activity higher than the relevant PANI(poly)-thiol under our experimental conditions. The covalent anchoring of anionic thiol groups on the PANI backbone to prepare electroactive PANI in neutral solutions is conceptually new and may be extended to the development of new functional materials from many other conducting polymers and thiols for wide applications in catalysis, biosensing, molecular electronics, and so on.

Analysis of effect of nanoporous alumina substrate coated with polypyrrole nanowire on cell morphology based on AFM topography.

https://www.ncbi.nlm.nih.gov/pubmed/20207084

In this study, in situ electrochemical synthesis of polypyrrole nanowires with nanoporous alumina template was described. The formation of highly ordered porous alumina substrate was demonstrated with Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM). In addition, Fourier transform infrared analysis confirmed that polypyrrole (PP) nanowires were synthesized by direct electrochemical oxidation of pyrrole. HeLa cancer cells and HMCF normal cells were immobilized on the polypyrrole nanowires/nanoporous alumina substrates to determine the effects of the substrate on the cell morphology, adhesion and proliferation as well as the biocompatibility of the substrate. Cell adhesion and proliferation were characterized using a standard MTT assay. The effects of the polypyrrole nanowires/nanoporous alumina substrate on the cell morphology were studied by AFM. The nanoporous alumina coated with polypyrrole nanowires was found to exhibit better cell adhesion and proliferation than polystyrene petridish, aluminum foil, 1st anodized and uncoated 2nd anodized alumina substrate. This study showed the potential of the polypyrrole nanowires/nanoporous alumina substrate as biocompatibility electroactive polymer substrate for both healthy and cancer cell cultures applications.

Melanin incorporated electroactive and antioxidant silk fibroin nanofibrous scaffolds for nerve tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/30423699

Nerve restoration and repair in the central nervous system is complicated and requires several factors to be considered while designing the scaffolds like being bioactive as well as having neuroinductive, neuroconductive and antioxidant properties. Aligned electrospun nanofibers provide necessary guidance and topographical cues required for directing the axonal and neurite outgrowth during regeneration. Conduction of nerve impulses is a mandatory feature of a typical nerve. The neuro-conductive property can be imparted by blending the biodegradable, bioactive polymers with conductive polymers. This will provide additional features, i.e., electrical cues to the already existing topographical and bioactive cues in order to make it a more multifaceted neuroregenerative approach. Hence in the present study, we used a combination of silk fibroin and melanin for the fabrication of random and aligned electrospun nanofibrous composite scaffolds. We performed the physico-chemical characterization and also assessed their antioxidant properties. We also evaluated their neurogenic potential using human neuroblastoma cells (SH-SY5Y) for their cellular viability, proliferation, adhesion and differentiation levels. Designed nanofibrous scaffolds had adequate physical properties suitable as neural substrates to promote neuronal growth and regeneration. They stimulated the neuroblastoma cell attachment and viability indicating their biocompatible nature. Silk/melanin composite scaffolds have specifically exhibited high antioxidant nature proven by the radical scavenging activity. Additionally, the melanin incorporated aligned silk fibroin scaffolds promoted the cell differentiation into neurons and orientation along their axis. Our results confirmed the potential of melanin incorporated aligned silk fibroin scaffolds as the promising candidates for effective nerve regeneration and recovery.

Highly stable Ni-MOF comprising triphenylamine moieties as a high-performance redox indicator for sensitive aptasensor construction.

https://www.ncbi.nlm.nih.gov/pubmed/30612659

Electroactive metal-organic frameworks (MOFs) with large surface area and manipulatable structural properties show promise as a new type of signal probe for electrochemical biosensing application. In this work, an electroactive Ni-MOF, assembled by the redox-active ligands 4,4',4â€³-Tricarboxytriphenylamine (H3TCA), a triphenylamine derivatives, as the electroactive source and magnetic ordered Ni4O4 clusters as electronic transport nodes, is first designed and

applied for electrochemical aptasensing of thrombin (Tb). The designed Ni-MOF probe realizes a stable and sensitive electrochemical signal output based on simple sandwich-type aptasensing because the high-content TCA active sites and good magnetic ordered intermediate of Ni4O4 clusters are periodically arranged in well-defined porous structure of the MOF. The Ni-MOF probe assembled by redox-active ligand presents the high stability and can be directly applied in electrochemical aptasensor, avoiding any post-modification and the addition of redox mediators. As a result, the constructed electrochemical aptasensor shows a wide linear relationship for Tb from 0.05 pM to 50â€¯nM and a detection limit of 0.016 pM (S/Nâ€¯=â€¯3). Furthermore, the proposed aptasensor is successfully applied to analysis of target Tb in real serum sample with satisfactory results. The present work indicates that fabricating a redox-active organic molecule in functionalized MOFs offer a feasible strategy to design high-stable electroactive MOFs for construction of electrochemical biosensors with simplicity, high selectivity and sensitivity.

Prospects for electroactive andÂ conducting framework materials.

https://www.ncbi.nlm.nih.gov/pubmed/31130095

Electroactive and conducting framework materials, encompassing coordination polymers and metal-organic frameworks, have captured the imagination of the scientific community owing to their highly designable nanoporous structures and their potential applications in electrochromic devices, electrocatalysts, porous conductors, batteries and solar energy harvesting systems, among many others. While they are now considered integral members of the broader field of inorganic materials, it is timely to reflect upon their strengths and challenges compared with 'traditional' solid-state materials such as minerals, pigments and zeolites. Indeed, the latter have been known since ancient times and have been prized for centuries in fields as diverse as art, archaeology and industrialÂ catalysis. This opinion piece considers a brief historical perspective of traditional electroactive and conducting inorganic materials, with a view towards very recent experimental progress and new directions forÂ future progress in the burgeoning area of coordination polymers and metal-organic frameworks. Overall, this article bears testament to the rich history of electroactive solids and looks at the challenges inspiring a new generation of scientists. This article is part of the theme issue 'Mineralomimesis: natural and synthetic frameworks in science and technology'.

Development of molecularly imprinted electrochemical sensor with reduced graphene oxide

and titanium dioxide enhanced performance for the detection of toltrazuril in chicken muscle and egg.

https://www.ncbi.nlm.nih.gov/pubmed/30469110

A molecularly imprinted electrochemical sensor for toltrazuril (TZR) detection based on molecularly imprinted polymers (MIPs) immobilized on reduced graphene oxide (rGO) and titanium dioxide (TiO2) modified platinum (Pt) electrode surface was fabricated for the first time. The synergistic fast electron transfer ability, large electroactive surface area and high catalytic activity from rGO and TiO2 contribute to amplify the electrochemical signal and consequently improve the sensitivity of the sensor. The cyclic voltammetry (CV), differential pulse voltammetry (DPV) and electrochemical impedance spectroscopy (EIS) tests were used to evaluate the performance of the electrochemical sensor. The results showed that the electrochemical sensor possessed high sensitivity, good selectivity and anti-interference ability toward TZR. By using the DPV, the electrochemical sensor displayed a wide linear concentration range from 0.43 to 42.54â€‰Î¼g/L, with a limit of detection of 0.21â€‰Î¼g/L (S/Nâ€‰=â€‰3). Moreover, the recoveries and relative standard deviations (RSD) were 85.0%-97.0% and 3.5%-6.4% at three concentration levels, respectively, implying that the established sensor is promising for the accurate detection of TZR at trace levels in chicken muscle and egg samples.

Assay of serum cholinesterase activity by an amperometric biosensor based on a co-crosslinked choline oxidase/overoxidized polypyrrole bilayer.

https://www.ncbi.nlm.nih.gov/pubmed/29363680

Based on choline oxidase immobilized by co-crosslinking on an overoxidised polypyrrole modified platinum electrode, a novel electrochemical assay for cholinesterase activity in human serum was developed. The assay was performed by adding an aliquot of cholinesterase standard solution or serum sample to phosphate buffer containing choline or thiocholine ester and measuring the oxidation current of hydrogen peroxide at the rotating modified electrode polarized at +0.7 V vs. SCE. The influence of some experimental parameters such as pH of the assay, mass transport at the electrode, type and concentration of the cholinesterase substrate was studied and optimised. Reversible inhibition of choline oxidase from cholinesterase substrates was evidenced for the first time, which increases in the order of acetylcholine, butyrylcholine and s-butyrylthiocholine. Wide linear range, fast response time and appreciable long-term stability were assured for both acethyl- and butyrylcholinesterase assays. On allowing the polypyrrole layer to efficiently remove

interferences from the electroactive compounds in the sample, the present method revealed to be suitable for the detection of butyrylcholinesterase in human serum at activities as low as 0.5 U L-1. The validation with a reference spectrophotometric method showed no significant differences when human serum samples were analysed.

Mussel-Inspired Electroactive and Antioxidative Scaffolds with Incorporation of Polydopamine-Reduced Graphene Oxide for Enhancing Skin Wound Healing.

https://www.ncbi.nlm.nih.gov/pubmed/30714361

Wound repair and tissue regeneration are complex processes that involve many physiological signals. Thus, employing novel wound dressings with potent biological activity and physiological signal response ability to accelerate wound healing is a possible solution. Herein, inspired by mussel chemistry, we developed a polydopamine (PDA)-reduced graphene oxide (pGO)-incorporated chitosan (CS) and silk fibroin (SF) (pGO-CS/SF) scaffold with good mechanical, electroactive, and antioxidative properties as an efficient wound dressing. First, pGO with good dispersibility and cell affinity was obtained upon reduction by PDA under alkali conditions. Second, pGO was dispersed into a CS/SF mixture, and then CS and SF chains were dual-cross-linked by poly(ethylene glycol) diglycidyl ether and glutaraldehyde to obtain a pGO-incorporated gel. Finally, the gel underwent a freeze-dry process to obtain the pGO-CS/SF scaffold. Owing to PDA reduction and functionalization, pGO in the scaffold plays important roles for the performances of the scaffolds. First, the pGO acts as nanoreinforcement to enhance the mechanical properties of the scaffold by combining the dual-cross-linked CS/SF network. Second, the uniformly distributed pGO in the scaffolds comprises a well-connected electric pathway, which can provide a channel for the transmission of electrical signals in the scaffold. Moreover, pGO in the scaffolds serves as an antioxidant agent to scavenge reactive oxygen species (ROS) and therefore terminates excessive ROS oxidation. In vitro studies show that electroactive pGO-CS/SF scaffolds can respond to electrical signals and promote cytological behavior. In addition, the pGO-CS/SF scaffolds can reduce cellular oxidation by removing excessive ROS. The in vivo full-thickness skin defect model demonstrates that the electroactive and antioxidative pGO-CS/SF scaffold can efficiently enhance wound healing. In summary, the pGO-CS/SF scaffold is a promising wound dressing because of its ability to promote physiological electrical signal transmission for cell growth and reduce ROS oxidation, resulting in an improved wound regeneration effect.

A complicated biocomputing system based on multi-responsive P(NIPAM-co-APBA) copolymer film electrodes and electrocatalysis of NADH.

https://www.ncbi.nlm.nih.gov/pubmed/28808714

In this paper, poly(N-isopropylacrylamide-co-3-aminophenylboronic acid) (P(NIPAM-co-APBA)) copolymer films were successfully electropolymerized on the Au electrode surface. The electroactive probe ferrocene carboxylic acid (FCA) in solution showed reversible thermal-, glucose- and pH-responsive on-off cyclic voltammetric (CV) behaviors at the film electrodes. The comparative experiments demonstrated that the thermo-responsive property of the film electrode was ascribed to the PNIPAM component of the films, whereas the glucose- and pH-sensitive behaviors came from the PAPBA constituent. The reduced form of nicotinamide adenine dinucleotide (NADH) could be electrocatalytically oxidized by FCA at the film electrodes, which would greatly amplify the multi-responsive CV signal difference between the on and off states. On the basis of these results, a binary 4-input/4-output logic circuit was fabricated with temperature, glucose, pH and NADH as inputs and the CV responses at 4 different levels as outputs. Moreover, a ternary CONSENSUS logic circuit was established on the same platform, which was the first report on the combination of ternary logic gate and bioelectrocatalysis without using enzymes. This work provided a novel idea for constructing complicated biocomputing systems by increasing the number of inputs/outputs with multi-sensitive interfaces and by designing new types of multi-valued logic gates on the basis of bioelectrocatalysis.

Enzyme immobilization on Ag nanoparticles/polyaniline nanocomposites.

https://www.ncbi.nlm.nih.gov/pubmed/19427191

We show a simple strategy to obtain an efficient enzymatic bioelectrochemical device, in which urease was immobilized on electroactive nanostructured membranes (ENMs) made with polyaniline and silver nanoparticles (AgNP) stabilized in polyvinyl alcohol (PAni/PVA-AgNP). Fabrication of the modified electrodes comprised the chemical deposition of polyaniline followed by drop-coating of PVA-AgNP and urease, resulting in a final ITO/PAni/PVA-AgNP/urease electrode configuration. For comparison, the electrochemical performance of ITO/PAni/urease electrodes (without Ag nanoparticles) was also studied. The performance of the modified electrodes toward urea hydrolysis was investigated via amperometric measurements, revealing a fast increase in cathodic current with a well-defined peak upon addition of urea to the electrolytic solution. The cathodic currents for the ITO/PAni/PVA-AgNP/urease electrodes were significantly higher than for the ITO/PAni/urease

electrodes. The friendly environment provided by the ITO/PAni/PVA-AgNP electrode to the immobilized enzyme promoted efficient catalytic conversion of urea into ammonium and bicarbonate ions. Using the Michaelis-Menten kinetics equation, a K(M)(app) of 2.7 mmol L(-1) was obtained, indicating that the electrode architecture employed may be advantageous for fabrication of enzymatic devices with improved biocatalytic properties.

Highly Transparent and Integrable Surface Texture Change Device for Localized Tactile Feedback.

https://www.ncbi.nlm.nih.gov/pubmed/29140605

Human-machine haptic interaction is typically detected by variations in friction, roughness, hardness, and temperature, which combines to create sensation of surface texture change. Most of the current technologies work to simulate changes in tactile perception (via electrostatic, lateral force fields, vibration motors, etc.) without creating actual topographical transformations. This makes it challenging to provide localized feedback. Here, a new concept for on-demand surface texture augmentation that is capable of physically forming local topographic features in any predesigned pattern is demonstrated. The transparent, flexible, integrable device comprises of a hybrid electrode system with conductive hydrogel, silver nanowires, and conductive polymers with acrylic elastomer as the dielectric layer. Desired surface textures can be controlled by a predesigned pattern of electrodes, which operates as independent or interconnected actuators. Surface features with up to a height of 0.155 mm can be achieved with a transformation time of less than a second for a device area of 18 cm2 . High transparency levels of 76% are achieved due to the judicious choice of the electrode and the active elastomer layer. The capability of localized and controlled deformations makes this system highly useful for applications such as display touchscreens, touchpads, braille displays, on-demand buttons, and microfluidic devices.

Study of micellar and phase separation behavior of mixed systems of triblock polymers.

https://www.ncbi.nlm.nih.gov/pubmed/19616785

Cyclic voltammetric (CV) techniques have been employed to study the mixed micellar behavior of binary mixtures of triblock polymers (TBP) such as F127+P85, F127+P85, F88+P85, and F88+P123 using 2,2,6,6-tetramethyl-1-piperidinyloxy (Tempo) as an electroactive probe. Critical micellar concentration (cmc) has been obtained for pure triblock polymers and their mixed systems from the plots of peak current (ip) variation versus the total concentration. Diffusion coefficients of the

electroactive species have been determined from the Randles-Sevcik equation. The interaction parameter (beta) for the mixed micelles was obtained from the regular solution theory. The values of beta suggest that the synergism does exist especially with the F88+P123 system. Cloud point measurements have also been made on the binary mixtures of triblock polymers following similar mixing criteria. An effort has been made to correlate the micellar behavior and phase separation (cloud point) phenomenon. From the correlation, it can be concluded that in the systems studied, an increase in cmc increases the cloud point of mixed systems of triblock polymers.

Electroactive biomaterials: Vehicles for controlled delivery of therapeutic agents for drug delivery and tissue regeneration.

https://www.ncbi.nlm.nih.gov/pubmed/29262296

Electrical stimulation for delivery of biochemical agents such as genes, proteins and RNA molecules amongst others, holds great potential for controlled therapeutic delivery and in promoting tissue regeneration. Electroactive biomaterials have the capability of delivering these agents in a localized, controlled, responsive and efficient manner. These systems have also been combined for the delivery of both physical and biochemical cues and can be programmed to achieve enhanced effects on healing by establishing control over the microenvironment. This review focuses on current state-of-the-art research in electroactive-based materials towards the delivery of drugs and other therapeutic signalling agents for wound care treatment. Future directions and current challenges for developing effective electroactive approach based therapies for wound care are discussed.

Heterogenization of a [NiFe] Hydrogenase Mimic through Simple and Efficient Encapsulation into a Mesoporous MOF.

https://www.ncbi.nlm.nih.gov/pubmed/29193978

In the quest for new, efficient, and noble-metal-free H2-evolution catalysts, hydrogenase enzymes are a source of inspiration. Here, we describe the development of a new hybrid material based on a structural and functional [NiFe]-hydrogenase model complex (NiFe) incorporated into the Zr-based MOF PCN-777. The bulk NiFe@PCN-777 material was synthesized by simple encapsulation. Characterization by solid-state NMR and IR spectroscopy, SEM-EDX, ICP-OES, and gas adsorption confirmed the inclusion of the guest. FTO-supported thin films of the NiFe@PCN-777 composite were obtained by electrophoretic deposition of the bulk material and characterized by SEM-EDX, ICP-OES, and cyclic voltammetry. The average surface concentration of electroactive NiFe catalyst

in the film was found to be âˆ¼9.6 Ã— 10-10 mol cm-2, implying that a surprisingly high fraction (37%) of NiFe units incorporated in the MOF are electroactive. By cyclic voltammetry, we showed that NiFe maintains its electrocatalytic capabilities for H+ reduction inside the MOF cavities, even if under controlled-potential electrolysis conditions the activity of NiFe cannot be discerned from that of free PCN-777 and FTO.

Direct electrochemistry and electrocatalysis of hemoglobin protein entrapped in graphene and chitosan composite film.

https://www.ncbi.nlm.nih.gov/pubmed/20188928

A novel, biocompatible sensing strategy based on graphene and chitosan composite film for immobilizing the hemoglobin protein was firstly adopted. The direct electron transfer and bioelectrocatalytic activity of hemoglobin after incorporation into the composite film were investigated. A pair of reversible redox waves of hemoglobin was appeared, and hemoglobin could exhibit its bioelectrocatalytic activity toward H(2)O(2) in a long term. Such results indicated that graphene and chitosan composite could be a friendly biocompatible interface for immobilizing biomolecules and keeping their native structure. Furthermore, the appearance of graphene in the composite film could facilitate the electron transfer between matrix and the electroactive center of hemoglobin. Hence, this graphene and chitosan based protocol would be a promising platform for protein immobilization and biosensor preparation.

Selective Amperometric Recording of Endogenous Ascorbate Secretion from a Single Rat Adrenal Chromaffin Cell with Pretreated Carbon Fiber Microelectrodes.

https://www.ncbi.nlm.nih.gov/pubmed/28776368

Quantitative description of ascorbate secretion at a single-cell level is of great importance in physiological studies; however, most studies on the ascorbate secretion have so far been performed through analyzing cell extracts with high performance liquid chromatography, which lacks time resolution and analytical performance on a single-cell level. This study demonstrates a single-cell amperometry with carbon fiber microelectrodes (CFEs) to selectively monitor amperometric vesicular secretion of endogenous ascorbate from a single rat adrenal chromaffin cell. The CFEs are electrochemically pretreated in a weakly basic solution (pH 9.5), and such pretreatment essentially enables the oxidation of ascorbate to occur at a relatively low potential (i.e., 0.0 V vs Ag/AgCl), and further a high selectivity for ascorbate measurement over endogenously existing electroactive

species such as epinephrine, norepinephrine, and dopamine. The selectivity is ensured by much larger amperometric response at the pretreated CFEs toward ascorbate over those toward other endogenously existing electroactive species added into the solution or ejected to the electrode with a micropuffer pipet, and by the totally suppressed current response by adding ascorbate oxidase into the cell lysate. With the pretreated CFE-based single-cell amperometry developed here, exocytosis of endogenous ascorbate of rat adrenal chromaffin cells is directly observed and ensured with the calcium ion-dependent high K+-induced secretion of endogenous ascorbate from the cells. Moreover, the quantitative information on the exocytosis of endogenous ascorbate is provided.

pH-Controllable bioelectrocatalysis based on "on-off" switching redox property of electroactive probes for spin-assembled layer-by-layer films containing branched poly(ethyleneimine).

https://www.ncbi.nlm.nih.gov/pubmed/20170091

Weak polybase branched poly(ethyleneimine) (BPEI) and strong polyacid poly(styrenesulfonate) (PSS) were assembled into BPEI/{PSS/BPEI}(n) layer-by-layer (LBL) films on electrodes by electrostatic interaction between them with spin-coating approach. The cyclic voltammetric (CV) response of ferrocenedicarboxylic acid (Fc(COOH)(2)) at BPEI/{PSS/BPEI}(n) film electrodes was very sensitive to the pH of the testing solutions. At pH 4.0, the probe showed a well-defined CV peak pair with relatively large peak currents for the films, while, at pH 7.0, the CV response was significantly depressed. By switching the film electrodes in buffers between pH 4.0 and 7.0, the CV peak currents changed periodically between a relatively high value at the "on" state and a very low value at the "off" state, indicating that the pH-sensitive "on-off" switching function of the films toward the probe is reversible. A series of comparative experiments indicates that the electrostatic interaction between the films and the probe plays a predominant role in deciding the pH-sensitive behavior of the films. This pH-dependent property of the films could be used to control or modulate the bioelectrocatalysis of glucose by glucose oxidase (GOD) with Fc(COOH)(2) as the mediator by changing the surrounding pH. This "smart" bioelectrocatalytic film system may establish a foundation for fabricating novel pH-controllable electrochemical biosensors.

Detection of DNA damage induced by styrene oxide in dsDNA layer-by-layer films using adriamycin as electroactive probe.

https://www.ncbi.nlm.nih.gov/pubmed/20022225

The detection of DNA damage is one of the most important topics in the DNA research fields. In this paper, an electrochemical method for the detection of DNA damage by combining the layer-by-layer assembly film with adriamycin (ADM) as an electrochemical probe was developed. Firstly, the layer-by-layer {dsDNA/PEI}(n) film was prepared by the alternate adsorption of polycationic polyethyleneimine (PEI) and negatively charged natural DNA onto glassy carbon electrode (GCE) surface. Its electrochemical behaviors were characterized by electrochemical impedance spectroscopy (EIS) and differential pulse voltammetry (DPV), and the optimal value of n was determined to be 2. Secondly, the {dsDNA/PEI}(2) film was immersed into the solution of ADM and the {dsDNA/PEI}(2)-ADM was obtained. While transferred into the blank solution, the {dsDNA/PEI}(2)-ADM would gradually release ADM, exhibiting the good reversibility of ADM incorporation. Finally, the DNA damage induced by styrene oxide (SO) was investigated and the promising results showed that the present method can be a useful tool for the detection of DNA damage.

Synthesis and application of a "plastic antibody" in electrochemical microfluidic platform for oxytocin determination.

https://www.ncbi.nlm.nih.gov/pubmed/28934696

By means of molecular imprinting of a conducting polymer, molecular cavities selective for oxytocin nonapeptide, an autism biomarker, were designed. Embedding of the oxytocin template, and then its extracting from the molecularly imprinted polymer (MIP) was confirmed by the XPS analysis. AFM imaging of the MIP film surface indicated changes in mechanical properties of the film after template extraction. The MIP synthetic receptor was deposited by potentiodynamic electropolymerization as a thin film on an Au film electrode in an electrochemical miniaturized microfluidic cell. The use of this cell allowed to shorten analysis time and to decrease the sample volume. The linear dynamic concentration range extended from 0.06 to 1mM with the limit of detection of 60ÂµM (S/N = 3). Advantageously, sensitivity of the diagnostic microfluidic platform devised for oxytocin determination in both synthetic serum samples and in aqueous solutions was similar and, moreover, it was selective to common interferences, such as oxytocin analogs and potential metabolites.

Synergistic contributions of fullerene, ferrocene, chitosan and ionic liquid towards improved performance for a glucose sensor.

https://www.ncbi.nlm.nih.gov/pubmed/19962876

The paper describes an ingenious approach for the fabrication of a promising glucose sensor, GOx/C(60)-Fc-CS-IL, that exploits the synergistic beneficial characteristics of fullerene (C(60)), ferrocene (Fc), chitosan (CS) and ionic liquid (IL) for glucose oxidase (GOx). Cyclic voltammetry, impedance spectroscopy and chronoamperometry were used to evaluate performance of the biosensor, respectively. Since efficient electron transfer between GOx and the electrode was achieved, the biosensor exhibits a high sensitivity (234.67 nA nM(-1) cm(-2)), low detection limit (S/N=3) (3x10(-9) M), fast response time (0.752 s), wide calibration range (from 1x10(-8) M to 1x10(-5) M) and excellent long-term stability (30 weeks). The apparent Michaelis-Menten constant (K(M)) of GOx on the composite medium, 0.03 mM, shows high bioelectrocatalytic activity of immobilized enzyme toward glucose oxidation. Due to low operating potential (100 V), the biosensor is relatively insensitive to electroactive interfering species in human blood such as ascorbic acid, and uric acid, which are commonly found in blood samples. Excellent electrochemical reversibility, high sensitivity and stability, technically simple and possibility of preparation at short period of time are of great advantages of these glucose biosensors.

Soft Ionic Electroactive Polymer Actuators with Tunable Non-Linear Angular Deformation.

https://www.ncbi.nlm.nih.gov/pubmed/28773036

The most rational approach to fabricate soft robotics is the implementation of soft actuators. Conventional soft electromechanical actuators exhibit linear or circular deformation, based on their design. This study presents the use of conjugated polymers, Poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT:PSS) to locally vary ion permeability of the ionic electroactive polymer actuators and manipulate ion motion through means of structural design to realize intrinsic angular deformation. Such angular deformations are closer to biomimetic systems and have potential applications in bio-robotics. Electrochemical studies reveal that the mechanism of actuation is mainly associated with the charging of electric double layer (EDL) capacitors by ion accumulation and the PEDOT:PSS layer's expansion by ion interchange and penetration. Dependence of actuator deformation on structural design is studied experimentally and conclusions are verified by analytical and finite element method modeling. The results suggest that the ion-material interactions are considerably dominated by the design of the drop-cast PEDOT:PSS on Nafion.

Engineered elastomer substrates for guided assembly of complex 3D mesostructures by

spatially nonuniform compressive buckling.

https://www.ncbi.nlm.nih.gov/pubmed/28970775

Approaches capable of creating three-dimensional (3D) mesostructures in advanced materials (device-grade semiconductors, electroactive polymers etc.) are of increasing interest in modern materials research. A versatile set of approaches exploits transformation of planar precursors into 3D architectures through the action of compressive forces associated with release of prestrain in a supporting elastomer substrate. Although a diverse set of 3D structures can be realized in nearly any class of material in this way, all previously reported demonstrations lack the ability to vary the degree of compression imparted to different regions of the 2D precursor, thus constraining the diversity of 3D geometries. This paper presents a set of ideas in materials and mechanics in which elastomeric substrates with engineered distributions of thickness yield desired strain distributions for targeted control over resultant 3D mesostructures geometries. This approach is compatible with a broad range of advanced functional materials from device-grade semiconductors to commercially available thin films, over length scales from tens of microns to several millimeters. A wide range of 3D structures can be produced in this way, some of which have direct relevance to applications in tunable optics and stretchable electronics.

Functional Aromatic Polyamides.

https://www.ncbi.nlm.nih.gov/pubmed/30965723

We describe herein the state of the art following the last 8 years of research into aromatic polyamides, wholly aromatic polyamides or aramids. These polymers belong to the family of high performance materials because of their exceptional thermal and mechanical behavior. Commercially, they have been transformed into fibers mainly for production of advanced composites, paper, and cut and fire protective garments. Huge research efforts have been carried out to take advantage of the mentioned characteristics in advanced fields related to transport applications, optically active materials, electroactive materials, smart materials, or materials with even better mechanical and thermal behavior.

Green synthesis of degradable conductive thermosensitive oligopyrrole/chitosan hydrogel intended for cartilage tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/29030197

Electroactive scaffolds containing conductive polymers can promote tissue repair and regeneration.

However, these polymers are non-degradable and cannot be removed from body. To overcome this limitation of conductive polymers, we developed a novel injectable electroactive hydrogel containing pyrrole oligomers which possessed the unique properties of being both electrically conductive and biodegradable. First, pyrrole oligomers were synthesized via chemical polymerization and were found to be amorphous with a non-globular morphology. Then, three different compositions of injectable chitosan/beta glycerophosphate hydrogels containing different concentrations of pyrrole oligomers were synthesized and characterized for chemical structure, morphology, conductivity, swelling ratio, In vitro biodegradation and gelation time. An increase in oligopyrrole content resulted in decreased pore size, and increased gelation time, swelling ratio, conductivity and degradation time. Among all the hydrogel compositions, the sample with pyrrole oligomer:chitosan ratio of 0.1 (w/w) showed the most prominent biodegradability, biocompatibility, electro-activity, swelling ratio and pore size values and was chosen as the optimal electroactive hydrogel composition in this work.

A new electrospun graphene-silk fibroin composite scaffolds for guiding Schwann cells.

https://www.ncbi.nlm.nih.gov/pubmed/28967299

Graphene (Gr) has been made of various forms used for repairing peripheral nerve injury with favorable electroactivity, however, graphene-based scaffolds in peripheral nerve regeneration are still rarely reported due to the difficulty of realizing uniform dispersion of graphene and electroactive materials at nanoscale as well as lacking biocompatibility. In this paper, graphene-silk fibroin (SF) composite nanofiber membranes with different mass ratios were prepared via electrospinning. Microscopic observation revealed that electrospun Gr/SF membranes had a nanofibrous structure. Electrochemical analysis provided electroactivity characterization of the Gr/SF membranes. The physiochemical results showed that the physiochemical properties of electrospun Gr/SF membranes could be changed by varying Gr concentration. Swelling ratio and contact angle measurements confirmed that electrospun Gr/SF membranes possessed large absorption capacity and hydrophilic surface, and the mechanical property was improved with increasing Gr concentration. Additionally, in-vitro cytotoxicity with L929 revealed that all the electrospun Gr/SF membranes are biocompatible. Moreover, the morphology and quantity showed that the membranes supported the survival and growth of the cultured Schwann cells. Collectively, all of the results suggest that the electrospun Gr/SF membranes combine the excellent electrically conductivity and mechanical strength of the graphene with biocompatibility property of silk to mimic the natural neural cell micro-environment for nerve development.

Photoredox-Based Actuation of an Artificial Molecular Muscle.

https://www.ncbi.nlm.nih.gov/pubmed/29363212

The use of light to actuate materials is advantageous because it represents a cost-effective and operationally straightforward way to introduce energy into a stimuli-responsive system. Common strategies for photoinduced actuation of materials typically rely on light irradiation to isomerize azobenzene or spiropyran derivatives, or to induce unidirectional rotation of molecular motors incorporated into a 3D polymer network. Although interest in photoredox catalysis has risen exponentially in the past decade, there are far fewer examples where photoinduced electron transfer (PET) processes are employed to actuate materials. Here, a novel mode of actuation in a series of redox-responsive hydrogels doped with a visible-light-absorbing ruthenium-based photocatalyst is reported. The hydrogels are composed primarily of polyethylene glycol and low molar concentrations of a unimolecular electroactive polyviologen that is activated through a PET mechanism. The rate and degree of contraction of the hydrogels are measured over several hours while irradiating with blue light. Likewise, the change in mechanical properties-determined through oscillatory shear rheology experiments-is assessed as a function of polyviologen concentration. Finally, an artificial molecular muscle is fabricated using the best-performing hydrogel composition, and its ability to perform work, while irradiated, is demonstrated by lifting a small weight.

Soft material for soft actuators.

https://www.ncbi.nlm.nih.gov/pubmed/28928384

Inspired by natural muscle, a key challenge in soft robotics is to develop self-contained electrically driven soft actuators with high strain density. Various characteristics of existing technologies, such as the high voltages required to trigger electroactive polymers (â€‰>â€‰1KV), low strain (â€‰<â€‰10%) of shape memory alloys and the need for external compressors and pressure-regulating components for hydraulicÂ or pneumaticÂ fluidicelastomer actuators, limit their practicality for untethered applications. Here we show a single self-contained soft robust composite material that combines the elastic properties of a polymeric matrix and the extreme volume change accompanying liquid-vapor transition. The material combines a high strain (up to 900%) and correspondingly high stress (up to 1.3â€‰MPa) with low density (0.84â€‰gâ€‰cm-3). Along with its extremely low cost (about 3 cent per gram), simplicity of fabrication and environment-friendliness, these properties could enable new kinds of electrically driven entirely soft robots.The development of self-contained electrically driven soft actuators with high strain density is difficult. Here the authors

show a single self-contained soft robust composite material that combines the elastic properties of a polymeric matrix and the extreme volume change accompanying liquid vapour transition.

One pot biocatalytic synthesis of a biodegradable electroactive macromonomer based on 3,4-ethylenedioxytiophene and poly(l-lactic acid).

https://www.ncbi.nlm.nih.gov/pubmed/29208286

A novel electroactive macromonomer based on poly(l-lactic acid) (PLLA) with (3,4-ethylenedioxythiophene) (EDOT) functional end groups, was prepared by a traditional approach of organometallic polymerization with stannous octanoate [Sn(oct2)] and enzymatic polymerization using immobilized Candida antarctica Lipase B (CAL-B) and Amano lipase Pseudomonas cepacia(PS-IM), as catalysts. In the synthetic strategy, (2,3-dihydrothieno[3,4-b] dioxin-2-yl)methanol (EDOT-OH) was used to initiate the ring opening polymerization of lactide to yield PLLA with EDOT end group. All macromonomers (EDOT-PLLA) were characterized by 1H and 13C RMN, MALDI-TOF, GPC and EDX. Moreover, ICP-OES analysis showed the presence of Sn traces in the material synthesized by the traditional approach, but that pathway led to macromonomers with higher molecular weight while the enzymatic route led to completely metal-free macromonomers with medium and lower molecular weights. Also, electrochemical and chemical polymerization of EDOT-PLLA were tested showing that it is possible to prepare degradable conducting polymers based on poly(3,4-ethylenedioxythiphene) (PEDOT). The biocatalytic synthesis is a very promising and environmental friendly pathway for the preparation of biodegradable materials for short time applications.

Synthesis and Photophysical Study of New Green Fluorescent TPA Based Poly(azomethine)s.

https://www.ncbi.nlm.nih.gov/pubmed/28812233

A series of poly(azomethine)s (PAMs) were synthesized from N1-(4-aminophenyl)-N1-(4-phenoxyphenyl)benzene-1,4-diamine (DA) and various dialdehydes to investigate the influence of structure of polymer chain and triphenylamine-based phenoxy pendant group on the optoelectronic properties. The structural characterization of the resulting poly(azomethine)s was carried out by solubility test, gel permeation chromatography, viscosity measurement, fourier transform infrared (FTIR) spectral and CHN elemental analysis. The photophysical and electrochemical properties of the materials were scrutinized by UV-vis,

photoluminescence, time correlation photon counting spectral analysis (TCSP) and cyclic voltammetry. The thermal stability of the poly(azomethine)s was assessed by differential scanning calorimetry and thermogravimetric analysis found to be stable upto 300Â Â°C. These polymers exhibit moderate inherent viscosity range from 0.99 to 1.15Â g dL-â€‰1 and appreciable organosolubility. The presence of triphenylamine and azomethine (CHâ€‰=â€‰N) linkage in our synthesized materials rendered them fluorescent, emitting green light upon excitation at 375Â nm with quantum efficiencies of 3.9-8.5%. The pendant phenoxy group at para-position in new poly(azomethine)s has also lowered the onset oxidation potentials and elevated the HOMO levels. Additionally, the presence of conjugation increases the fluorescence time of the excited state in conjugated polymers which was found in the range 9.22-11.17Â ns, sufficient to be use in future optoelectronic applications.

Wearable kinesthetic systems and emerging technologies in actuation for upperlimb neurorehabilitation.

https://www.ncbi.nlm.nih.gov/pubmed/19964915

Kinesthetic and haptic interfaces between humans and machines are currently under development in a truly wearable form, using innovative technologies based on electroactive polymers. The integration of electroactive polymeric materials into wearable garments is becoming a viable mean to confer the garment strain sensing and actuation properties. In this paper, the implementation and testing of fabric-based wearable interfaces for the upper limb endowed with spatially redundant strain sensing are reported. Electroactive polymer actuators, which we are currently investigating, are discussed with emphasis given to their unique capabilities in the phenomenological mimicking of skeletal muscle actuation and control. Finally, current work in preliminary evaluation of prototypes in the field of post-stroke rehabilitation is also briefly presented.

Spatio-temporal control of cell coculture interactions on surfaces.

https://www.ncbi.nlm.nih.gov/pubmed/19551797

Coculture control: We report a combined photochemical and electroactive self-assembled monolayer (SAM)-based substrate strategy to generate a coculture platform with spatial and temporal control of cell-cell interactions. These dynamic substrates can present a variety of ligands on the surface for biospecific interactions between the ligands and cell surface receptors. Photopatterning enables the ligands to be immobilized in patterns and even gradients.

Mercaptobenzothiazole-on-gold organic phase biosensor systems: 1. Enhanced organosphosphate pesticide determination.

https://www.ncbi.nlm.nih.gov/pubmed/19130375

This paper reports the construction of the gold/mercaptobenzothiazole/polyaniline/acetylcholinesterase/polyvinylacetate (Au/MBT/PANI/AChE/PVAc) thick-film biosensor for the determination of certain organophosphate pesticide solutions in selected aqueous organic solvent solutions. The Au/MBT/PANI/AChE/PVAc electrocatalytic biosensor device was constructed by encapsulating acetylcholinesterase (AChE) enzyme in the PANI polymer composite, followed by the coating of poly(vinyl acetate) (PVAc) on top to secure the biosensor film from disintegration in the organic solvents evaluated. The electroactive substrate called acetylthiocholine (ATCh) was employed to provide the movement of electrons in the amperometric biosensor. The voltammetric results have shown that the current shifts more anodically as the Au/MBT/PANI/AChE/PVAc biosensor responded to successive acetylthiocholine (ATCh) substrate addition under anaerobic conditions in 0.1 M phosphate buffer, KCl (pH 7.2) solution and aqueous organic solvent solutions. For the Au/MBT/PANI/AChE/PVAc biosensor, various performance and stability parameters were evaluated. These factors include the optimal enzyme loading, effect of pH, long-term stability of the biosensor, temperature stability of the biosensor, the effect of polar organic solvents, and the effect of non-polar organic solvents on the amperometric behavior of the biosensor. The biosensor was then applied to detect a series of 5 organophosphorous pesticides in aqueous organic solvents and the pesticides studied were parathion-methyl, malathion and chlorpyrifos. The results obtained have shown that the detection limit values for the individual pesticides were 1.332 nM (parathion-methyl), 0.189 nM (malathion), 0.018 nM (chlorpyrifos).

Rectified tunneling current response of bio-functionalized metal-bridge-metal junctions.

https://www.ncbi.nlm.nih.gov/pubmed/19910182

Biomolecular bridged nanostructures allow direct electrical addressing of electroactive biomolecules, which is of interest for the development of bioelectronic and biosensing hybrid junctions. In the present paper, the electroactive biomolecule microperoxidase-11 (MP-11) was integrated into metal-bridge-metal (MBM) junctions assembled from a scanning tunneling microscope (STM) setup. Before immobilization of MP-11, the Au working electrode was first modified by a self-assembled monolayer of 1-undecanethiol (UDT). A symmetric and potential independent response of

current-bias voltage (I(t)/V(b)) was observed for the Au (substrate)/UDT/Au (tip) junction. However, the I(t)/V(b) characteristics became potential dependent and asymmetrical after binding of MP-11 between the electrodes of the junction. The rectification ratio of the asymmetric current response varies with gate electrode modulation. A resonant tunneling process between metal electrode and MP-11 enhances the tunneling current and is responsible for the observed rectification. Our investigations demonstrated that functional building blocks of proteins can be reassembled into new conceptual devices with operation modes deviating from their native function, which could prove highly useful in the design of future biosensors and bioelectronic devices.

Polymeric Redox-Active Electrodes for Sodium-Ion Batteries.

https://www.ncbi.nlm.nih.gov/pubmed/28834226

Polymer binding agents are critical for the good performance of the electrodes of Na- and Li-ion batteries during cycling as they hold the electroactive material together to form a cohesive assembly because of their mechanical and chemical stability as well as adhesion to the current collector. New redox-active polymer binders that insert Na+ ions and show adhesion properties were synthesized by adding polyether amine blocks (Jeffamine) based on mixed propylene oxide and ethylene oxide blocks to p-phenylenediamine and terephthalaldehyde units to form electroactive Schiff-base groups along the macromolecule. The synthetic parameters and the electrochemical properties of these terpolymers as Na-ion negative electrodes in half cells were studied. Reversible capacities of 300â€…mAhâ€‰g-1 (50â€…wtâ€‰% conducting carbon) and 200â€…mAhâ€‰g-1 (20â€…wtâ€‰% conducting carbon) were achieved in powder and Cu-supported electrodes, respectively, for a polySchiff-polyether terpolymer synthesized by using a poly(ethylene oxide) block of 600â€…gâ€‰mol-1 in place of one third of the aniline units. The new redox-active polymers were also used as a binding agent of another anode material (hard carbon), which led to an increase of the total capacity of the electrode compared to that prepared with other standard fluorinated polymer binders such as poly(vinylidene) fluoride.

Facile Synthesis of Electroactive and Electrochromic Triptycene Poly(ether-imide)s Containing Triarylamine Units via Oxidative Electro-Coupling.

https://www.ncbi.nlm.nih.gov/pubmed/30965800

Two bisimide compounds, TPAâ•»TPDI and NPCâ•»TPDI, consisting of a triptycene core and two triphenylamine (TPA) or N-phenylcarbazole (NPC) end groups were successfully synthesized by the

condensation reactions from 1,4-bis(3,4-dicarboxyphenoxy)triptycene dianhydride with 4-aminotriphenylamine and N-(4-aminophenyl)carbazole, respectively. These two monomers could polymerize electrochemically via the oxidative coupling reactions of triarylamine units. The electrochemical and spectroelectrochemical properties of the electro-generated triptycene poly(ether-imide)s (TPAâ•»TPPI and NPCâ•»TPPI) were studied. Both polymers have two colored oxidation states, and TPAâ•»TPPI showed better electrochromic performance than NPCâ•»TPPI.

Contributions by a novel edge effect to the permselectivity of an electrosynthesized polymer for microbiosensor applications.

https://www.ncbi.nlm.nih.gov/pubmed/19371060

Pt electrodes of different sizes (2 x 10(-5)-2 x 10(-2) cm(2)) and geometries (disks and cylinders) were coated with the ultrathin non-conducting form of poly(o-phenylenediamine), PPD, using amperometric electrosynthesis. Analysis of the ascorbic acid (AA) and H(2)O(2) apparent permeabilities for these Pt/PPD sensors revealed that the PPD deposited near the electrode insulation (Teflon or glass edge) was not as effective as the bulk surface PPD for blocking AA access to the Pt substrate. This discovery impacts on the design of implantable biosensors where electrodeposited polymers, such as PPD, are commonly used as the permselective barrier to block electroactive interference by reducing agents present in the target medium. The undesirable "edge effect" was particularly marked for small disk electrodes which have a high edge density (ratio of PPD-insulation edge length to electrode area), but was essentially absent for cylinder electrodes with a length of >0.2 mm. Sample biosensors, with a configuration based on these findings (25 microm diameter Pt fiber cylinders) and designed for brain neurotransmitter L-glutamate, behaved well in vitro in terms of Glu sensitivity and AA blocking.

Polyvinyl alcohol-ionic liquid composition for promoting the direct electron transfer and electrocatalysis of hemoglobin.

https://www.ncbi.nlm.nih.gov/pubmed/19361962

The direct electron transfer and electrocatalysis of hemoglobin (Hb) entrapped in polyvinyl alcohol (PVA)-room temperature ionic liquid (i.e., 1-octyl-3-methylimidazolium hexafluorophosphate [OMIM]PF(6)) composition has been investigated by using cyclic voltammetry and chronocoulometry. It is found that the composition can promote the direct electron transfer of Hb and the heterogeneous electron transfer rate constant (k(s)) of immobilized Hb is enhanced to 19.9

s(-1). The immobilized Hb also shows high electro-catalytic activity towards the redox of oxygen, hydrogen peroxide and nitrite. The Michaelis constants (K(m)) decrease to 1.2x10(-4) M (for hydrogen peroxide) and 9.4x10(-3) M (for nitrite). The surface concentration of electroactive Hb is estimated and it is ca. 1.4x10(-10) mol cm(-2), meaning that several layers of immobilized Hb take part in the electrochemical reaction. When gold nanoparticles (GNP) is introduced into the composition, the resulting PVA-GNP-[OMIM]PF(6) composition presents better performance. The electrochemical characteristic of immobilized Hb is improved further. Thus PVA-GNP-[OMIM]PF(6) composition is more suitable for the immobilization of Hb. Therefore, it is a good strategy to prepare novel composition for protein immobilization by using several materials with different function.

Lignosulfonate-modified electrodes: electrochemical properties and electrocatalysis of NADH oxidation.

https://www.ncbi.nlm.nih.gov/pubmed/19456182

Lignosulfonic acid (LS1) and partially desulfonated lignosulfonic acid (LS2) were oxidatively deposited on a preactivated glassy carbon (GC) electrode, giving rise to redox active films showing three distinct redox couples at midpeak potentials (E degrees ') of 0.22, 0.44, and 0.53 V (vs Ag/AgCl in 0.1 M H(2)SO(4)). The redox activity was assigned to quinone moieties of different degrees of substitution, formed upon the oxidation of electroactive groups in the lignosulfonate structure. The most predominant couple (E degrees ' = 0.44 V) shifted negatively with pH at a rate of 59.5 mV per pH unit. In neutral electrolytes, the LS1- and LS2-modified electrodes behaved as anionic coatings, showing an increase in the charge transfer resistance (R(ct)) for the ferrocyanide/ferricyanide redox couple. The change in R(ct) was highly dependent on the LS sulfonation degree, and in comparison to an unmodified electrode it increased by ca. 490% for LS1-modified electrodes and by only 53% for LS2-modified electrodes. The LS-modified electrodes showed high electrocatalytic activity toward oxidation of reduced nicotinamide adenine dinucleotide (NADH). Electrocatalysis was studied in TRIS-HNO(3) buffers having pH of 5.0, 7.5, and 8.5 in the absence and presence of 20 mM Mg(2+), using the rotating disk electrode technique. Determined kinetic constants revealed that the impact of electrocatalysis depended strongly on the pH, the LS sulfonation degree, and the presence of bivalent metal ions. At fixed pH, the observed oxidation rate constant was lower for LS1-based electrodes than for LS2-based electrodes. On the other hand, the relative enhancement of this constant caused by the presence of Mg(2+) ions was much higher for LS1-based electrodes than for LS2-based electrodes. This phenomenon was explained by the

participation of sulfonic groups in the formation of a ternary complex between quinone moiety, metal ions, and NADH. The values of other kinetic constants, including the Michaelis-Menten constant (K(M)), suggested that the formation of such a complex is preferred in alkaline pHs.

A mesoporous silica nanosphere-based drug delivery system using an electrically conducting polymer.

https://www.ncbi.nlm.nih.gov/pubmed/19528680

In this study, a mesoporous silica nanoparticle (MSN)-based nerve growth factor (NGF) delivery system has been successfully embedded within an electroactive polypyrrol (Ppy). The spherical particles with approximately 100 nm diameter possess a large surface-to-volume ratio for the entrapment of NGF into the pores of MSNs while retaining their bioactivity. Direct incorporation of MSN-NGF within Ppy was achieved during electrochemical polymerization. The loading amount and release profile of NGF from the composite was investigated by sandwich ELISA. The NGF incorporation can be controllable by varying particle concentration or by extending electrodeposition time. The morphology and chemical composition of the Ppy/MSN-NGF composite was evaluated by atomic force microscopy (AFM), transmission electron microscopy (TEM), scanning electron microscopy (SEM), and x-ray photoelectron spectroscopy (XPS). Optical and electron microscopy revealed a characteristic attachment of PC 12 cells and the outgrowth of their neurites when grown on the Ppy/MSN-NGF composite as a result of a sustained and controlled release of NGF. In order to observe the effectiveness of electrical stimulation, neurite extension of cells cultured on unstimulated and stimulated Ppy/MSN-NGF was compared. The NGF release in the presence of electrical stimulation promoted significantly greater neurite extension.

Fabrication of enzymatic glucose biosensor based on palladium nanoparticles dispersed onto poly(3,4-ethylenedioxythiophene) nanofibers.

https://www.ncbi.nlm.nih.gov/pubmed/19157993

A new methodology involving the combination of a soft template (surfactant) and an ionic liquid (co-surfactant) is used to electrodeposit poly(3,4-ethylenedioxythiophene) (PEDOT) nanofibers. Electrochemical deposition of palladium nanoparticles and glucose oxidase (GOx) immobilization are done sequentially into nanofibrous PEDOT to fabricate the modified electrode (ME) (denoted as PEDOT-Pd/GOx-ME). The PEDOT-Pd/GOx-ME displays excellent performances for glucose at +0.4 V (vs. Ag/AgCl) with a high sensitivity (1.6 mA M(-)(1) cm(-2)) in a wider linear concentration range,

0.5 to 30 mM (correlation coefficient of 0.9985). Further, the electrode is insusceptible to the electroactive interfering species.

Conducting polymer networks cross-linked by "isolated" functional dyes: design, synthesis, and electrochemical polymerization of doubly strapped light-harvesting porphyrin/oligothiophene monomers.

https://www.ncbi.nlm.nih.gov/pubmed/19526470

Dye-functionalized conducting polymers: A new concept in the design of monomers gives bithiophene-based monomers as "isolated" functional dyes, thus yielding electroactive films through anodic electrochemical polymerization (see picture).We have synthesized doubly strapped porphyrin derivatives with four bithiophene segments that diverge from the porphyrin core, namely, Por(BT)(4) and PorZn(BT)(4). These molecules are designed as electrochemically polymerizable monomers that will yield the highly cross-linked conducting polymeric networks poly[Por(BT)(4)] and poly[PorZn(BT)(4)], respectively, through an oxidative coupling reaction among the bithiophene moieties. Selective synthesis of the distal doubly strapped porphyrin derivatives was successful from the bis(formylphenyl) and bis(dipyrrolylmethylphenyl) straps under Lindsey conditions. Slow kinetics observed for the zinc insertion reaction toward the doubly strapped porphyrin derivative revealed that both faces of the porphyrin plane are overlaid with alkyl chain straps. To probe this "isolation" effect, photophysical properties of the monomers and their model components were investigated by UV/Vis and fluorescence spectroscopic analysis. An absorption spectral comparison between the diluted solution and the thin solid film of Por(BT)(4) demonstrated that the porphyrin molecule is shielded by the double strap and self-aggregation is prevented. It is noteworthy that the fluorescence of the spin-coated film of the doubly strapped porphyrin monomer was twice as strong as that of an unstrapped porphyrin, thus indicating that the double strap can suppress undesired deactivation processes from the photoexcited state. In addition, fluorescence spectral measurements revealed that quantitative energy transfer from the oligothiophene segments to the porphyrin molecule takes place, which demonstrates an effective electronic interaction between these two chromophores. Electrochemical polymerization of the monomers Por(BT)(4) and PorZn(BT)(4) gave robust films that showed stable electrochemistry. Absorption spectral measurements and electrochemical characterization of the obtained films showed that the doubly strapped porphyrins are incorporated into the conducting polymer networks without any decomposition and protonation. Given all these observations above, our new monomer design

based on functional dyes shielded by the double strap will lead to new organic optoelectronic materials in which functional molecules are spatially incorporated and isolated and yet show an effective electronic interactions with the conducting polymer backbones.

Analytical methodology for the electro-catalytic determination of estradiol and progesterone based on graphene quantum dots and poly(sulfosalicylic acid) co-modified electrode.

https://www.ncbi.nlm.nih.gov/pubmed/28738575

The goal of this study was to develop an electroanalytical method for the simultaneous determination of steroid hormones for the first time. The key factor in the electrochemical methods is the choice of suitable electrode materials. For this purpose, graphene quantum dots (GQDs) doped poly(sulfosalicylic acid) (PSSA) was immobilized on a glassy carbon electrode (GCE). Apart from exhibition strong and stable electrocatalytic response towards estradiol (E2) and progesterone (P4), the proposed sensor was able to distinguish two hormone's oxidation peaks clearly. Under the optimal conditions, for selective determination of E2, good linear relationships were obtained in the range of 0.001-6.0Î¼molL-1, with detection limit of 0.23nmolL-1, and for P4 in the range of 0.001-6.0Î¼molL-1, with the detection limit of 0.31nmolL-1. The prepared sensor possessed accurate and rapid response toward E2 and P4 with an improved stability, selectivity and repeatability. More importantly, the facile and environment-friendly electrochemical construction strategy provided here, may be open a cost-effective way for setting up nanocomposites or nanohybrid-based sensing platform, which extend the application of electrochemical sensor for the green, facile and sensitive analysis of electroactive compounds in biological systems and pharmaceutical formulations.

Sulfadiazine-potentiometric sensors for flow and batch determinations of sulfadiazine in drugs and biological fluids.

https://www.ncbi.nlm.nih.gov/pubmed/19276592

New PVC membrane electrodes for the determination of sulfadiazine (SDZ) are presented. The electrodes are fabricated with conventional and tubular configurations with a graphite-based electrical contact, and no internal reference solution. The selective membranes consist of bis(triphenylphosphoranilidene)ammonium.SDZ (electrode A), tetraoctylammonium bromide (electrode B), or iron(II)-phthalocyanine (FePC) (electrode C) electroactive materials dispersed in a PVC matrix of o-nitrophenyl octyl ether (o-NPOE) plasticizer. The sensors A, B, and C displayed

linear responses over the concentration ranges 1.0 x 10(-2) - 1.0 x 10(-5), 1.0 x 10(-2) - 7.5 x 10(-6), and 3.2 x 10(-2) - 7.0 x 10(-6) mol l(-1) (detection limits of 1.09, 2.04 and 0.87 microg ml(-1)) with anionic slopes of -57.3 +/- 0.1, -46.7 +/- 0.5, and -65.1 +/- 0.2 mV decade(-1), respectively. No effect from pH was observed within 4.0 - 5.5, 4.8 - 10, and 4.5 - 8, respectively, and good selectivity was found. The sensors were applied to the analysis of pharmaceuticals and biological fluids in steady state and in flow conditions.

Contactless electrofunctionalization of a single pore.

https://www.ncbi.nlm.nih.gov/pubmed/19588464

Customized pores are smart components that find challenging applications in a variety of fields including purification membranes and biosensing systems. The incorporation of recognition probes within pores is therefore a challenge, due to the technical difficulty of delimiting the area functionalized and obtaining the localized, specific chemical modification of pore walls. An innovative approach, named contactless electrofunctionalization (CLEF), is presented to overcome this problem. CLEF allows easy, one-step modification of the inner surface of a pore etched in a dielectric membrane. The pore wall is coated under the influence of an electric field created by the application of a voltage between two electrodes, located near but not in contact with the pore openings. This specific localization of the deposited material within the pore is extremely rapid. Coatings were reliably and reproducibly obtained using polypyrrole co-polymers bearing oligonucleotides, demonstrating that this technology has a promising future in the design of biosensors. Moreover, the versatility of this process allows the deposition of various electroactive entities such as iridium oxide and therefore indicates a strong potential for diverse applications involving porous materials.

Electrochemical detection of natural DNA damage induced by ferritin/ascorbic acid/H2O2 system and amplification of DNA damage by endonuclease Fpg.

https://www.ncbi.nlm.nih.gov/pubmed/19632106

Oppositely charged natural DNA and chitosan (CS) were assembled into (CS/DNA)(n) layer-by-layer films on electrode surface, and Ru(bpy)(3)(2+) (bpy = bipyridyl) in solution was used as electroactive catalyst to detect damage of DNA in the films after incubation of the films in ferritin/AA/H(2)O(2) solutions (AA = ascorbic acid). The mechanism of DNA damage caused by the ferritin/AA/H(2)O(2) system was similar to that of Fenton reaction, where the reaction of ferritin with AA would release

some Fe(II) ions from ferritin and the following reaction between Fe(II) ions and H(2)O(2) would produce hydroxyl radical, which could induce DNA oxidative damage. This system provided an in vitro model to imitate the DNA damage indirectly induced by ferritin in real bio-systems. In addition, formamidopyrimidine DNA glycosylase (Fpg), a key endonuclease enzyme in repair of oxidatively damaged DNA, was used to amplify the DNA damage caused by ferritin/AA/H(2)O(2) system through conversion of oxidative purine bases into single-strand breaks. The high sensitivity of electrocatalytic method with Ru(bpy)(3)(2+) as the catalyst in detection of DNA damage and the magnification function of Fpg may provide a novel idea to detect natural DNA lesion sensitively.

A label-free electrochemical immunosensor based on the novel signal amplification system of AuPdCu ternary nanoparticles functionalized polymer nanospheres.

https://www.ncbi.nlm.nih.gov/pubmed/29291595

A sensitive label-free electrochemical immunosensor was designed using a novel signal amplification system for quantitative detecting hepatitis B surface antigen (HBsAg). Nitrogen-doped graphene quantum dots (N-GQDs) supported surfactant-free AuPdCu ternary nanoparticles (AuPdCu/N-GQDs), which featured with good conductivity and excellent catalytic properties for the reduction of hydrogen peroxide (H2O2), was synthesized by a simple and benign hydrothermal procedure. At the same time, the electroactive polymer nanospheres (PS) was synthesized by infinite coordination polymers of ferrocenedicarboxylic acid, which could play as carrier and electronic mediator to load AuPdCu/N-GQDs. The PS not only improved the ability to load antibodies because of the good biocompatibility, but also accelerated electron transport of the electrode interface attribute to plentiful ferrocene unit. Thus, the prepared AuPdCu/N-GQDs@PS has abilities of good biocompatibility, catalytic activity and electrical conductivity to be applied as transducing materials to amplify electrochemical signal in detection of HBsAg. Under optimal conditions, the fabricated immunosensor exhibited high sensitivity and stability in the detection of HBsAg. A linear relationship between current signals and the concentrations of HBsAg was obtained in the range from 10fg/mL to 50ng/mL and the detection limit of HBsAg was 3.3fg/mL (signal-to-noise ratio of 3). Moreover, the designed immunosensor with excellent selectivity, reproducibility and stability shows excellent performance in detection of human serum samples. Furthermore, this label-free electrochemical immunosensor has promising application in clinical diagnosis of HBsAg.

Toward living radical polymerization.

https://www.ncbi.nlm.nih.gov/pubmed/18700787

Radical polymerization is one of the most widely used processes for the commercial production of high-molecular-weight polymers. The main factors responsible for the preeminent position of radical polymerization are the ability to polymerize a wide array of monomers, tolerance of unprotected functionality in monomer and solvent, and compatibility with a variety of reaction conditions. Radical polymerization is simple to implement and inexpensive in relation to competitive technologies. However, conventional radical polymerization severely limits the degree of control that researchers can assert over molecular-weight distribution, copolymer composition, and macromolecular architecture. This Account focuses on nitroxide-mediated polymerization (NMP) and polymerization with reversible addition-fragmentation chain transfer (RAFT), two of the more successful approaches for controlling radical polymerization. These processes illustrate two distinct mechanisms for conferring living characteristics on radical polymerization: reversible deactivation (in NMP) and reversible or degenerate chain transfer (in RAFT). We devised NMP in the early 1980s and have exploited this method extensively for the synthesis of styrenic and acrylic polymers. The technique has undergone significant evolution since that time. New nitroxides have led to faster polymerization rates at lower temperatures. However, NMP is only applicable to a restricted range of monomers. RAFT was also developed at CSIRO and has proven both more robust and more versatile. It is applicable to the majority of monomers subject to radical polymerization, but the success of the polymerization depends upon the selection of the RAFT agent for the monomers and reaction conditions. We and other groups have proposed guidelines for selection, and the polymerization of most monomers can be well-controlled to provide minimal retardation and a high fraction of living chains by using one of just two RAFT agents. For example, a tertiary cyanoalkyl trithiocarbonate is suited to (meth)acrylate, (meth)acrylamide, and styrenic monomers, while a cyanomethyl xanthate or dithiocarbamate works with vinyl monomers, such as vinyl acetate or N-vinylpyrrolidone. With the appropriate choice of reagents and polymerization conditions, these reactions possess most of the attributes of living polymerization. We have used these methods in the synthesis of well-defined homo-, gradient, diblock, triblock, and star polymers and more complex architectures, including microgels and polymer brushes. Applications of these polymers include novel surfactants, dispersants, coatings and adhesives, biomaterials, membranes, drug-delivery media, electroactive materials, and other nanomaterials.

Molecular architecture of electroactive and biodegradable copolymers composed of polylactide and carboxyl-capped aniline trimer.

https://www.ncbi.nlm.nih.gov/pubmed/20201489

Two-, four-, and six-armed branched copolymers with electroactive and biodegradable properties were synthesized by coupling reactions between poly(l-lactides) (PLLAs) with different architecture and carboxyl-capped aniline trimer (CCAT). The aniline oligomer CCAT was prepared from amino-capped aniline trimer and succinic anhydride. FT-IR, NMR, and SEC analyses confirmed the structure of the branched copolymers. UV-vis spectra and cyclic voltammetry of CCAT and copolymer solution showed good electroactive properties, similar to those of polyaniline. The water contact angle of the PLLAs was the highest, followed by the undoped copolymer and the doped copolymers. The values of doped four-armed copolymers were 54-63 degrees . Thermal properties of the polymers were studied by DSC and TGA. The copolymers had better thermal stability than the pure PLLAs, and the T(g) between 48-58 degrees C and T(m) between 146-177 degrees C of the copolymers were lower than those of the pure PLLA counterparts. This kind of electroactive and biodegradable copolymer has a great potential for applications in cardiovascular or neuronal tissue engineering.

An electropolymerized Nile Blue sensing film-based nitrite sensor and application in food analysis.

https://www.ncbi.nlm.nih.gov/pubmed/18620926

This paper reports a poly-Nile Blue (PNB) sensing film based electrochemical sensor and the application in food analysis as a possible alternative for electrochemical detection of nitrite. The PNB-modified electrode in the sensor was prepared by in situ electropolymerization of Nile Blue at a prepolarized glassy carbon (GC) electrode and then characterized by cyclic voltammetry (CV) and pulse voltammetry in phosphate buffer (pH 7.1). Several key operational parameters affecting the electrochemical response of PNB sensing film were examined and optimized, such as polarization time, PNB film thickness and electrolyte pH values. As the electroactive PNB sensing film provides plenty of active sites for anodic oxidation of nitrite, the nitrite sensor exhibited high performance including high sensitivity, low detection limit, simple operation and good stability at the optimized conditions. The nitrite sensor revealed good linear behavior in the concentration range from 5.0x10(-7) mol L(-1) to 1.0x10(-4) mol L(-1) for the quantitative analysis of nitrite anion with a limit of detection of 1.0x10(-7) mol L(-1). Finally, the application in food analysis using sausage as testing

samples was investigated and the results were consistent with those obtained by standard spectrophotometric method.

Light switching of molecules on surfaces.

https://www.ncbi.nlm.nih.gov/pubmed/18999995

Smart surfaces, surfaces that respond to an external stimulus in a defined manner, hold considerable potential as components in molecular-based devices, not least as discrete switching elements. Many stimuli can be used to switch surfaces between different states, including redox, light, pH, and ion triggers. The present review focuses on molecular switching through the electronic excitation of molecules on surfaces with light. In developing light-responsive surfaces, investigators face several challenges, not only in achieving high photostationary states and fully reversible switching, but also in dealing with fatigue resistance and the effect of immobilization itself on molecular properties. The immobilization of light-responsive molecules requires the design and synthesis of functional molecular components both to achieve light switching and to anchor the molecular entity onto a surface. This review discusses several demonstrative examples of photoswitchable molecular systems in which the photochemistry has been explored in the immobilized state under ambient conditions and especially on electroactive surfaces, including self-assembled monolayers, bilayers, and polymer films.

Self-assembly and electrochemical oxidation of polyamidoamine-carbazole dendron surfmer complexes: nanoring formation.

https://www.ncbi.nlm.nih.gov/pubmed/19206356

We report a detailed and quantitative study on the supramolecular complexation of amine-functionalized polyamidoamine (PAMAM) dendrimer G(4)-NH(2) with carboxylic acid terminal dendrons containing peripheral electroactive carbazole groups of different generations (G(0)COOH, G(1)COOH, and G(2)COOH). While the focus is on a detailed understanding and mechanism of complex formation, subsequent electrochemical oxidation of the dendron surfmers resulted in the formation of nanoring structures electrodeposited on the conducting substrate. Complexation was confirmed by NMR, UV-vis, and IR measurements. Critical micelle concentration (CMC), atomic force microscopy (AFM), and X-ray photoelectron spectroscopy (XPS) studies revealed that the ringlike structures were formed during the equilibrium-decomplexation stage and that the electrochemical process did not destroy the complex but rather stabilized it. The different

generations of the dendrons provided various structures and complex formation efficacy. This type of template polymerization combined with electrochemically anodic oxidation has not been previously reported.

Demonstration of an integrated electroactive polymer actuator on a microfluidic electrophoresis device.

https://www.ncbi.nlm.nih.gov/pubmed/19568678

The construction of microfluidic devices from siloxane-based polymers is widely reported in the current literature. While the use of these materials is primarily due to their rapid and facile fabrication, low cost and robustness, they also have the ability to function as smart materials. This feature, however, has not been commonly exploited in conjunction with their fluid-handling capabilities. Siloxanes are considered smart materials because their shapes can be modified in the presence of an electric field. The energy in the electric field can be transduced into mechanical energy and directly coupled with a microfabricated channel network in order to affect or initiate the movement of fluids. Here, we present a novel microfluidic device into which an electroactive polymer (EAP) actuation unit is integrated. The EAP actuation unit features a microfluidic channel placed above a patterned electrode. The patterned electrode is insulated from the channel by an EAP layer that is composed of PDMS. When a potential is applied across the EAP layer, it changes shape, which also changes the volume of the microfluidic channel above it. With this proof-of-concept device we demonstrated the ability to inject plugs of sample on a standard electrophoresis cross chip solely by changing the magnitude of the electric field between the channel and the electrode. Using an EAP actuation unit, the size of the injection plugs can be varied as a function of the electric field, the active area of the EAP actuation unit and the softness of the EAP.

Site-specific installation and study of electroactive units in every layer of dendrons.

https://www.ncbi.nlm.nih.gov/pubmed/19905006

Whereas encapsulation of functional groups at the core of dendrimers is well-understood, very little is known about their intermediate layers or even the periphery. Here we report on a systematic investigation of every layer of dendrimers by incorporating a single ferrocene unit in well-defined locations in dendrons. Site-specific incorporation of the ferrocene unit was achieved by utilizing the dendrimer sequencing methodology. We show here that the redox potential values of ferrocene at intermediate layers were remarkably different from those at the core and the periphery. Although

redox potential values were location-dependent, no significant change in the rate of heterogeneous electron transfer (k(0)) was observed with respect to locations. This was attributed to the possibility that free rotation of dendrimer nullifies the distance between the electrode and ferrocene unit. Finally, we also show that no Faradaic current was observed for the amphiphilic assemblies of these dendrons, whereas the same dendron did exhibit significant Faradaic current in nonassembling solvent environments.

Poly(1,1-bis(dialkylamino)propan-1,3-diyl)s; conformationally-controlled oligomers bearing electroactive groups.

https://www.ncbi.nlm.nih.gov/pubmed/19532986

The design of polymers with repeating [C(NR2)2CH2CH2] units which may simultaneously provide conformational control and contain repeating electroactive centres is discussed; (NR2)2 groups would be ideally provided by ortho-phenylenediamine derivatives, with 1,8-diaminonaphthalenes as alternatives. Oligomers containing 1,8-bis(methylamino)naphthalenes, up to the hexamer, were obtained by condensation of oligomers of CH3[COCH2CH2](n)COCH3 with 1,8-bis(methylamino)naphthalene, but attempts to prepare related oligomers from 1,2-bis(alkylamino)benzenes were unsuccessful, as only terminal ketone groups could be converted to aminals. Evidence for a strong preference for all-anti conformations of the main chain in the naphthalenediamine oligomers is provided by ring current effects on 1H NMR shifts, and by X-ray structures, which also provide evidence of intercalation in the solid state. Electrochemical studies of these oligomers show irreversible oxidation of oligomers in solution, but oxidation of longer oligomers leads to the deposition of a reddish-pink insoluble material which shows two reversible oxidation waves. Possible interpretation of these results is discussed.

Detection of nicotine based on molecularly imprinted TiO2-modified electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/19110125

Amperometric detection of nicotine (NIC) was carried out on a titanium dioxide (TiO(2))/poly(3,4-ethylenedioxythiophene) (PEDOT)-modified electrode by a molecular imprinting technique. In order to improve the conductivity of the substrate, PEDOT was coated onto the sintered electrode by in situ electrochemical polymerization of the monomer. The sensing potential of the NIC-imprinted TiO(2) electrode (ITO/TiO(2)[NIC]/PEDOT) in a phosphate-buffered saline (PBS) solution (pH 7.4) containing 0.1M KCl was determined to be 0.88 V (vs. Ag/AgCl/saturated

KCl). The linear detection range for NIC oxidation on the so-called ITO/TiO(2)[NIC]/PEDOT electrode was 0-5mM, with a sensitivity and limit of detection of 31.35 microA mM(-1)cm(-2) and 4.9 microM, respectively. When comparing with the performance of the non-imprinted one, the sensitivity ratio was about 1.24. The sensitivity enhancement was attributed to the increase in the electroactive area of the imprinted electrode. The at-rest stability of the ITO/TiO(2)[NIC]/PEDOT electrode was tested over a period of 3 days. The current response remained about 85% of its initial value at the end of 2 days. The ITO/TiO(2)[NIC]/PEDOT electrode showed reasonably good selectivity in distinguishing NIC from its major interferent, (-)-cotinine (COT). Moreover, scanning electrochemical microscopy (SECM) was employed to elucidate the surface morphology of the imprinted and non-imprinted electrodes using Fe(CN)(6)(3-)/Fe(CN)(6)(4-) as a redox probe on a platinum tip. The imprinted electrode was further characterized by scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR).

Electroconductive hydrogels: synthesis, characterization and biomedical applications.

https://www.ncbi.nlm.nih.gov/pubmed/20060580

Electroconductive hydrogels (ECHs) are composite biomaterials that bring together the redox switching and electrical properties of inherently conductive electroactive polymers (CEPs) with the facile small molecule transport, high hydration levels and biocompatibility of cross-linked hydrogels. General methods for the synthesis of electroconductive hydrogels as polymer blends and as polymer co-networks via chemical oxidative, electrochemical and/or a combination of chemical oxidation followed by electrochemical polymerization techniques are reviewed. Specific examples are introduced to illustrate the preparation of electroconductive hydrogels that were synthesized from poly(HEMA)-based hydrogels with polyaniline and from poly(HEMA)-based hydrogels with polypyrrole. The key applications of electroconductive hydrogels; as biorecognition membranes for implantable biosensors, as electro-stimulated drug release devices for programmed delivery, and as the low interfacial impedance layers on neuronal prostheses are highlighted. These applications provide great new horizons for these stimuli responsive, biomimetic polymeric materials.

pH-Sensitive "on-off" switching behavior of layer-by-layer films assembled by concanavalin A and dextran toward electroactive probes and its application in bioelectrocatalysis.

https://www.ncbi.nlm.nih.gov/pubmed/19908870

Concanavalin A (Con A) and dextran (Dex) were assembled into {Con A/Dex}(n) layer-by-layer films

on electrodes by the biospecific interaction between them. At {Con A/Dex}(n) film electrodes, the cyclic voltammetric (CV) response of different electroactive probes, such as Fe(CN)(6)(3-), Ru(NH(3))(6)(3+), ferrocenecarboxylic acid (Fc(COOH)), and ferrocenedicarboxylic acid (Fc(COOH)(2)), was very sensitive to the solution pH. For example, in pH 4.0 buffers, the films showed good permeability toward Fe(CN)(6)(3-), leading to a well-defined CV peak pair of Fe(CN)(6)(3-) with large peak currents at about 0.17 V vs SCE. In pH 9.0 buffers, however, the CV response of Fe(CN)(6)(3-) was significantly depressed or even could hardly be observed. This pH-sensitive "on-off" switching property of the films toward the probe should be attributed to the different electrostatic interaction between Fe(CN)(6)(3-) and the Con A constituent in the films at different pH and could be further used to control the electrocatalytic reduction of H(2)O(2) by horseradish peroxidase (HRP) with Fe(CN)(6)(3-) as the diffusional electron transfer mediator. Fc(COOH)(2) showed the similar pH-dependent "on-off" behavior at {Con A/Dex}(n) film electrodes, and the corresponding pH-sensitive electrocatalytic oxidation of glucose by glucose oxidase (GOD) with Fc(COOH)(2) as the mediator was also realized. This work provides a new interface system that has the pH-sensitive "on-off" CV property, and the better understanding of the interactions involved in this model system may guide us to develop the novel kind of controllable biosensors based on enzymatic electrocatalysis.

Improved conductivity and antibacterial activity of poly(2-aminothiophenol)-silver nanocomposite against human pathogens.

https://www.ncbi.nlm.nih.gov/pubmed/29178993

A rapid and simple chemical synthesis of poly(2-aminothiophenol)â€‘silver (P2ATP-Ag) nanocomposite using conductive and electroactive silver nanoparticles (AgNPs) is reported. The AgNPs was synthesized by chemical reduction method using triâ€‘sodium citrate as reducing agent and poly(N-vinyl-2-pyrrolidone) (PVP) as stabilizing agent. P2ATP-Ag nanocomposite was synthesized by using potassium peroxodisulphate as oxidant and the samples were characterized. The presence of AgNPs in the composite was confirmed from UV-Vis, FTIR and X-ray diffraction studies. Morphology of the P2ATP and its composite were investigated by SEM. HR-TEM images show spherical, trigonal and rod like morphologies with sizes of Ag nanoparticles and its composite. Thermal analysis revealed that the thermal stability of the P2ATP-Ag nanocomposite is improved when compared with pure P2ATP. The synthesized AgNPs, pure P2ATP and P2ATP-Ag nanocomposite were screened for antibacterial activity test against human pathogen such as Gram

positive (Bacillus subtilis, ATCC-6051) and Gram negative (Vibrio cholerae, ATCC-14035), carried out by agar-well diffusion method at micro molar concentration. The result shows that P2ATP-Ag nanocomposite has excellent antibacterial activity due to the presence of Ag nanoparticles. The electrical conductivity of the P2ATP-Ag nanocomposite is better than that of pure P2ATP. The reported nanocomposite will be a potential material for electrocatalysis, sensors and biomedical applications.

Towards a Biocompatible, Biodegradable Copolymer Incorporating Electroactive Oligothiophene Units.

https://www.ncbi.nlm.nih.gov/pubmed/20046223

As part of an ongoing effort to develop biocompatible, biodegradable conducting polymers, we report here the synthesis and characterization of a novel copolymer, 5,5'''bishydroxymethyl-3,3'''-dimethyl-2,2':5',2'':5'',2'''-quaterthiophene-co-adipic acid polyester (QAPE). This system was designed so as to incorporate alternating electroactive quaterthiophene units and biodegradable ester units into one macromolecular framework, while allowing for facile preparation of the polymer via a polycondensation reaction. In agreement with the design expectations, the ester groups were found to be incorporated into the polymer between the quaterthiophene subunits, as inferred from standard chemical and spectroscopic analyses. QAPE exhibited redox activity as detected by cyclic voltammetry and a new red-shifted absorption peak upon doping, providing support for the notion that the quaterthiophene units maintain electroactivity after incorporation into the QAPE polymer framework. The degradation, likely through surface erosion, of this polymer in the presence of cholesterol esterase was confirmed by the detection of a fluorescence signal at wavelengths corresponding to the quaterthiophene subunit and comparisons to appropriate controls. In vitro cytocompatability studies, carried out over 48 h, indicate that the QAPE polymer is nontoxic to Schwann cells.

Self-cleaned electrochemical protein imprinting biosensor basing on a thermo-responsive memory hydrogel.

https://www.ncbi.nlm.nih.gov/pubmed/28750337

Herein, the self-cleaned electrochemical protein imprinting biosensor basing on a thermo-responsive memory hydrogel was constructed on a glassy carbon electrode (GCE) with a free radical polymerization method. Combining the advantages of thermo-responsive molecular imprinted

polymers and electrochemistry, the resulted biosensor presents a novel self-cleaned ability for bovine serum albumin (BSA) in aqueous media. As a temperature controlled gate, the hydrogel film undergoes the adsorption and desorption of BSA basing on a reversible structure change with the external temperature stimuli. In particular, these processes have been revealed by the response of cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) of electroactive [Fe(CN)6]3-/4-. The results have been supported by the evidences of scanning electron microscopy (SEM) and contact angles measurements. Under the optimal conditions, a wide detection range from 0.02Î¼molL-1 to 10Î¼molL-1 with a detection limit of 0.012 Î¼molL-1 (S/N = 3) was obtained for BSA. This proposed BSA sensor also possesses high selectivity, excellent stability, acceptable recovery and good reproducibility in its practical applications.

Comparative performances of a bare graphite-polyurethane composite electrode unmodified and modified with graphene and carbon nanotubes in the electrochemical determination of escitalopram.

https://www.ncbi.nlm.nih.gov/pubmed/29136792

A bare composite graphite-polyurethane electrode (EGPU) and two other modified with graphene (EGPU-GR) and functionalized multi-walled carbon nanotubes (EGPU-CNTs) were prepared and compared regarding their voltammetric response to escitalopran (EST). The modifiers were characterized by Raman spectroscopy and the resulting electrode materials by contact angle measurements with a hydrophilicity character in the ascending order for the composites: GPU > GPU-GR > GPU-CNTs and scanning electron microscopy (SEM). The electroactive areas of the EGPU, EGPU-GR, and EGPU-CNTs were 0.065, 0.080, and 0.092cm2, respectively, calculated from the chronocoulometry using K3[Fe(CN)6] as a probe and the Cottrell equation. The cyclic voltammograms obtained for EST indicated irreversible electrochemical behavior, with an anodic peak at ca. +0.80V (Î½s. SCE). These measurements were carried out with the three electrodes, and comparison of the analytical responses led to the EGPU-GR electrode being selected for use in the subsequent experiments. Under optimal conditions, square wave and differential pulse voltammetry at EGPU-GR presented linear dynamic ranges between 1.5 Ã— 10-6 and 1.2 Ã— 10-5mol L-1, with a detection limit of 2.5 Ã— 10-7molL-1 (SWV) and 1.5 Ã— 10-6 and 1.2 Ã— 10-5molL-1, with a detection limit of 3.2 Ã— 10-7molL-1 (DPV) for EST. The proposed method was applied for the quantification of EST in synthetic urine and cerebrospinal fluid samples, offering advantages including simplicity of fabrication, no requirement for analyte preconcentration and

surface renewal, fast response, and selectivity.

Enhancement of Au nanoparticles formed by in situ electrodeposition on direct electrochemistry of myoglobin loaded into layer-by-layer films of chitosan and silica nanoparticles.

https://www.ncbi.nlm.nih.gov/pubmed/19006267

In the present work, a new kind of myoglobin (Mb)/Au nanoparticles composite film was fabricated on pyrolytic graphite (PG) electrodes. Oppositely charged chitosan (CS) and silica (SiO(2)) nanoparticles were alternately adsorbed on the PG surface by the electrostatic interaction between them, forming {CS/SiO(2)}(5) layer-by-layer films. Mb and HAuCl(4) in solution were then simultaneously loaded into {CS/SiO(2)}(5) films. The loaded Au(III) in the films were electrochemically reduced into Au nanoparticles, forming nanocomposite films, designated as {CS/SiO(2)}(5)-Mb-Au. Various techniques such as cyclic voltammetry (CV), square wave voltammetry (SWV), quartz crystal microbalance (QCM), electrochemical impedance spectroscopy (EIS), scanning electron microscopy (SEM), and energy dispersive X-ray (EDX) analysis were used to characterize the films. Compared with {CS/SiO(2)}(5)-Mb films without Au nanoparticles inside, the {CS/SiO(2)}(5)-Mb-Au films exhibited much better behavior in electrochemistry and electrocatalysis of Mb, mainly because the Au nanoparticles formed inside the films were located in proximity to Mb and acted as electron bridges between Mb molecules, making more Mb molecules in the films become electroactive. In addition, the permeability or porosity of the films also played an important role in realizing the direct electrochemistry of Mb. This system provides a novel platform to develop electrochemical biosensors based on the direct electron transfer of redox enzymes without using mediators.

Direct heteroarylation polymerization: guidelines for defect-free conjugated polymers.

https://www.ncbi.nlm.nih.gov/pubmed/28966781

Direct (hetero)arylation polymerization (DHAP) has emerged as a valuable and atom-economical alternative to traditional cross-coupling methods for the synthesis of low-cost and efficient conjugated polymers for organic electronics. However, when applied to the synthesis of certain (hetero)arene-based materials, a lack of C-H bond selectivity has been observed. To prevent such undesirable side-reactions, we report the design and synthesis of new, bulky, phosphine-based ligands that significantly enhance selectivity of the DHAP process for both halogenated and

non-halogenated electron-rich and electron-deficient thiophene-based comonomers. To better understand the selectivity issues, density functional theory (DFT) calculations have been performed on various halogenated and non-halogenated electron-rich and electron-deficient thiophene-based comonomers. Calculations showed that the presence of bromine atoms decreases the energy of activation (Ea) of the adjacent C-H bonds, allowing undesirable Î²-defects for some brominated aromatic units. Both calculations and the new ligands should lead to the rational design of monomers and methods for the preparation of defect-free conjugated polymers from DHAP.

Spatially Probed Plasmonic Photothermic Nanoheater Enhanced Hybrid Polymeric-Metallic PVDF-Ag Nanogenerator.

https://www.ncbi.nlm.nih.gov/pubmed/29239097

Surface plasmon-based photonics offers exciting opportunities to enable fine control of the site, span, and extent of mechanical harvesting. However, the interaction between plasmonic photothermic and piezoresponse still remains underexplored. Here, spatially localized and controllable piezoresponse of a hybrid self-polarized polymeric-metallic system that correlates to plasmonic light-to-heat modulation of the local strain is demonstrated. The piezoresponse is associated to the localized plasmons that serve as efficient nanoheaters leading to self-regulated strain via thermal expansion of the electroactive polymer. Moreover, the finite-difference time-domain simulation and linear thermal model also deduce the local strain to the surface plasmon heat absorption. The distinct plasmonic photothermic-piezoelectric phenomenon mediates not only localized external stimulus light response but also enhances dynamic piezoelectric energy harvesting. The present work highlights a promising surface plasmon coordinated piezoelectric response which underpins energy localization and transfer for diversified design of unique photothermic-piezotronic technology.

Voltammetric detection of 5-hydroxytryptamine release in the rat brain.

https://www.ncbi.nlm.nih.gov/pubmed/19827792

5-Hydroxytryptamine (5-HT) is an important molecule in the brain that is implicated in mood and emotional processes. In vivo, its dynamic release and uptake kinetics are poorly understood due to a lack of analytical techniques for its rapid measurement. Whereas fast-scan cyclic voltammetry with carbon fiber microelectrodes is used frequently to monitor subsecond dopamine release in freely moving and anesthetized rats, the electrooxidation of 5-HT forms products that quickly polymerize

and irreversibly coat the carbon electrode surface. Previously described modifications of the electrochemical waveform allow stable and sensitive 5-HT measurements in mammalian tissue slice preparations and in the brain of fruit fly larvae. For in vivo applications in mammals, however, the problem of electrode deterioration persists. We identify the root of this problem to be fouling by extracellular metabolites such as 5-hydoxyindole acetic acid (5-HIAA), which is present in 200-1000 times the concentration of 5-HT and displays similar electrochemical properties, including filming of the electrode surface. To impede access of the 5-HIAA to the electrode surface, a thin layer of Nafion, a cation exchange polymer, has been electrodeposited onto cylindrical carbon-fiber microelectrodes. The presence of the Nafion film was confirmed with environmental scanning electron microscopy and was demonstrated by the diminution of the voltammetric signals for 5-HIAA as well as other common anionic species. The modified microelectrodes also display increased sensitivity to 5-HT, yielding a characteristic cyclic voltammogram that is easily distinguishable from other common electroactive brain species. The thickness of the Nafion coating and a diffusion coefficient (D) in the film for 5-HT were evaluated by measuring permeation through Nafion. In vivo, we used physiological, anatomical, and pharmacological evidence to validate the signal as 5-HT. Using Nafion-modified microelectrodes, we present the first endogenous recording of 5-HT in the mammalian brain.

Electric field assisted transdermal drug delivery from salicylic acid-loaded polyacrylamide hydrogels.

https://www.ncbi.nlm.nih.gov/pubmed/19624247

The apparent diffusion coefficients, D(app), and the release mechanisms of salicylic acid from polyacrylamide hydrogels through pigskin were investigated. D(app) increases with increasing electric field strength and reaches the maximum value at electric field strength of 0.1 V; beyond that it decreases with increasing electric field strength and becomes saturated at 5 V. The increase in D(app) at low electric field strength can be attributed to the combination of iontophoresis, electroporation of matrix pore, and induced pathway in pigskin. D(app) obeys the scaling behavior D(app)/D(o) = (drug size/pore size)m with m equal to 0.67 and 0.49 at the electric field strengths of 0 and 0.1 V, respectively.

Dual contactless conductivity and amperometric detection on hybrid PDMS/glass electrophoresis microchips.

https://www.ncbi.nlm.nih.gov/pubmed/20024187

A new approach for the integration of dual contactless conductivity and amperometric detection with an electrophoresis microchip system is presented. The PDMS layer with the embedded channels was reversibly sealed to a thin glass substrate (400 microm), on top of which a palladium electrode had been previously fabricated enabling end-channel amperometric detection. The thin glass substrate served also as a physical wall between the separation channel and the sensing copper electrodes for contactless conductivity detection. The latter were not integrated in the microfluidic device, but fabricated on an independent plastic substrate allowing a simpler and more cost-effective fabrication of the chip. PDMS/glass chips with merely contactless conductivity detection were first characterized in terms of sensitivity, efficiency and reproducibility. The separation efficiency of this system was found to be similar or slightly superior to other systems reported in the literature. The simultaneous determination of ionic and electroactive species was illustrated by the separation of peroxynitrite degradation products, i.e. NO(3)(-) (non-electroactive) and NO(2)(-) (electroactive), using hybrid PDMS/glass chips with dual contactless conductivity and amperometric detection. While both ions were detected by contactless conductivity detection with good efficiency, NO(2)(-) was also simultaneously detected amperometrically with a significant enhancement in sensitivity compared to contactless conductivity detection.

Reactive conducting thiepin polymers.

https://www.ncbi.nlm.nih.gov/pubmed/19911841

We report the design and synthesis of annulated thiepins designed to undergo bent-to-planar transformation driven by aromatization under electrochemical control. Thiepins are conjugated seven-membered ring systems with a thioether in the macrocycle. We synthesized thermally stable thiepins that are electropolymerizable to give rise to thiepin-containing electroactive polymers. Extended thiepin systems undergo sulfur extrusion with oxidation, and this feature has utility in peroxide sensing.

In situ growth of copper sulfide nanoparticles on ordered mesoporous carbon and their application as nonenzymatic amperometric sensor of hydrogen peroxide.

https://www.ncbi.nlm.nih.gov/pubmed/20188929

A simple and facile synthetic method to incorporate copper sulfide (Cu(2)S) nanoparticles inside the mesopores of ordered mesoporous carbons (OMCs) is reported. The Cu(2)S/OMCs nanocomposite

was characterized by transmission electron microscopy (TEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and nitrogen adsorption-desorption. The results show that the incorporation of Cu(2)S nanoparticles inside the pores of OMCs does not change the highly ordered two-dimensional hexagonal mesostructure of OMCs matrix. Nonenzymatic amperometric sensor of hydrogen peroxide based on the Cu(2)S/OMCs nanocomposite modified glassy carbon (GC) electrode is developed. Compared with the pristine OMCs modified electrode, the Cu(2)S/OMCs modified electrode displays high electrocatalytic activity towards hydrogen peroxide and gives linear range from 1 to 3030 microM (R=0.9986). The sensor also exhibits good ability of anti-interference to electroactive molecules. The combination of the unique properties of Cu(2)S nanoparticles and the ordered mesostructure of OMCs matrix guarantee the excellent electrocatalysis for hydrogen peroxide. The good analytical performance and low-cost make Cu(2)S/OMC nanocomposite promising for the development of effective sensor for hydrogen peroxide.

FRET and competing processes between conjugated polymer and dye substituted DNA strands: a comparative study of probe selection in DNA detection.

https://www.ncbi.nlm.nih.gov/pubmed/19334782

Fluorescence resonance energy transfer (FRET) between water-soluble conjugated polymer, poly-(9,9-bis(6'-N,N,N-trimethylammonium)-hexyl-fluorene phenylene) bromide, and ssDNA's labeled with four different types of dyes (Pacific-blue, Alexa-fluor 430, Fluorescein, and ROX) has been investigated. The effect of spectral overlap and Stokes-shift on the efficiency and properties of FRET were studied. In the DNA sequence detection technique that using cationic conductive polymer and the negatively charged DNA the electrostatic interaction leads to strong aggregation. The effective concentration of these aggregates is quite high leading to strong self-absorption. In this case, labeling with small Stokes shift dyes shows a strong output emission limitation even in extremely dilute system. The steady state fluorescence quenching of the CCP by FRET reveals that the competition between FRET and self-absorption plays a major role when accounting for the FRET ratio. Time-resolved fluorescence lifetime analysis was carried out to measure the energy transfer between the donor and the acceptor excluding self-absorption and quenching by ground-state complex formation. Time-resolved analysis indicates only around 30% of the total CCP excited-state population is quenched by FRET, whereas 55% is quenched by the DNA/buffer solution.

A strategy to promote the electroactive platform adopting poly(o-anisidine)-silver nanocomposites probed for the voltammetric detection of NADH and dopamine.

https://www.ncbi.nlm.nih.gov/pubmed/28866184

A study on the voltammetric detection of NADH (Î²-nicotinamide adenine dinucleotide), Dopamine (DA) and their simultaneous determination is presented in this work. The electrochemical sensor was fabricated with the hybrid nanocomposites of poly(o-anisidine) and silver nanoparticles prepared by simple and cost-effective insitu chemical oxidative polymerization technique. The nanocomposites were synthesized with different (w/w) ratios of o-anisidine and silver by increasing the amount of o-anisidine in each, by keeping silver at a fixed quantity. The XRD patterns revealed the semi-crystalline nature of poly(o-anisidine) and the face centered cubic structure of silver. The presence of silver in its metallic state and the formation of nanocomposite were established by XPS analysis. Raman studies suggested the presence of site-selective interaction between poly(o-anisidine) and silver. HRTEM studies revealed the formation of polymer matrix type nanocomposite with the embedment of silver nanoparticles. The sensing performance of the materials were studied via cyclic voltammetry, differential pulse voltammetry and chronoamperometry techniques. Fabricated sensor with 3:1 (w/w) ratio of poly(o-anisidine) and silver exhibited good catalytic activity towards the detection of NADH and DA in terms of potential and current response, when compared to others. Several important electrochemical parameters regulating the performance of the sensor have been evaluated. Under the optimum condition, differential pulse voltammetry method exhibited the linear response in the range of 0.03 to 900Î¼M and 5 to 270Î¼M with a low detection limit of 0.006Î¼M and 0.052Î¼M for NADH and DA, respectively. The modified electrodes exhibited good sensitivity, stability, reproducibility and selectivity with well-separated oxidation peaks for NADH and DA in the simultaneous determination of their binary mixture. The analytical performance of the nanocomposite as an electrochemical sensor was also established for the determination of NADH in human urine and water samples and DA in pharmaceutical dopamine injections with satisfactory coverage.

Cellular adhesion, proliferation and viability on conducting polymer substrates.

https://www.ncbi.nlm.nih.gov/pubmed/18683167

This work reports a comprehensive study about cell adhesion and proliferation on the surface of different electroactive substrates formed by pi-conjugated polymers. Biological assays were performed considering four different cellular lines: two epithelial and two fibroblasts. On the other

hand, the electroactivity of the three conducting systems was determined in physiological conditions. Results indicate that the three substrates behave as a cellular matrix, even though compatibility with cells is larger for PPy and the 3-layered system. Furthermore, the three polymeric systems are electro-compatible with the cellular monolayers.

Development of an implantable D-serine biosensor for in vivo monitoring using mammalian D-amino acid oxidase on a poly (o-phenylenediamine) and Nafion-modified platinum-iridium disk electrode.

https://www.ncbi.nlm.nih.gov/pubmed/19945264

D-serine has been implicated as a brain messenger, promoting not only neuronal signalling but also synaptic plasticity. Thus, a sensitive tool for D-serine monitoring in brain is required to understand the mechanisms of D-serine release from glia cells. A biosensor for direct fixed potential amperometric monitoring of D-serine incorporating mammalian D-amino acid oxidase (DAAO) immobilized on a Nafion coated poly-ortho-phenylenediamine (PPD) modified Pt-Ir disk electrode was therefore developed. The combined layers of PPD and Nafion enhanced the enzyme activity and biosensor efficiency by approximately 2-fold compared with each individual layer. A steady state response time (t(90%)) of 0.7+/-0.1s (n=8) and limit of detection 20+/-1 nM (n=8) were obtained. Cylindrical geometry showed lower sensitivity compared to disk geometry (61+/-7 microA cm(-2) mM(-1), (n=4), R(2)=0.999). Interference by ascorbic acid (AA), the main interference species in the central nervous system and other neurochemical electroactive molecules was negligible. Implantation of the electrode and microinjection of D-serine into rat brain striatal extracellular fluid demonstrated that the electrode was capable of detecting D-serine in brain tissue in vivo.

Electrochemical identification of the property of peripheral nerve fiber based on a biocompatible polymer film via in situ incorporating gold nanoparticles.

https://www.ncbi.nlm.nih.gov/pubmed/18363334

We report a simple electrochemical method for the identification of properties of peripheral nerve fibers, based on the detection of a neurotransmitter enzyme, acetylcholinesterase (AChE). A poly(diallydimethylammonium) (PDDA) adulterated poly(dimethylsiloxane) (PDMS) film is spin-coated on the surface of gold electrodes. Gold nanoparticles (AuNPs) are in situ synthesized on the polymer film, which act as "electron antennae" between the film and the electrode surface and also provide a biocompatible interface. This PDMS-PDDA/AuNPs film shows different

adsorption sites to choline oxidase (ChO) and AChE; after incubation with ChO, the polymer-gold nanocomposite film also shows excellent adsorption ability to AChE. Moreover the adsorption sites of AChE would not be blocked by bovine serum albumin (BSA) which provides a good platform for the quantitative amperometric determination of AChE via the oxidation of the enzymatically generated H 2O 2 in the bienzyme system in the presence of acetylcholine. The detection limit is down to 1.0 unit/mL. The polymer-gold nanocomposite film shows excellent anti-interference ability to the coexistent electroactive substances such as ascorbic acid. Thus it was applied to determine AChE in peripheral nerve fibers homogenates and identify the motor and sensory fibers for the first time. Compared with histochemical staining methods, the electrochemical technique shows good accurate rate and faster response, which has good potential for a clinical application.

Printing inks of electroactive polymer PEDOT:PSS: The study of biocompatibility, stability, and electrical properties.

https://www.ncbi.nlm.nih.gov/pubmed/29274101

Biocompatibility tests and a study of the electrical properties of thin films prepared from six electroactive polymer ink formulations based on poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) were performed. The aim was to find a suitable formulation of PEDOT:PSS and conditions for preparing thin films in order to construct printed bioelectronic devices for biomedical applications. The stability and electrical properties of such films were tested on organic electrochemical transistor (OECT)-based sensor platforms and their biocompatibility was evaluated in assays with 3T3 fibroblasts and murine cardiomyocytes. It was found that the thin films prepared from inks without an additive or any thin film post-treatment provide limited conductivity and stability for use in biomedical applications. These properties were greatly improved by using ethylene glycol and thermal annealing. Addition or post-treatment by ethylene glycol in combination with thermal annealing provided thin films with electrical resistance and a stability sufficient to be used in sensing of animal cell physiology. These films coated with collagen IV showed good biocompatibility in the assay with 3T3 fibroblasts when compared to standard cell culture plastics. Selected films were then used in assays with murine cardiomyocytes. We observed that these cells were able to attach to the PEDOT:PSS films and form an active sensor element. Spontaneously beating clusters were formed, indicating a good physiological status for the cardiomyocyte cells. These results open the door to construction of cheap printed electronic devices for biointerfacing in biomedical applications.

Effect of Brownian motion on reduced agglomeration of nanostructured metal oxide towards development of efficient cancer biosensor.

https://www.ncbi.nlm.nih.gov/pubmed/29153946

We report results of the studies relating to fabrication of nanostructured metal oxide (NMO) based cancer biosensor. With the help of 2D electroactive reduced graphene oxide (RGO), we successfully inhibited the Brownian motion of NMO that led to reduced agglomeration of NMO. The nanostructured hafnium oxide (nHfO2) was used as a model NMO. The reduced agglomeration of nHfO2 was achieved through controlled hydrothermal synthesis and investigated via nanoparticles tracking analysis (NTA). X-ray diffraction (XRD), scanning electron microscopy (SEM) and transmission electron microscope (TEM) techniques were used for phase identification as well as morphological analysis of the synthesized nanohybrid (nHfO2@RGO) material. The 3-aminopropyl triethoxysilane (APTES) was used for the functionalization of nHfO2@RGO and electrophoretic deposition (EPD) technique was used for its deposition onto ITO coated glass electrode. Further, antibodies of cancer biomarker (anti-CYFRA-21-1) were immobilized via EDC-NHS chemistry and Bovine serum albumin (BSA) was used for blocking of the non-specific binding sites. The electrochemical response studies of fabricated immunoelectrode (BSA/anti-CYFRA-21-1/APTES/nHfO2@RGO/ITO) revealed higher sensitivity (18.24ÂµAmLng-1), wide linear detection range (0 to 30ngmL-1), with remarkable lower detection limit (0.16ngmL-1). The obtained results showed good agreement with the concentration of CYFRA-21-1 obtained through enzyme linked immunosorbent assay (ELISA) in saliva samples of oral cancer patients.

Nitric oxide monitoring in brain extracellular fluid: characterisation of Nafion-modified Pt electrodes in vitro and in vivo.

https://www.ncbi.nlm.nih.gov/pubmed/19768208

A Nafion(5 pre-coats/2 dip-coats)-modified Pt sensor developed for real-time neurochemical monitoring has now been characterised in vitro for the sensitive and selective detection of nitric oxide (NO). A potentiodynamic profile at bare Pt established +0.9 V (vs. SCE) to be the most appropriate applied potential for NO oxidation. The latter was confirmed using oxyhaemoglobin and N(2), both of which reduced the NO signal to baseline levels. Results indicated enhanced NO sensitivity at the Nafion(5/2) sensor (1.67 +/- 0.08 nA microM(-1)) compared to bare Pt (1.08 +/- 0.20 nA microM(-1)) and negligible interference from a wide range of endogenous electroactive interferents such as ascorbic acid, dopamine and its metabolites, NO(2)(-) and H(2)O(2). The

response time of 33.7 +/- 2.7 s was found to improve (19.0 +/- 3.4 s) when the number of Nafion layers was reduced to 2/1 and an insulating outer layer of poly(o-phenylenediamine) added. When tested under physiological conditions of 37 degrees C the response time of the Nafion(5/2) sensor improved to 14.00 +/- 2.52 s. In addition, the NO response was not affected by physiological concentrations of O(2) despite the high reactivity of the two species for each other. The limit of detection (LOD) was estimated to be 5 nM while stability tests in lipid (phosphatidylethanolamine; PEA) and protein (bovine serum albumin; BSA) solutions (10%) found an initial ca. 38% drop in sensitivity in the first 24 h which remained constant thereafter. Preliminary in vivo experiments involving systemic administration of NO and L-arginine produced increases in the signals recorded at the Nafion(5/2) sensor implanted in the striatum of freely-moving rats, thus supporting reliable in vivo recording of NO.

Fabrication of a novel glucose biosensor based on a highly electroactive polystyrene/polyaniline/Au nanocomposite.

https://www.ncbi.nlm.nih.gov/pubmed/18598073

A novel nanocomposite with a core-shell structure containing polystyrene (PS), polyaniline (PANI), and Au nanoparticles (NPs) was synthesized. The nanocomposite was characterized by scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and Fourier transform infrared spectroscopy (FTIR). Cyclic voltammetric experiments indicated that the nanocomposite had excellent redox ability in a wide range of pH values. The existence of Au NPs resulted in a higher electrical conductivity of the nanocomposite. As a model, glucose oxidase (GOD) was entrapped onto the nanocomposite-modified glassy carbon electrode (GCE) and applied to construct a sensor. The immobilized GOD showed a pair of well-defined redox peaks and high catalytic activity for the oxidation of glucose.

Electroactive elastomeric haptic displays of organ motility and tissue compliance for medical training and surgical force feedback.

https://www.ncbi.nlm.nih.gov/pubmed/19527955

This paper presents a novel approach used to develop haptic displays of motility of organs and compliance of tissues, aimed at combining structural simplicity with realistic appearance and consistence. The dielectric elastomer actuation technology was used to mimic mechanical passive

properties and electromechanical active functions of tissues by means of electroresponsive elastomeric devices. Proof-of-concept displays were conceived for medical training in cardiology and surgical force feedback in minimally invasive procedures. In particular, prototype displays of cardiac contractility, pulsatile blood pressure, and compliance of soft tissues were manufactured with silicone and acrylic elastomers. Preliminary physical and psychophysical tests suggested the feasibility of the considered approach, while emphasizing required improvements.

Synthesis of a novel biodegradable and electroactive polyphosphazene for biomedical application.

https://www.ncbi.nlm.nih.gov/pubmed/19468157

To prepare one electroactive and biodegradable biomaterial for biomedical application, a new synthetic strategy was developed to synthesize a novel electrically conductive biodegradable polyphosphazene polymer containing parent aniline pentamer (PAP) and glycine ethyl ester (GEE) as side chains by a nucleophilic substitution reaction. The electrical conductivity of the polymer is approximately 2 x 10(-5) S cm(-1) in the semiconducting region upon preliminarily protonic-doped experiment. The degradation and RSC96 Schwann cells experiments in vitro prove that the polymer is biodegradable and beneficial to the cell adhesion and proliferation. The as-synthesized polymer also shows good solubility in common organic solvent and good film-forming properties. This new type of polymer has potential applications as scaffolds for neuronal and cardiovascular tissue engineering or other biomedical devices that require electroactivity.

Poly(2,7-carbazole)s: structure-property relationships.

https://www.ncbi.nlm.nih.gov/pubmed/18656967

Conjugated polymers combine the interesting optical and electrical properties of metals with the processing advantages and mechanical properties of traditional synthetic polymers. With clever use of a variety of synthetic tools, researchers have prepared highly pure polymers with optimized physical properties during the past 30 years. For example, the synthesis of well-defined polyacetylenes, polyphenylenes, polythiophenes, polyfluorenes, and other conjugated polymers have significantly improved the performance of these polymeric materials. However, one important class of conjugated polymers was missing from this chemical inventory: easy access to well-defined poly(2,7-carbazole)s and related polymers. This Account highlights advances in the synthesis of poly(2,7-carbazole) derivatives since they were first reported in 2001. Starting from 2-nitro-biphenyl

derivatives, 2,7-functionalized carbazoles are typically obtained from Cadogan ring-closure reactions. In a second step, Yamamoto, Stille, Suzuki, or Horner-Emmons coupling polymerization leads to various poly(2,7-carbazole) derivatives. We discuss the characterization of their optical and electrical properties with a strong emphasis on the structure-property relationships. In addition, we carefully evaluate these polymers as active components in light-emitting diodes, transistors, and photovoltaic cells. In particular, several low band gap poly(2,7-carbazole) derivatives have revealed highly promising features for solar cell applications with hole mobilities of about 3 x 10(-3) cm2 V(-1) s(-1) and power conversion efficiencies up to 4.8%. Finally, we show how these new synthetic strategies have led to the preparation of novel poly(heterofluorene) derivatives and ladder-type conjugated polymers.

Dexamethasone electrically controlled release from polypyrrole-coated nanostructured electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/20143134

One of the key challenges to engineering neural interfaces is to reduce their immune response toward implanted electrodes. One potential approach to minimize or eliminate this undesired early inflammatory tissue reaction and to maintain signal transmission quality over time is the delivery of anti-inflammatory biomolecules in the vicinity of the implant. Here, we report on a facile and reproducible method for the fabrication of high surface area nanostructured electrodes coated with an electroactive polymer, polypyrrole (PPy) that can be used to precisely release drug by applying an electrical stimuli. The method consists of the electropolymerization of PPy incorporated with drug, dexamethasone (DEX), onto a brush of metallic nanopillars, obtained by electrodeposition of the metal within the nanopores of gold-coated polycarbonate template. The study of the release of DEX triggered by electrochemical stimuli indicates that the system is a true electrically controlled release system. Moreover, it appears that the presence of metallic nanowires onto the electrode surface improves the adherence between the polymer and the electrode and increases the electroactivity of the PPy coating.

A review on robotic fish enabled by ionic polymer-metal composite artificial muscles.

https://www.ncbi.nlm.nih.gov/pubmed/29264109

A novel actuating material, which is lightweight, soft, and capable of generating large flapping motion under electrical stimuli, is highly desirable to build energy-efficient and maneuverable

bio-inspired underwater robots. Ionic polymer-metal composites are important category of electroactive polymers, since they can generate large bending motions under low actuation voltages. IPMCs are ideal artificial muscles for small-scale and bio-inspired robots. This paper takes a system perspective to review the recent work on IPMC-enabled underwater robots, from modeling, fabrication, and bio-inspired design perspectives. First, a physics-based and control-oriented model of IPMC actuator will be reviewed. Second, a bio-inspired robotic fish propelled by IPMC caudal fin will be presented and a steady-state speed model of the fish will be demonstrated. Third, a novel fabrication process for 3D actuating membrane will be introduced and a bio-inspired robotic manta ray propelled by two IPMC pectoral fins will be demonstrated. Fourth, a 2D maneuverable robotic fish propelled by multiple IPMC fin will be presented. Last, advantages and challenges of using IPMC artificial muscles in bio-inspired robots will be concluded.

A nanocellulose polypyrrole composite based on microfibrillated cellulose from wood.

https://www.ncbi.nlm.nih.gov/pubmed/20205378

It is demonstrated that it is possible to coat the individual fibers of wood-based nanocellulose with polypyrrole using in situ chemical polymerization to obtain an electrically conducting continuous high-surface-area composite. The experimental results indicate that the high surface area of the water dispersed material, to a large extent, is maintained upon normal drying without the use of any solvent exchange. Thus, the employed chemical polymerization of polypyrrole on the microfibrillated cellulose (MFC) nanofibers in the hydrogel gives rise to a composite, the structure of which-unlike that of uncoated MFC paper-does not collapse upon drying. The dry composite has a surface area of approximately 90 m(2)/g and a conductivity of approximately 1.5 S/cm, is electrochemically active, and exhibits an ion-exchange capacity for chloride ions of 289 C/g corresponding to a specific capacity of 80 mAh/g. The straightforwardness of the fabrication of the present nanocellulose composites should significantly facilitate industrial manufacturing of highly porous, electroactive conductive paper materials for applications including ion-exchange and paper-based energy storage devices.

Aqueous Processing for Printed Organic Electronics: Conjugated Polymers with Multistage Cleavable Side Chains.

https://www.ncbi.nlm.nih.gov/pubmed/28979937

The ability to process conjugated polymers via aqueous solution is highly advantageous for reducing

the costs and environmental hazards of large scale roll-to-roll processing of organic electronics. However, maintaining competitive electronic properties while achieving aqueous solubility is difficult for several reasons: (1) Materials with polar functional groups that provide aqueous solubility can be difficult to purify and characterize, (2) many traditional coupling and polymerization reactions cannot be performed in aqueous solution, and (3) ionic groups, though useful for obtaining aqueous solubility, can lead to a loss of solid-state order, as well as a screening of any applied bias. As an alternative, we report a multistage cleavable side chain method that combines desirable aqueous processing attributes without sacrificing semiconducting capabilities. Through the attachment of cleavable side chains, conjugated polymers have for the first time been synthesized, characterized, and purified in organic solvents, converted to a water-soluble form for aqueous processing, and brought through a final treatment to cleave the polymer side chains and leave behind the desired electronic material as a solvent-resistant film. Specifically, we demonstrate an organic soluble polythiophene that is converted to an aqueous soluble polyelectrolyte via hydrolysis. After blade coating from an aqueous solution, UV irradiation is used to cleave the polymer's side chains, resulting in a solvent-resistant, electroactive polymer thin film. In application, this process results in aqueous printed materials with utility for solid-state charge transport in organic field effect transistors (OFETs), along with red to colorless electrochromism in ionic media for color changing displays, demonstrating its potential as a universal method for aqueous printing in organic electronics.

Force requirements for artificial muscle to create an eyelid blink with eyelid sling.

https://www.ncbi.nlm.nih.gov/pubmed/20083738

To determine the force requirements, optimal vector, and appropriate materials of a novel eyelid sling device that will be used to rehabilitate eyelid closure (blink) in congenital or acquired permanent facial paralysis with an artificial muscle.

A simple-potentiometric method for determination of acid and alkaline phosphatase enzymes in biological fluids and dairy products using a nitrophenylphosphate plastic membrane sensor.

https://www.ncbi.nlm.nih.gov/pubmed/19362623

A novel poly(vinyl chloride) matrix membrane sensor responsive to 4-nitrophenylphosphate (4-NPP) substrate is described, characterized and used for the potentiometric assay of acid (ACP) and alkaline (ALP) phosphatase enzymes. The sensor is based on the use of the ion-association

complex of 4-NPP anion with nickel(II)-bathophenanthroline cation as an electroactive material and nitrophenyloctyl ether (NPOE) as a solvent mediator. The sensor displays good selectivity and stability and demonstrates a near-Nernstian response for 4-NPP over the concentration range 9.6x10(-6) to 1.0x10(-2) M with an anionic slope of 28.6+/-0.3 mV decade(-1) and a detection limit of 6.3x10(-6) M over the pH range 4.5-10. The sensor is used to measure the decrease of a fixed concentration of 4-NPP substrate as a function of acid and alkaline phosphatase enzyme activities at optimized conditions of pH and temperature. A linear relationship between the initial rate of 4-NPP substrate hydrolysis and enzyme activity holds over 0.05-3.0 and 0.03-3.4 IU L(-1) of ACP and ALP enzymes, respectively. Validation of the method by measuring the lower detection limit, range, accuracy, precision, within-day repeatability and between-day-variability reveals good performance characteristics of the proposed sensor. The sensor is used for the determination of acid and alkaline phosphatase enzyme activities in biological fluids of some patients suffering from alcoholic cirrhosis, acute myelocytic leukemia, pre-eclampsia and prostatic cancer. The sensor is also utilized for assessment of alkaline phosphatase enzyme in milk and dairy products. The results obtained agree fairly well with data obtained by the standard spectrophotometric methods.

Enzyme containing redox polymer networks for biosensors or biofuel cells: a photochemical approach.

https://www.ncbi.nlm.nih.gov/pubmed/20039603

A photochemical approach to the generation of (microstructured) redox hydrogels with incorporated enzymes is presented and evaluated with respect to its potential in biosensor and biofuel cell applications. For this, poly(dimethylacrylamide) polymers containing both electroactive ferrocene moieties and photoreactive benzophenone groups are synthesized and deposited as thin films on electrode surfaces. Upon short irradiation with UV light, the polymer layer cross links and becomes firmly adhered to the glassy carbon electrodes. If glucose oxidase is mixed into the polymer solution prior to coating, then glucose-oxidizing electrodes with very high catalytic current responses are obtained. The influence of multivalent ions and proteins on the performance of the electrocatalytic films is studied. It is found that the interaction between bivalent HPO(4)(2-) and the oxidized redox moieties can shorten the lifetime of the redox electrodes significantly whereas the same electrodes are quite stable in the presence of monovalent ions and the reduced form of the mediator. Coating a thin, covalently attached poly(dimethylacrylamide) protective layer onto the redox polymer networks can greatly reduce the adsorption of proteins onto the surfaces and improve the long-term stability

of the electrodes in physiological environments. Because the adsorption of proteins onto unprotected surfaces is one of the major causes of bioelectrode failure, this aspect is expected to contribute to the design of more biostable sensors and fuel cells.

Active polymer gel actuators.

https://www.ncbi.nlm.nih.gov/pubmed/20162001

Many kinds of stimuli-responsive polymer and gels have been developed and applied to biomimetic actuators or artificial muscles. Electroactive polymers that change shape when stimulated electrically seem to be particularly promising. In all cases, however, the mechanical motion is driven by external stimuli, for example, reversing the direction of electric field. On the other hand, many living organisms can generate an autonomous motion without external driving stimuli like self-beating of heart muscles. Here we show a novel biomimetic gel actuator that can walk spontaneously with a worm-like motion without switching of external stimuli. The self-oscillating motion is produced by dissipating chemical energy of oscillating reaction. Although the gel is completely composed of synthetic polymer, it shows autonomous motion as if it were alive.

Polyaniline/multiwall carbon nanotubes/starch nanocomposite material and hemoglobin modified carbon paste electrode for hydrogen peroxide and glucose biosensing.

https://www.ncbi.nlm.nih.gov/pubmed/29360546

This paper describes the application of novel nanocomposite material polyaniline/multiwall carbon nanotubes/starch (designated as PCS) as a good electrode material for electrochemical sensing. The developed ternary composite system has manifold interactions and synergistic improved properties - high surface area, good electro-activity, conductivity, stable dispersion, biocompatible, hydrophilic and hydrophobic regions, multifunctional, and nanoturmeric shape morphology. Hydrogen peroxide biosensor was fabricated as a model system using PCS and hemoglobin (HB) modified carbon paste electrode. PCS and HB compatible and effectively communicate with each other, facilitate the charge transfer (potassium ferricyanide used as electroactive marker). Thus, PCS and HB (in combination) is a good electrode material for sensitive and selective detection of peroxide. The developed biosensor showed a linear range (0.1â€¯mM-5â€¯mM, R2â€¯=â€¯0.9975), limit of detection (0.032â€¯mM), sensitivity (76.43â€¯Î¼A/mMâ€¯cm2) and long-term storage and stability. This material could be used a platform to develop some other sensors by using other redox enzymes. As a model, we incorporate glucose oxidase to detect Glucose. Thus, the favorable

properties indicate that the proposed material system suitable for low-cost sensor strips.

Influence of Temperature on the Electromechanical Properties of Ionic Liquid-Doped Ionic Polymer-Metal Composite Actuators.

https://www.ncbi.nlm.nih.gov/pubmed/30971036

Ionic polymer-metal composite (IPMC) actuators have considerable potential for a wide range of applications. Although IPMC actuators are widely studied for their electromechanical properties, most studies have been conducted at the ambient conditions. The electromechanical performance of IPMC actuators at higher temperature is still far from understood. In this study, the effect of temperature on the electromechanical behavior (the rate of deformation and curvature) and electrochemical behavior (current flow) of ionic liquid doped IPMC actuators are examined and reported. Both electromechanical and electrochemical studies were conducted in air at temperatures ranging from 25 Â°C to 90 Â°C. Electromechanically, the actuators showed lower cationic curvature with increasing temperature up to 70 Â°C and a slower rate of deformation with increasing temperature up to 50 Â°C. A faster rate of deformation was recorded at temperatures higher than 50 Â°C, with a maximum rate at 60 Â°C. The anionic response showed a lower rate of deformation and a higher anionic curvature with increasing temperatures up to 50 Â°C with an abrupt increase in the rate of deformation and decrease of curvature at 60 Â°C. In both cationic and anionic responses, actuators started to lose functionality and show unpredictable performance for temperatures greater than 60 Â°C, with considerable fluctuations at 70 Â°C. Electrochemically, the current flow across the actuators was increased gradually with increasing temperature up to 80 Â°C during the charging and discharging cycles. A sudden increase in current flow was recorded at 90 Â°C indicating a shorted circuit and actuator failure.

Electrochemical aptasensor for multi-antibiotics detection based on endonuclease and exonuclease assisted dual recycling amplification strategy.

https://www.ncbi.nlm.nih.gov/pubmed/29310232

An ultrasensitive electrochemical aptasensor for multiplex antibiotics detection based on endonuclease and exonuclease assisted dual recycling amplification strategy was proposed. Kanamycin and chloramphenicol were selected as candidates. Firstly, aptamers of the antibiotics were immobilized on bar A and then binding with their endonuclease labeled complementary DNA strands to construct enzyme-cleavage probes. Secondly, The nano zirconium-metal organic

framework (NMOF) particles with 1,4-benzene-dicarboxylate (BDC) as linker was defined as UiO-66. And its updated version, hierarchically porous UiO-66 (HP-UIO-66) decorated with different electroactive materials as signal tags were synthesized. Then they were immobilized on bar B linked by two duplex DNA strands which can be specifically cleaved by corresponding enzyme-cleavage probes in bar A. Once targets were introduced into system, aptamers can capture them and then release enzyme-cleavage probes. In the presence of exonuclease-I, exonuclease assisted target recycling amplification was triggered and more enzyme-cleavage probes were released into solution. The probes can trigger endonuclease assisted recycles and repeatedly cleave their corresponding duplex DNA strands on bar B then released numerous signal tags into supernatant. Thus two recycling amplification was performed in the system. Finally, MB and Fc in the signal tags were detected by square wave voltammetry after removing bar A/B and the current intensities were correspondent with the concentration of KANA and CAP respectively. Under the optimum condition, the limits of detection for the KANA and CAP were 35fM and 21fM respectively with a wide linear range from 1 Ã— 10-4 to 50nM. This dual recycling amplification detection system exhibited high sensitivities and specificity. It can be easily extended to detect other targets if changing the corresponding aptamers and has potential application values for screening of multiplex antibiotics residues in food safety.

Electroactive linear-hyperbranched block copolymers based on linear poly(ferrocenylsilane)s and hyperbranched poly(carbosilane)s.

https://www.ncbi.nlm.nih.gov/pubmed/19637258

A convenient two-step protocol is presented for synthesis of linear-hyperbranched diblock copolymers consisting of a linear, organometallic poly(ferrocenylsilane) (PFS) block and hyperbranched poly(carbosilane) (hbPCS) segments. Linear PFS diblock copolymers were synthesized through photolytic ring-opening polymerization of dimethyl[1]silaferrocenophane as the first block and methylvinyl[1]silaferrocenophane as the second. These block copolymers served as polyfunctional cores in a subsequent hydrosilylation polyaddition of different silane-based AB(2) monomers. Three AB(2) monomers (methyldiallylsilane; methyldiundecenylsilane, and ferrocenyldiallylsilane) were investigated; they introduced structural diversity to the hyperbranched block and showed variable reactivity for the hydrosilylation reaction. In the case with the additional ferrocene moiety in the ferrocenyldiallylsilane monomer, an electroactive hyperbranched block was generated. No slow monomer addition was necessary for molecular-weight control of the

hyperbranching polyaddition, as the core had much higher functionality and reactivity than the carbosilane monomers. Different block ratios were targeted and hybrid block copolymers with narrow polydispersity (<1.2) were obtained. All the resulting polymers were investigated and characterized by size exclusion chromatography, NMR spectroscopy, cyclic voltammetry, and TEM, and exhibited strongly anisotropic aggregation.

Redox-active conducting polymers modulate Salmonella biofilm formation by controlling availability of electron acceptors.

https://www.ncbi.nlm.nih.gov/pubmed/28883986

Biofouling is a major problem caused by bacteria colonizing abiotic surfaces, such as medical devices. Biofilms are formed as the bacterial metabolism adapts to an attached growth state. We studied whether bacterial metabolism, hence biofilm formation, can be modulated in electrochemically active surfaces using the conducting conjugated polymer poly(3,4-ethylenedioxythiophene) (PEDOT). We fabricated composites of PEDOT doped with either heparin, dodecyl benzene sulfonate or chloride, and identified the fabrication parameters so that the electrochemical redox state is the main distinct factor influencing biofilm growth. PEDOT surfaces fitted into a custom-designed culturing device allowed for redox switching in Salmonella cultures, leading to oxidized or reduced electrodes. Similarly large biofilm growth was found on the oxidized anodes and on conventional polyester. In contrast, biofilm was significantly decreased (52-58%) on the reduced cathodes. Quantification of electrochromism in unswitched conducting polymer surfaces revealed a bacteria-driven electrochemical reduction of PEDOT. As a result, unswitched PEDOT acquired an analogous electrochemical state to the externally reduced cathode, explaining the similarly decreased biofilm growth on reduced cathodes and unswitched surfaces. Collectively, our findings reveal two opposing effects affecting biofilm formation. While the oxidized PEDOT anode constitutes a renewable electron sink that promotes biofilm growth, reduction of PEDOT by a power source or by bacteria largely suppresses biofilm formation. Modulating bacterial metabolism using the redox state of electroactive surfaces constitutes an unexplored method with applications spanning from antifouling coatings and microbial fuel cells to the study of the role of bacterial respiration during infection.

Electroosmotic flow and its contribution to iontophoretic delivery.

https://www.ncbi.nlm.nih.gov/pubmed/18947198

Iontophoresis is the movement of charged molecules in solution under applied current using pulled multibarrel glass capillaries drawn to a sharp tip. The technique is generally nonquantitative, and to address this, we have characterized the ejection of charged and neutral species using carbon-fiber electrodes attached to iontophoretic barrels. Our results show that observed ejections are due to the sum of iontophoretic and electroosmotic forces. With the use of the neutral, electroactive molecule 2-(4-nitrophenoxy) ethanol (NPE), which is only transported by electroosmotic flow (EOF), a positive correlation between the amount ejected and the diameter of each barrel's tip was found. In addition, using various charged and neutral electroactive compounds we found that, when each compound is paired with the EOF marker, the percentage of the ejection due to EOF remains constant. This percentage varies for each pair of compounds, and the differences in mobility are positively correlated to differences in electrophoretic mobility. Overall, the results show that capillary electrophoresis (CE) can be used to predict the percentage of ejection that will be due to EOF. With this information, quantitative iontophoresis is possible for electrochemically inactive drugs by using NPE as a marker for EOF.

Electrochemically controlled swelling and mechanical properties of a polymer nanocomposite.

https://www.ncbi.nlm.nih.gov/pubmed/19624148

We present the layer-by-layer assembly of an electroactive polymer nanocomposite thin film containing cationic linear poly(ethyleneimine) (LPEI) and 68 vol % anionic Prussian Blue (PB) nanoparticles, which allow for electrochemical control over film thickness and mechanical properties. Electrochemical reduction of the PB doubles the negative charge on the particles, causing an influx of water and ions from solution to maintain electroneutrality in the film; concomitant swelling and increased elastic compliance of the film result. Reversible swelling upon reduction is on the order of 2-10%, as measured via spectroscopic ellipsometry and electrochemical atomic force microscopy. Reversible changes in the Young's elastic modulus of the hydrated composite film upon reduction are on the order of 50% (from 3.40 to 1.75 GPa) as measured with in situ nanoindentation, and a qualitative increase in viscous contributions to energy dissipation upon redox is indicated by electrochemical quartz crystal microbalance. Electrochemical stimuli maintain a mild operating environment and can be applied rapidly, reversibly, and locally. We maintain that electrochemical control over the swelling and mechanical behavior of polymer nanocomposites could have important implications for responsive coatings of nanoscale devices, including mechanically tunable surfaces

to modulate behavior of adherent cells.

Electrochemically mediated in situ growth of electroactive polymers for highly sensitive detection of double-stranded DNA without sequence-preference.

https://www.ncbi.nlm.nih.gov/pubmed/29031128

The ability to directly detect double-stranded DNA (dsDNA) without sequence-preference continues to be a major challenge. Herein, we report an electrochemical method for the direct, highly sensitive detection of dsDNA based on the strand replacement of dsDNA by peptide nucleic acid (PNA) and the in situ growth of electroactive polymers through the surface-initiated electrochemically mediated atom transfer radical polymerization (SI-eATRP). Thiolated PNA molecules are firstly self-assembled onto gold electrode surface for the specific recognition of target dsDNA (dsDNA-T), which in turn leads to the formation of a high density of PNA/DNA heteroduplexes on the electrode surface for the subsequent attachment of ATRP initiators via the phosphate-Zr4+-carboxylate chemistry. By applying a negative potential to the electrode, the air-stable CuII deactivators can be reduced into the CuI activators so as to trigger the surface-initiated polymerization for the in situ growth of electroactive polymers. Due to the strand replacement of dsDNA by PNA, dsDNA can be directly detected without sequence-preference. Besides, the growth of polymers enables the modification of numerous electroactive probes, thereby greatly improving the electrochemical signal. Under optimal conditions, a good linearity between the electrochemical signal and the logarithm of dsDNA-T concentration over the range from 1.0 fM to 1.0nM, with a detection limit of 0.47 fM, can be obtained. Results indicate that it is highly selective, and holds high anti-interference capability in the presence of human serum samples. Therefore, this method offers great promises in providing a universal and efficient solution for the direct detection of dsDNA.

Biocompatibility Assessment of Conducting PANI/Chitosan Nanofibers for Wound Healing Applications.

https://www.ncbi.nlm.nih.gov/pubmed/30965990

As electroactive polymers have recently presented potential in applications in the tissue engineering and biomedical field, this study is aiming at the fabrication of composite nanofibrous membranes containing conducting polyaniline and at the evaluation of their biocompatibility. For that purpose, conducting polyanilineâ•»chitosan (PANI/CS) defect free nanofibres of different ratios (1:3; 3:5 and 1:1) were produced with the electrospinning method. They were characterized as for their

morphology, hydrophilicity and electrical conductivity. The membranes were then evaluated for their cellular biocompatibility in terms of cell attachment, morphology and cell proliferation. The effect of the PANI content on the membrane properties is discussed. Increase in PANI content resulted in membranes with higher hydrophobicity and higher electrical conductivity. It was found that none of the membranes showed any toxic effects on osteoblasts and fibroblasts, and that they all supported cell attachment and growth, even to a greater extent than tissue culture plastic. The membrane with the PANI/CS ratio 1:3 supports better cell attachment and proliferation for both cell lines due to a synergistic effect of hydrophilicity retention due to the high chitosan content and the conductivity that PANI introduced to the membrane.

Electrochemically Mediated Surface-Initiated de Novo Growth of Polymers for Amplified Electrochemical Detection of DNA.

https://www.ncbi.nlm.nih.gov/pubmed/28806877

The development of convenient and efficient strategies without involving any complex nanomaterials or enzymes for signal amplification is of great importance in bioanalytical applications. In this work, we report the use of electrochemically mediated surface-initiated atom transfer radical polymerization (SI-eATRP) as a novel amplification strategy based on the de novo growth of polymers (dnGOPs) for the electrochemical detection of DNA. Specifically, the capture of target DNA (tDNA) by the immobilized peptide nucleic acid (PNA) probes provides a high density of phosphate groups for the subsequent attachment of ATRP initiators onto the electrode surface by means of the phosphate-Zr4+-carboxylate chemistry, followed by the de novo growth of electroactive polymer via the SI-eATRP. De novo growth of long polymeric chains enables the labeling of numerous electroactive probes, which in turn greatly improves the electrochemical response. Moreover, it circumvents the slow kinetics and poor coupling efficiency encountered when nanomaterials or preformed polymers are used and features sufficient flexibility and simplicity in controlling the degree of signal amplification. Under optimal conditions, it allows a highly sensitive and selective detection of tDNA within a broad linear range from 0.1 fM to 0.1 nM (R2 = 0.996), with the detection limit down to 0.072 fM. Compared with the unamplified method, more than 1.2 Ã—106-fold sensitivity improvement in DNA detection can be achieved. By virtue of its simplicity, high efficiency, and cost-effectiveness, the proposed dnGOPs-based signal amplification strategy holds great potential in bioanalytical applications for the sensitive detection of biological molecules.

Electrically controlled release of salicylic acid from poly(p-phenylene vinylene)/polyacrylamide hydrogels.

https://www.ncbi.nlm.nih.gov/pubmed/19162150

The apparent diffusion coefficients, Dapp, and the release mechanisms of salicylic acid from salicylic acid-loaded polyacrylamide hydrogels, SA-loaded PAAM, and salicylic acid-doped poly(phenylene vinylene)/polyacrylamide hydrogels, SA-doped PPV/PAAM, were investigated. In the absence of an electric field, the diffusion of SA from the SA-doped PPV/PAAM is delayed in the first 3 h due to the ionic interaction between the anionic drug (SA anion) and the PPV. Beyond this period, SA is dissolved in and can diffuse into the buffer solution through the PAAM matrix. The Dapp of the SA-doped PPV/PAAM is higher than that of the SA-loaded PAAM, and the former increases with increasing electric field strength due to combined mechanisms: the expansion of PPV chains inside the hydrogel; the reduction reaction under a negative potential driving the anionic SA through the PAAM matrix; and the expansion of the matrix pore. The Dapp of SA from the SA-loaded PAAM and the SA-doped PPV/PAAM apparently obey the scaling behavior: Dapp/D0 = (drug size/pore size)m with the scaling exponent m equal to 0.50 at 0.1 V for both SA-loaded PAAM and SA-doped PPV/PAAM. Thus, the presence of the conductive polymer and the applied electric field can be combined to control the drug release rate at an optimal desired level.

Development of Coarse-Grained Liquid-Crystal Polymer Model with Efficient Electrostatic Interaction: Toward Molecular Dynamics Simulations of Electroactive Materials.

https://www.ncbi.nlm.nih.gov/pubmed/29316621

Liquid-crystal polymers (LCPs) are well known materials for functional sensor and actuators, because of their high-responsiveness to an electric field. Owing to their complex physical nature, however, the prediction of the functions of LCPs is a challenge. To attack this problem from a molecular point of view, a simulation study is a promising approach. In this work, for future applications of molecular dynamics simulations to problems involving an electric field, we develop an LCP model which consists of coarse-grained mesogenic molecules and smeared charges. For the smearing function of the electrostatic force, the Gauss error function is introduced. This smearing is optimized to attain a reasonable accuracy for phase transition phenomena of liquid crystal while numerical instabilities arising from the singularity of the Coulomb potential are circumvented. For swelling systems, our LCP model exhibits the characteristics of both liquid crystals and unentangled polymer chains; orientational order of the mesogenic units and Rouse-like relaxation dynamics. Our

coarse-grained LCP model successfully incorporates electric charges and dipoles and is therefore applicable to problems concerning an electric field.

A Sensitive Electrochemical Aptasensor for Thrombin Detection Based on Electroactive Co-Based Metal-Organic Frameworks with Target-Triggering NESA Strategy.

https://www.ncbi.nlm.nih.gov/pubmed/29019234

In this work, an improved target-triggering nicking enzyme signaling amplification (NESA) strategy as signal enhancer has been fabricated to obtain a sensitive electrochemical thrombin (TB) biosensor combined with PtPd NPs decorated electroactive Co-based metal-organic frameworks (Co-MOFs/PtPdNPs) as a redox mediator. Traditionally, in the NESA strategy, only one of the output double strands DNA is available in the next cycle. However, in this work, all of the output DNA involved in the improved NESA strategies could be further employed, resulting in high utilization of output DNA, which further enhanced signal amplification and sensitivity of the biosensor. In addition, the electroactive Co-MOFs were not only used as nanocarriers but also acted as signal labels, avoiding adding extra redox media. Simultaneously, in the presence of H2O2, PtPd NPs decorated on the Co-MOFs act the same as horseradish peroxidase to promote the oxidation of H2O2, further promoting the conversion of Co2+ to Co3+, leading to electrochemical signal amplification. With such design, the TB biosensor exhibited good sensitivity from 1 pM to 30 nM with a detection limit of 0.32 pM. This new NESA strategy with high utilization of output DNA can supply one efficient approach to improve signal amplification, which also open an avenue for sensitivity enhancement in detection of analytes.

PdPt nanoparticles anchored on the N-G with the integration of PANI nanohybrids as novel redox probe and catalyst for the detection of rs1801177.

https://www.ncbi.nlm.nih.gov/pubmed/29175215

Single nucleotide polymorphism (SNP) in lipoprotein lipase (LPL) gene (rs1801177) is strongly associated with the increased progression of atherosclerosis, threatening global public health. In this work, a relatively simple, specific and ultrasensitive electrochemical DNA biosensor was constructed to detect rs1801177 for the first time. A glass carbon electrode was modified with fullerene (C60)/polyamidoamine (PAMAM)/gold (Au) nanoparticles nanocomposites film. In addition the nitrogen-doped graphene (N-G)/palladium platinum (PdPt) bimetallic nanoparticle/ polyaniline (PANI) nanohybrids were synthesised and used to label the signal probes. These nanohybrids have

abundant active groups, and efficient redox and catalytic activity, allowing them to be used as the nanocarrier for a redox nanoprobe without the additional modification of electroactive substance and catalyst, which could effectively simplify the operation procedure and shorten the analysis time. With the catalysis of H2O2 by nanohybrids, the detection signal of N-G/PdPt/PANI itself could be significantly enhanced, lead to the improvement of the sensitivity. Under optimal conditions, the electrochemical DNA biosensor exhibited desirable performance for the determination of rs1801177 with a wide linearity ranging from 10 fM to 10nM and a relatively low detection limit of 3.33 fM (S/N=3). The proposed biosensor showed excellent selectivity to the target DNA compared to possible interfering substances. The results suggested that this method has potential applications in clinical research.

Selective nanomolar detection of dopamine using a boron-doped diamond electrode modified with an electropolymerized sulfobutylether-beta-cyclodextrin-doped poly(N-acetyltyramine) and polypyrrole composite film.

https://www.ncbi.nlm.nih.gov/pubmed/19382752

N-acetyltyramine was synthesized and electropolymerized together with a negatively charged sulfobutylether-beta-cyclodextrin on a boron-doped diamond (BDD) electrode followed by the electropolymerization of pyrrole to form a stable and permselective film for selective dopamine detection. The selectivity and sensitivity of the formed layer-by-layer film was governed by the sequence of deposition and the applied potential. Raman results showed a decrease in the peak intensity at 1329 cm(-1) (sp(3)), the main feature of BDD, upon each electrodeposition step. Such a decrease was correlated well with the change of the charge-transfer resistance derived from impedance data, i.e., reflecting the formation of the layer-by-layer film. The polycrystalline BDD surface became more even with lower surface roughness as revealed by scanning electron and atomic force microscopy. The modified BDD electrode exhibited rapid response to dopamine within 1.5-2 s and a low detection limit of 4-5 nM with excellent reproducibility. Electroactive interferences caused by 4-dihydroxyphenylalanine, 3,4-dihydroxyphenylacetic acid, ascorbic acid, and uric acid were completely eliminated, whereas the signal response of epinephrine and norepinephrine was significantly suppressed by the permselective film.

Effect of donor to acceptor ratio on electrochemical and spectroscopic properties of oligoalkylthiophene 1,3,4-oxadiazole derivatives.

https://www.ncbi.nlm.nih.gov/pubmed/29110005

A structure-property study across a series of donor-acceptor-donor structures composed of mono- and bi-(1,3,4-oxadiazole) units symmetrically substituted with alkyl functionalized bi-, ter- and quaterthiophene segments is presented. Synthetically tailoring the ratio of electron-withdrawing 1,3,4-oxadiazole to electron-releasing thiophene units and their alkyl grafting pattern permitted us to scrutinize the impact of these structural factors on the redox, absorptive and emissive properties of these push-pull molecules. Contrasting trends of redox potentials were observed, with the oxidation potential closely following the donor-to-acceptor ratio, whereas the reduction potential being tuned independently by either the number of acceptor units or the conjugation length of the donor-acceptor system. Increasing the thiophene unit contribution delivered a shift from blue to green luminescence, while the structural rigidity afforded by intramolecular non-covalent interactions between 1,3,4-oxadiazole and the thiophene moieties has been identified as the prime factor determining the emission efficiency of these molecules. All six structures investigated electro-polymerize easily, yielding electroactive and electrochromic polymers. The polymer doping process is largely influenced by the length of the oligothiophene repeating unit and the alkyl chain grafting density. Polymers with relatively short oligothiophene segments are able to support polarons and polaron-pairs, whereas those with segments longer than six thiophene units could also stabilize diamagnetic charge carries - bipolarons. Increasing the alkyl chain grafting density improved the reversibility and broadened the working potential window of the p-doping process. Stable radical anions have also been investigated, bringing detailed information about the conjugation pattern of these electron-surplus species. This study delivers interesting clues towards the conscious structural design of bespoke frontier energy level oligothiophene functional materials and their polymers by incorporating a structurally matching 1,3,4-oxadiazole unit.

Novel Polyamides with 5H-Dibenzo[b,f]azepin-5-yl-Substituted Triphenylamine: Synthesis and Visible-NIR Electrochromic Properties.

https://www.ncbi.nlm.nih.gov/pubmed/30965843

In this study, a new diamine monomer, namely 4,4'-diamino-4â€³-(5H-dibenzo[b,f]azepin-5-yl)triphenylamine, was prepared and polymerized with four kinds of dicarboxylic acids via direct polycondensation reaction resulting in a novel series of soluble and electroactive polyamides (PAs). The tough thin films of all PAs could be solution-cast onto an indium-tin oxide (ITO)-coated glass substrate owing to the good solubility in polar organic

solvents. Two pairs of obvious redox peaks for these films were observed in cyclic voltammetry (CV) with low onset potentials (Eonset) of 0.37â•»0.42 V accompanying with remarkable reversible color changes between light yellow and dark blue. A new absorption peak at around 915 nm emerged in near infrared (NIR) spectra; the increasing potential indicated that PAs could be used as a NIR electrochromic material. Moreover, the PAs showed high coloration efficiency (CE; Î·) in the range of 190â•»259 cmÂ² C-1.

Electrosynthesis of Aromatic Poly(amide-amine) Films from Triphenylamine-Based Electroactive Compounds for Electrochromic Applications.

https://www.ncbi.nlm.nih.gov/pubmed/30966007

Two electropolymerizable monomers with a methoxytriphenylamine core linked via amide groups to two triphenylamine (TPA) or N-phenylcarbazole (NPC) terminal groups, namely 4,4'-bis(4-diphenylaminobenzamido)-4''-methoxytriphenylamine (MeOTPA-(TPA)â„) and 4,4'-bis(4-(carbazol-9-yl)benzamido)-4''-methoxytriphenylamine (MeOTPA-(NPC)â„), were synthesized and characterized by FTIR and Â¹H NMR spectroscopy, mass spectrometry, and cyclic voltammetry. The electrochemical polymerization reactions of these MeOTPA-cored monomers over indium tin oxide (ITO) electrode allow the generation of electroactive poly(amide-amine) films. The electro-generated polymer films exhibited reversible redox processes and multi-colored electrochromic behaviors upon electro-oxidation, together with moderate coloration efficiency and cycling stability. The optical density changes (Î”OD) were observed in the range of 0.18â•»0.68 at specific absorption maxima, with the calculated coloration efficiencies of 42â•»123 cmÂ²/C. Single-layer electrochromic devices using the electrodeposited polymer films as active layers were fabricated for the preliminary investigation of their electrochromic applications.

Electro-fluorescence switching of bis-imidazolium ionic liquids.

https://www.ncbi.nlm.nih.gov/pubmed/19049073

Room-temperature ionic liquids (RTILs) containing bis-imidazolium salts were explored to control their optical properties of them in an organic device. The neat bis-imidazolium salts showed ionic conductivity of 3.5 x 10(-4) S/cm at room-temperature and the electrochemical window was exhibited within +/-2.5 V in a two electrode cell. The bis-imidazolium salts were transparent yellow and showed fluorescence upon excitation with light in the range of 360 to 500 nm. A two electrode organic ionic liquid cell was fabricated using a mixture of PEO200Blm-TFSI and electroactive

molecules to control the emission property of the ionic liquid by electrochemical methods. The first example of the ionic liquid containing electro-fluorescence switch was explored with an electroactive benzyl viologen (BzV) blend of bis-imidazolium ionic liquid.

Facile Synthesis of Polyaniline Nanotubes with Square Capillary Using Urea as Template.

https://www.ncbi.nlm.nih.gov/pubmed/30965813

Polyaniline nanotubes were successfully synthesized by a facile in situ chemical oxidative polymerization method using urea as soft template. When the urea/aniline molar ratio is 3:1, the as-prepared nanotubular polyaniline (PANI-3) shows regular and uniform square capillaries, which provides a high electrode/electrolyte contact, easy ion diffusion and enhanced electroactive regions during the electrochemical process, leading to weak internal resistance and improved electrochemical performance. The PANI-3 sample exhibits a high specific capacitance of 405 F/g at current density of 0.2 A/g, and PANI only has a specific capacitance of 263 F/g. At current density of 1 A/g, the capacitance of PANI-3 is still 263 F/g (64.9% of the capacitance at 0.2 A/g). Such a PANI-3 nanotube, with regular and uniform capillary, is a promising electrode material for high-performance supercapacitors.

Recent development of interaction of transition metal complexes with DNA based on biosensor and its applications.

https://www.ncbi.nlm.nih.gov/pubmed/18804591

In this article interaction of transition metal complexes with DNA and its applications in electrochemical DNA biosensors as hybridization indicator or electroactive marker of DNA are reviewed. Special emphasis has been given to the efforts for the development of new transition metal complexes and their interaction to DNA. DNA and polymers covalently conjugated with transition metal complexes were also reviewed.

Carbon-fiber microelectrodes for in vivo applications.

https://www.ncbi.nlm.nih.gov/pubmed/19082168

Carbon-fiber microelectrodes (CFMEs) have been a useful tool for measuring rapid changes in neurotransmitters because of their small size, sensitivity, and good electrochemical properties. In this article, we highlight recent advances using CFMEs for measuring neurotransmitters in vivo.

Dopamine has been a primary neurotransmitter of interest but direct electrochemical detection of other neurochemicals including nitric oxide and adenosine has also been investigated. Surface treatments have been studied to enhance electrode sensitivity, such as covalent modification or the addition of a layer of carbon nanotubes. Enzyme-modified microelectrodes that detect non-electroactive compounds further extend the usefulness of CFMEs beyond the traditional monoamines. CFMEs continue to be used in vivo to understand basic neurobiological mechanisms and the actions of pharmacological agents, including drugs of abuse. Advances in sensitivity and instrumentation now allow CFMEs to be used for measurements of natural dopamine release that occur during behavioral experiments. A new technique combining electrochemistry with electrophysiology at a single microelectrode facilitates a better understanding of neurotransmitter concentrations and their effects on cell firing. Future research in this field will likely concentrate on fabricating smaller electrodes and electrode arrays, as well as expanding the use of CFMEs in neuroscience beyond dopamine.

Effect of the supporting electrolyte anion on the thickness of PSS/PAH multilayer films and on their permeability to an electroactive probe.

https://www.ncbi.nlm.nih.gov/pubmed/19123805

Quartz crystal microbalance and cyclic voltammetry are used to investigate the influence of the supporting salt of polyelectrolyte solutions on the buildup and the structure of PSS/PAH polyelectrolyte multilayers (PSS: poly(4-styrene sulfonate); PAH: poly(allylamine hydrochloride)). This film constitutes a model polyelectrolyte multilayer system. The supporting electrolytes were sodium salts where the nature of the anion was changed by following the Hofmeister series from cosmotropic to chaotropic anions (F-, Cl-, NO3-, ClO4-). For all the investigated anions, the film thickness increases linearly with the number of deposition steps.Wefind that chaotropic anions lead to larger thickness increments per bilayer during the film buildup than cosmotropic ones, confirming results found on PSS/PDADMA multilayers (PDADMA:poly(diallyldimethylammonium)). Films constituted by more than nine PSS/PAH bilayers are still permeable to hexacyanoferrate(II) ions, Fe(CN)(6)4-, whatever the nature of the supporting salt anion. On the other hand, these films are impermeable to ruthenium(II) hexamine ions, Ru(NH3)(6)2+, after the third PAH layer in the presence of NaF, NaCl, or NaNO3. These results are explained by the presence of an excess of positive charges in the film, which leads to a positive Donnan potential. We find that this potential is more positive when more chaotropic anions are used during the film buildup. We also find that a film

constructed in the presence of chaotropic anions swells and becomes more permeable to Fe(CN)(6)4- ions when the film is brought into contact with a solution containing more cosmotropic anions. All our experimental findings can be explained by a strong interaction between chaotropic anions with the NH3+groups of PAH that is equivalent, as far as the multilayer buildup and electrochemical response is concerned, to a deprotonation of PAH as it is observed when the film is constructed at a higher pH. We thus arrive to a coherent explanation of the effect of the nature of the anions of the supporting electrolyte on the polyelectrolyte multilayer. We also find that great care must be taken when investigating polyelectrolyte multilayer films by electrochemical probing because electrochemical reactions involving the probes can appreciably modify the multilayer structure.

Electroactive aniline pentamer cross-linking chitosan for stimulation growth of electrically sensitive cells.

https://www.ncbi.nlm.nih.gov/pubmed/18698845

A new kind of electroactive polymers was synthesized by using aniline pentamer (AP) cross-linking chitosan (CS) in acetic acid/DMSO/DMF solution. UV-vis and CV confirmed the electroactivity of polymers in acidic aqueous solution. The amphiphilic polymers self-assembled into 200-300 nm micelles by dialysis against deionized water from the acetic acid buffer solution. Three samples with different weight percentages of AP were used to identify the relationship between the content of AP and the differentiation of rat neuronal pheochromocytoma PC-12 cells without external stimulation. From the results, samples with AP showed an obvious improvement in inducing PC-12 differentiation, while PC-12 on pure CS films had only little neurites on the fifth day; the cells on the films prepared from the samples with 4.9% and 9.5% AP even formed intricate networks. However, the influence of the AP content was the most significant at 4.9 wt % and it decreased when the content increased further.

Cholera toxin subunit B detection in microfluidic devices.

https://www.ncbi.nlm.nih.gov/pubmed/18777170

Fluorescence and electrochemical microfluidic biosensors were developed for the detection of cholera toxin subunit B (CTB) as a model analyte. The microfluidic devices were made from polydimethylsiloxane (PDMS) using soft lithography from silicon templates. The polymer channels were sealed with a glass plate and packaged in a polymethylmethacrylate housing that provided

leakproof sealing and a connection to a syringe pump. In the electrochemical format, an interdigitated ultramicroelectrode array (IDUA) was patterned onto the glass slide using photolithography, gold evaporation and lift-off processes. For CTB recognition, CTB-specific antibodies were immobilized onto superparamagnetic beads and ganglioside GM(1) was incorporated into liposomes. The fluorescence dye sulforhodamine B (SRB) and the electroactive compounds potassium hexacyanoferrate (II)/hexacyanoferrate (III) were used as detection markers that were encapsulated inside the liposomes for the fluorescence and electrochemical detection formats, respectively. Initial optimization experiments were carried out by applying the superparamagnetic beads in microtiter plate assays and SRB liposomes before they were transferred to the microfluidic systems. The limits of detection (LoD) of both assay formats for CTB were found to be 6.6 and 1.0 ng mL(-1) for the fluorescence and electrochemical formats, respectively. Changing the detection system was very easy, requiring only the synthesis of different marker-encapsulating liposomes, as well as the exchange of the detection unit. It was found that, in addition to a lower LoD, the electrochemical format assay showed advantages over the fluorescence format in terms of flexibility and reliability of signal recording.

Electrodes modified with electroinactive layers: distinguishing through-film transport from pinhole (pore) diffusion.

https://www.ncbi.nlm.nih.gov/pubmed/19199745

Electrodes modified with layers, for example, of polymers or self-assembled monolayers, are of great importance from both the fundamental and applied points of view. Two different models of electrodes covered with electroinactive layers can be proposed. First, the electrode is covered with a uniform layer into which the electroactive species dissolves and then diffuses through, or second, the layer contains pinholes that are exclusively responsible for diffusional transport to the electrode. Both models are simulated and then compared to identify conditions under which they can be distinguished. The models are studied for a broad range of parameters reflecting experimentally viable values. Different types of cyclic voltammograms can be observed in the studied models corresponding to classical Randles-Sevcik, thin layer, and steady-state behaviors. We show that the models can be distinguished experimentally through recording cyclic voltammograms over a sufficiently broad range of voltage scan rates.

Polymeric membrane sensors for the selective determination of dextromethorphan in

pharmaceutical preparations.

https://www.ncbi.nlm.nih.gov/pubmed/18997367

The construction and electrochemical response characteristics of poly(vinyl chloride) matrix ion-selective electrodes (ISEs) for dextromethorphan (DXM) hydrobromide are described. The membranes incorporate ion-association complexes of DXM with reineckate salt {[Cr(NH3)2(SCN)4]NH4} or phosphomolybdic acid [H3(PMo12O40)], as electroactive materials and dioctylphthalate or dibutylsebacate as a plasticizing solvent mediator. The sensors display a fast, stable and linear response with slopes of 54.4 to 59.5 mV/decade at pH 2.5-6.5 and a detection limit of 1.0 x 10(-6) M. Moreover, the sensors exhibit very good selectivity for DXM over opiate alkaloids, as well as organic and inorganic cations. The sensors proved to be useful for the determination of 5.0 x 10(-5)-1.0 x 10(-3) M DXM hydrobromide in pure as well as in dosage forms by direct potentiometry and standard addition methods. Determination of 5.0 x 10(-4) M DXM using the standard addition method and a sensor based on phosphomolybdate and dioctylphthalate shows an average recovery of 99.8% and a relative standard deviation (RSD) of 0.4%.

Highly disordered polymer field effect transistors: N-alkyl dithieno[3,2-b:2',3'-d]pyrrole-based copolymers with surprisingly high charge carrier mobilities.

https://www.ncbi.nlm.nih.gov/pubmed/18767846

A series of novel electroactive and photoactive conjugated copolymers based on N-alkyl dithieno[3,2-b:2',3'-d]pyrroles (DTP) and thiophene (TH) units (DTP-co-THs) were synthesized using a Stille coupling reaction and exhibited molecular weights of 1.6 x 10(4) to 5.0 x 10(4) g/mol. The incorporation of soluble substituted thiophenes and planar DTP units resulted in low band gap, highly conductive polymers. DTP-co-THs exhibited excellent solubility in common organic solvents and formed high-quality films. Optical characterization revealed that the band gaps of DTP-co-THs were between 1.74 and 2.00 eV, lower than regioregular poly(3-alkylthiophenes). Electrochemical characterization showed that the HOMO energy levels of DTP-co-THs are between -4.68 and -4.96 eV. When doped, DTP-co-THs exhibited high conductivities up to 230 S/cm with excellent stability. The different thiophene substituent patterns' effect on the polymers' optical and electronic properties was then examined by density functional theory computations. The microstructure and surface morphologies of poly(2,6-(4-dodecyl-4H-bisthieno[3,2-b:2',3'-d]pyrrole)-random-2,5-(3-dodecylthiophene)) (P4) and poly(2-(4,4'-didodecyl-2,2'-bithiophen-5-yl)-4-octyl-4H-bisthieno[3,2-b:2',3'-d]pyrrole) (P6) thin films

were studied by X-ray diffraction and atomic force microscopy. As-cast P4 and P6 thin films exhibited poorly defined, randomly ordered lamellar structure that improved significantly after thermal annealing. Field effect transistor devices fabricated from P4 and P6 showed typical p-channel transistor behavior. Interestingly, the mobilities of as-cast, less ordered samples were much higher than those observed after annealing. The highest values of maximum and average mobilities were observed for the polymer P6 as-cast (0.21 and 0.13 cm(2) V(-1) s(-1), respectively). One of our goals was to test the idea that high mobility and excellent electrical and structural reproducibility could perhaps be achieved by the creation of amorphous pi-conjugated materials that could possess long arrange pi connectivity on the microscopic scale. The results of these studies strongly suggest that the presence of highly ordered microcrystalline structures in thin films of organic semiconductors is not necessary for excellent performance of organic transistors.

Enhanced electroactive and mechanical properties of poly(vinylidene fluoride) by controlling crystallization and interfacial interactions with low loading polydopamine coated BaTiOâ‚ƒ.

https://www.ncbi.nlm.nih.gov/pubmed/25985420

Poly(vinylidene fluoride) (PVDF) is a semi-crystalline polymer and the polar Î²-phase of PVDF shows superb electroactive properties. In order to enhance the Î²-phase of PVDF, extreme low content of BaTiO3 nanoparticles (BT-NPs) coated with polydopamine (Pdop) were incorporated into PVDF matrix by solution casting. The Î²-phase of the resulting PVDF nanocomposites film was dramatically increased and the d33 value reached 34.3Â±0.4 pCN(-1). It is found that the Pdop layer could improve the dispersibility and stability of the BT NPs in solution and endow the BT NPs good dispersity in the PVDF matrix. Moreover, the interfacial interaction between PVDF chains and the surface of BT-Pdop nanoparticles (BT-Pdop NPs) were revealed, in which the CF2 groups on PVDF could interact with the electron-rich plane of aromatic ring of Pdop moiety. This interaction, led to the increase of the crystallization activation energy as derived from the DSC nonisothermal crystallization measurement. The Î±-Î² crystal transformation, organization of interfacial interactions as well as the prevention of agglomeration of BT-NPs confer the improvement of mechanical and thermal properties of PVDF, such as toughness, tensile strength, elongation at break, and thermal conductivity.

Enzyme-free electrochemical immunosensor based on host-guest nanonets catalyzing amplification for procalcitonin detection.

https://www.ncbi.nlm.nih.gov/pubmed/25629216

An enzyme-free electrochemical immunosensor based on the host-guest nanonets of N,N-bis(ferrocenoyl)-diaminoethane/Î²-cyclodextrins/poly(amidoamine) dendrimer-encapsulated Au nanoparticles (Fc-Fc/Î²-CD/PAMAM-Au) for procalcitonin (PCT) detection has been developed in this study. The signal probe was constructed as follows: amine-terminated Î²-CD was adsorbed to PAMAM-Au first, and then the prepared Fc-Fc was recognized by the Î²-CD to form stable host-guest nanonets. Next, secondary antibodies (Ab2) were attached into the formed netlike nanostructure of Fc-Fc/Î²-CD/PAMAM-Au by chemical absorption between PAMAM-Au and -NH2 of Î²-CD. Herein, the PAMAM-Au act not only as nanocarriers for anchoring large amounts of the Î²-CD and Ab2 but also as nanocatalysts to catalyze the oxidation of ascorbic acid (AA) for signal amplification. Moreover, the Fc-Fc could be stably immobilized by the hydrophobic inner cavity of Î²-CD as well as improving solubility by the hydrophilic exterior of Î²-CD. With the unique structure of two ferrocene units, Fc-Fc not only affords more electroactive groups to make the electrochemical response more sensitive but also plays a role of combining dispersive Î²-CD-functionalized PAMAM-Au to form the netlike nanostructure. Furthermore, Fc-Fc exhibits good catalytic activity for AA oxidation. When the detection solution contained AA, the synergetic catalysis of PAMAM-Au and Fc-Fc to AA oxidation could be obtained, realizing enzyme-free signal amplification. The proposed immunosensor provided a linear range from 1.80 pg/mL to 500 ng/mL for PCT detection and a detection limit of 0.36 pg/mL under optimal experimental conditions. Moreover, the immunosensor has shown potential application in clinical detection of PCT.

Preparation of a porous conductive scaffold from aniline pentamer-modified polyurethane/PCL blend for cardiac tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/25765879

A novel biodegradable electroactive polyurethane containing aniline pentamer (AP) was blended with polycaprolactone (PCL). The prepared blend (PB) and PCL were further fabricated in to scaffolds using a mixture of poly(ethylene glycol) and salt particles in a double porogen particulate leaching and compression molding methodology. Scaffolds held open and interconnected pores having pore size ranging from several Î¼m to 150 Âµm. PB scaffolds had compression modulus and strength of 4.1 and 1.3 MPa, respectively. The conductivity of the scaffold was measured as 10(-5) Â± 0.09 S .cm(-1) and preserved for at least 100 h post fabrication. Scaffolds supported neonatal cardiomyocytes adhesion and growth with PB showing more extensive effect on the expression of

the cardiac genes involved in muscle contraction and relaxation (troponin-T) and cytoskeleton alignment (actinin-4). Our results highlight the potential of incorporation of AP as an electroactive moiety for induction of cardiomyocyte proliferation and repair of damaged heart tissue.

Parylene-coated ionic liquid-carbon nanotube actuators for user-safe haptic devices.

https://www.ncbi.nlm.nih.gov/pubmed/26132784

Simple fabrication, high power-to-weight and power-to-volume ratios, and the ability to operate in open air at low voltage make the ionic electroactive polymer actuators highly attractive for haptic applications. Whenever a direct tactile stimulation of the skin is involved, electrical and chemical insulation as well as a long-term stability of the actuator are required. Because of its inherent physicochemical properties such as high dielectric strength, resistance to solvents, and biological inactivity, Parylene C meets the requirements for making biocompatible actuators. We have studied the displacement and the generated force of Parylene-coated carbon nanotube actuators as well as the encapsulation quality. A 2 Î¼m coating creates an effective electrical insulation of the actuators without altering the blocking force at frequencies from 50 mHz to 1 Hz. Moreover, the generated strain is preserved at higher frequencies (from 0.5 to 5 Hz). We employed a simple mechanical model to explain the relation between the key parameters-flexural stiffness, displacement, and force-for uncoated and coated actuators. In addition, we demonstrated that our Parylene-coated actuators are not damaged by rinsing in liquid media such as 2-propanol or water. In conclusion, our results indicate that Parylene C encapsulated actuators are safe to touch and can be used in contact with human skin and in biomedical applications in direct contact with tissues and physiological fluids.

Electroactive polymer-peptide conjugates for adhesive biointerfaces.

https://www.ncbi.nlm.nih.gov/pubmed/26372182

Electroactive polymer-peptide conjugates have been synthesized by combining poly(3,4-ethylenedioxythiophene), a polythiophene derivative with outstanding properties, and an Arg-Gly-Asp (RGD)-based peptide in which Gly has been replaced by an exotic amino acid bearing a 3,4-ethylenedioxythiophene ring in the side chain. The incorporation of the peptide at the ends of preformed PEDOT chains has been corroborated by both FTIR and X-ray photoelectron spectroscopy. Although the morphology and topology are not influenced by the incorporation of the peptide at the ends of PEDOT chains, this process largely affects other surface properties. Thus,

the wettability of the conjugates is considerably higher than that of PEDOT, independently of the synthetic strategy, whereas the surface roughness only increases when the conjugate is obtained using a competing strategy (i.e. growth of the polymer chains against termination by end capping). The electrochemical activity of the conjugates has been found to be higher than that of PEDOT, evidencing the success of the polymer-peptide links designed by chemical similarity. Density functional theory calculations have been used not only to ascertain the conformational preferences of the peptide but also to interpret the electronic transitions detected by UV-vis spectroscopy. Electroactive surfaces prepared using the conjugates displayed the higher bioactivities in terms of cell adhesion, with the relative viabilities being dependent on the roughness, wettability and electrochemical activity of the conjugate. In addition to the influence of the peptide fragment in the initial cell attachment and subsequent cell spreading and survival, the results indicate that PEDOT promotes the exchange of ions at the conjugate-cell interface.

In vivo histamine voltammetry in the mouse premammillary nucleus.

https://www.ncbi.nlm.nih.gov/pubmed/25902865

Histamine plays a major role in the mediation of allergic reactions such as peripheral inflammation. This classical monoamine is also a neurotransmitter involved in the central nervous system but its role in this context is poorly understood. Studying histamine neurotransmission is important due to its implications in many neurological disorders. The sensitivity, selectivity and high temporal resolution of fast scan cyclic voltammetry (FSCV) offer many advantages for studying electroactive neurotransmitters. Histamine has previously been studied with FSCV; however, the lack of a robust Faradaic electrochemical signal makes it difficult to selectively identify histamine in complex media, as found in vivo. In this work, we optimize an electrochemical waveform that provides a stimulation-locked and unique electrochemical signal towards histamine. We describe in vitro waveform optimization and a novel in vivo physiological model for stimulating histamine release in the mouse premammillary nucleus via stimulation of the medial forebrain bundle. We demonstrate that a robust signal can be used to effectively identify histamine and characterize its in vivo kinetics.

Ion-selective electrodes using carbon nanotubes as ion-to-electron transducers.

https://www.ncbi.nlm.nih.gov/pubmed/18271511

This study developed a new type of all-solid-state ion-selective electrode based on a transducing layer of a network of single-walled carbon nanotubes. The extraordinary capacity of carbon

nanotubes to promote electron transfer between heterogeneous phases made the presence of electroactive polymers or any other ion-to-electron-transfer promoter unnecessary. The new transducer layer was characterized by environmental scanning electron microscopy and electrochemical impedance spectroscopy. The stability of the electrical potential of the new solid-contact electrode was examined by performing current-reversal chronopotentiometry, and the influence of the interfacial water film was assessed by the potentiometric water layer test. The performance of the new electrode was evaluated by determining K+ with an ion-selective membrane that contained the well-known valinomycin ion carrier. The new electrode had a Nernstian slope (58.4 mV/decade), dynamic ranges of four logarithmic units, and selectivities and limits of detection comparable to other solid-contact electrodes. The short response time (less than 10 s for activities higher than 10(-5.5) M) and the stability of the signal over several days makes these new electrodes very promising candidates for attaining true miniaturization.

Permeation study of indomethacin from polycarbazole/natural rubber blend film for electric field controlled transdermal delivery.

https://www.ncbi.nlm.nih.gov/pubmed/25754446

Transdermal drug delivery is an alternative route to transport the drug into the blood system. This method has been continuously developed to overcome limitations and is now suitable for a wide variety of drug molecules. In this work, the influences of electric field and conductive polymer were investigated for developing a unique drug delivery system from double-centrifuged natural rubber (DCNR) matrix. Indomethacin (IN) was loaded into polycarbazole (PCz) as a conductive polymer drug host to promote the efficient transportation of the drug. The IN-loaded PCz was blended with DCNR to form a transdermal patch. The permeation of IN through the PCz/NR film and pig skin was carrried out by a modified Franz diffusion cell. The IN diffused from DCNR film by the diffusion controlled combined with erosion mechanism depending on the pore formation period. The drug permeation increased with decreasing cross-link ratio because of more accessible pathways for the drug permeation. Moreover, an electric field and the inclusion of PCz as the drug carrier dramatically improved the diffusion of the drug from the membrane by through the electrorepulsive force and electro-reduced PCz expansion. Thus, the PCz/DCNR films are shown here as a potential transdermal patch under applied electric field.

The influence of hydrogen bonding on the dielectric constant and the piezoelectric energy

harvesting performance of hydrated metal salt mediated PVDF films.

https://www.ncbi.nlm.nih.gov/pubmed/26077827

Polyvinylidene fluoride (PVDF) films are filled with various mass fractions (wt%) of hydrated metal salt (MgCl2Â·6H2O) (Mg-salt) to fabricate high performance piezoelectric energy harvesters (PEHs). They deliver up to 4 V of open circuit voltage by simply repeated human finger imparting (under a pressure of âˆ¼4.45 kPa) and also generate sufficient power to turn on at least ten commercial blue light emitting diodes (LEDs) instantly. The enhanced piezo-response is attributed to the combined effect of the change in the inherent dipole moment of the electroactive phase containing PVDF itself and H-bonding arising between the Mg-salt filler and PVDF via electrostatic interactions. Furthermore, it also successfully charged the capacitors, signifying practical applicability as a piezoelectric based energy harvester power source. UV-visible optical absorption spectral analysis revealed the possibility to estimate a change in the optical band gap value at different concentrations of Mg-salt filler added PVDF films that possess a useful methodology where the Mg-salt can be used as an optical probe. In addition dielectric properties have been studied to understand the role of molecular kinetic and interfacial polarization occurs in H-bond PVDF films at different applied frequencies at room temperature.

PVC membrane electrode for the potentiometric determination of Ipratropium bromide using batch and flow injection techniques.

https://www.ncbi.nlm.nih.gov/pubmed/18585199

Ipratropium (IP(+)) ion-selective electrode (ISE) has been constructed from poly(vinyl chloride) matrix membrane containing Ipratropium-tetraphenylborate (IP-TPB) as the electroactive component using 2-nitrophenyloctylether as plasticizer. The electrode exhibits near Nernstian response to Ipratropium bromide (IPBr) over the concentration range 10(-5) to 10(-2) mol L(-1) and detection limit 5.1x10(-6) mol L(-1). The electrode offers significant advantages including long lifetime (>2 months), excellent stability and reproducibility, fast response time (<10 s), wide pH working range (pH 2-9), high thermal stability (isothermal coefficient 0.37 mV/degrees C) and superior selectivity for IPBr over a large number of inorganic and organic substances. The electrode was successfully used as indicator electrode in the potentiometric titration of IPBr versus sodium tetraphenylborate (NaTPB) and in the determination of IPBr in Atrovent vials and spiked urine samples applying batch and flow injection techniques, with satisfactory results.

Modeling and Simulation of Viscous Electro-Active Polymers.

https://www.ncbi.nlm.nih.gov/pubmed/25267881

Electro-active materials are capable of undergoing large deformation when stimulated by an electric field. They can be divided into electronic and ionic electro-active polymers (EAPs) depending on their actuation mechanism based on their composition. We consider electronic EAPs, for which attractive Coulomb forces or local re-orientation of polar groups cause a bulk deformation. Many of these materials exhibit pronounced visco-elastic behavior. Here we show the development and implementation of a constitutive model, which captures the influence of the electric field on the visco-elastic response within a geometrically non-linear finite element framework. The electric field affects not only the equilibrium part of the strain energy function, but also the viscous part. To adopt the familiar additive split of the strain from the small strain setting, we formulate the governing equations in the logarithmic strain space and additively decompose the logarithmic strain into elastic and viscous parts. We show that the incorporation of the electric field in the viscous response significantly alters the relaxation and hysteresis behavior of the model. Our parametric study demonstrates that the model is sensitive to the choice of the electro-viscous coupling parameters. We simulate several actuator structures to illustrate the performance of the method in typical relaxation and creep scenarios. Our model could serve as a design tool for micro-electro-mechanical systems, microfluidic devices, and stimuli-responsive gels such as artificial skin, tactile displays, or artificial muscle.

Conductive interpenetrating networks of polypyrrole and polycaprolactone encourage electrophysiological development of cardiac cells.

https://www.ncbi.nlm.nih.gov/pubmed/26407651

Conductive and electroactive polymers have the potential to enhance engineered cardiac tissue function. In this study, an interpenetrating network of the electrically-conductive polymer polypyrrole (PPy) was grown within a matrix of flexible polycaprolactone (PCL) and evaluated as a platform for directing the formation of functional cardiac cell sheets. PCL films were either treated with sodium hydroxide to render them more hydrophilic and enhance cell adhesion or rendered electroactive with PPy grown via chemical polymerization yielding PPy-PCL that had a resistivity of 1.0 Â± 0.4 kÎ© cm, which is similar to native cardiac tissue. Both PCL and PPy-PCL films supported cardiomyocyte attachment; increasing the duration of PCL pre-treatment with NaOH resulted in higher numbers of adherent cardiomyocytes per unit area, generating cell densities which were more similar to those

on PPy-PCL films (1568 Â± 126 cells mm(-2), 2880 Â± 439 cells mm(-2), 3623 Â± 456 cells mm(-2) for PCL with 0, 24, 48 h of NaOH pretreatment, respectively; 2434 Â± 166 cells mm(-2) for PPy-PCL). When cardiomyocytes were cultured on the electrically-conductive PPy-PCL, more cells were observed to have peripheral localization of the gap junction protein connexin-43 (Cx43) as compared to cells on NaOH-treated PCL (60.3 Â± 4.3% vs. 46.6 Â± 5.7%). Cx43 gene expression remained unchanged between materials. Importantly, the velocity of calcium wave propagation was faster and calcium transient duration was shorter for cardiomyocyte monolayers on PPy-PCL (1612 Â± 143 Î¼m/s, 910 Â± 63 ms) relative to cells on PCL (1129 Â± 247 Î¼m/s, 1130 Â± 20 ms). In summary, PPy-PCL has demonstrated suitability as an electrically-conductive substrate for culture of cardiomyocytes, yielding enhanced functional properties; results encourage further development of conductive substrates for use in differentiation of stem cell-derived cardiomyocytes and cardiac tissue engineering applications.

Electrically controlled release of sulfosalicylic acid from crosslinked poly(vinyl alcohol) hydrogel.

https://www.ncbi.nlm.nih.gov/pubmed/18242901

Electrically controlled drug delivery using poly(vinyl alcohol) (PVA) hydrogels as the matrix/carriers for a model drug was investigated. The drug-loaded PVA hydrogels were prepared by solution-casting using sulfosalicylic acid as the model drug and glutaraldehyde as the crosslinking agent. The average molecular weight between crosslinks, the crosslinking density, and the mesh size of the PVA hydrogels were determined from the equilibrium swelling theory as developed by Peppas and Merril, and the latter data were compared with those obtained from scanning electron microscopy. The release mechanisms and the diffusion coefficients of the hydrogels were studied using modified Franz-Diffusion cells in an acetate buffer with pH 5.5 and temperature 37 degrees C during a period of 48 h, in order to determine the effects of crosslinking ratio, electric field strength, and electrode polarity. The amounts of drug released were analyzed by UV-vis spectrophotometry. The amounts of drug released vary linearly with square root of time. The diffusion coefficients of drug-loaded PVA hydrogels decrease with increasing crosslink ratio. Moreover, the diffusion coefficients of the charged drug in the PVA hydrogels depend critically on the electric field strength between 0 and 5 V as well as on the electrode polarity. Thus, the release rate of sulfosalicylic acid can be altered and controlled precisely through electric field stimulation.

Label-free DNA electrochemical sensor based on a PNA-functionalized conductive polymer.

https://www.ncbi.nlm.nih.gov/pubmed/18585264

An electrochemical hybridization biosensor based on peptide nucleic acid (PNA) probe is presented. PNA were attached covalently onto a quinone-based electroactive polymer. Changes in flexibility of the PNA probe strand upon hybridization generates electrochemical changes at the polymer-solution interface. A reagentless and direct electrochemical detection was obtained by detection of the electrochemical changes using square wave voltammetry (SWV). An increase in the peak current of quinone was observed upon hybridization of probe on the target, whereas no change is observed with non-complementary sequence. In addition, the biosensor is highly selective to effectively discriminate a single mismatch on the target sequence. The sensitivity is also presented and discussed.

Polypyrrole-supported membrane proteins for bio-inspired ion channels.

https://www.ncbi.nlm.nih.gov/pubmed/25585165

Biomedical platforms constructed by immobilizing membrane proteins in matrixes made of synthetic organic polymers is a challenge because the structure and function of these proteins are affected by environmental conditions. In this work, an operative composite that regulates the diffusion of alkali ions has been prepared by functionalizing a supporting matrix made of poly(N-methylpyrrole) (PNMPy) with a Î²-barrel membrane protein (Omp2a) that forms channels and pores. The protein has been unequivocally identified in the composite, and its structure has been shown to remain unaltered. The PNMPy-Omp2a platform fulfills properties typically associated with functional bio-interfaces with biomedical applications (e.g., biocompatibility, biodegrabadility, and hydrophilicity). The functionality of the immobilized protein has been examined by studying the passive ion transport response in the presence of electrolytic solutions with Na(+) and K(+) concentrations close to those found in blood. Although the behavior of PNMPy and PNMPy-Omp2a is very similar for solutions with very low concentration, the resistance of the latter decreases drastically when the concentration of ions increases to âˆ¼100 mM. This reduction reflects an enhanced ion exchange between the biocomposite and the electrolytic medium, which is not observed in PNMPy, evidencing that PNMPy-Omp2a is particularly well suited to prepare bioinspired channels and smart biosensors.

An amperometric biosensor based on hemoglobin immobilized in poly(epsilon-caprolactone)

film and its application.

https://www.ncbi.nlm.nih.gov/pubmed/18282699

In this study, poly(epsilon-caprolactone) (PCL) was synthesized using the epsilon-caprolactone (CL) monomer ring-opening polymerization. We demonstrated that the hemoglobin (Hb) entrapped in PCL film could retain its original conformation by FT-IR spectra. A pair of well-defined redox peaks with a formal potential (E0') of about -0.38V (vs. SCE) in a pH 7.0 phosphate buffer solution was obtained at the Hb-PCL film modified GC electrode. The dependence of E(0') on the pH of the buffer solution indicated that the conversion of heme Fe(III)/Fe(II) was a reaction of one electron coupled to one proton. The apparent heterogeneous electron transfer rate constants (ks) of Hb confined to PCL was valuated as (18.7+/-0.8)s(-1) according to Laviron's equation. The surface concentration (Gamma*) of the electroactive Hb in the PCL film was estimated to be (7.27+/-0.57)x10(-11)molcm(-2). The Hb-PCL film modified electrode was shown to be an excellent amperometric sensor for the detection of hydrogen peroxide. The linear range is from 2 to 30microM with a detection limit of 6.07x10(-6)M. The sensor was effectively testified by the determination of the hydrogen peroxide in eyedrops as real samples.

Stimulation of Wound Healing by Electroactive, Antibacterial, and Antioxidant Polyurethane/Siloxane Dressing Membranes: In Vitro and in Vivo Evaluations.

https://www.ncbi.nlm.nih.gov/pubmed/26473663

A series of novel polyurethane/siloxane-based wound dressing membranes was prepared through sol-gel reaction of methoxysilane end-functionalized urethane prepolymers composed of castor oil and ricinoleic methyl ester as well as methoxysilane functional aniline tetramer (AT) moieties. The samples were fully characterized and their physicochemical, mechanical, electrical, and biological properties were assayed. The biological activity of these dressings against fibroblast cells and couple of microbes was also studied. It was revealed that samples that displayed electroactivity by introduction of AT moieties showed a broad range of antimicrobial activity toward different microorganisms, promising antioxidant (radical scavenging) efficiency and significant activity for stimulation of fibroblast cell growth and proliferation. Meanwhile, these samples showed appropriate tensile strength and ability for maintaining a moist environment over a wound by controlled equilibrium water absorption and water vapor transmission rate. The selected electroactive dressing was subjected to an in vivo assay using a rat animal model and the wound healing process was monitored and compared with analogous dressing without AT moieties. The recorded results

showed that the electroactive dressings induced an increase in the rate of wound contraction, promoted collagen deposition, and encouraged vascularization in the wounded area. On the basis of the results of in vitro and in vivo assays, the positive influence of designed dressings for accelerated healing of a wound model was confirmed.

Multifunctional Electrochemical Platforms Based on the Michael Addition/Schiff Base Reaction of Polydopamine Modified Reduced Graphene Oxide: Construction and Application.

https://www.ncbi.nlm.nih.gov/pubmed/26222894

In this paper, a new strategy for the construction of multifunctional electrochemical detection platforms based on the Michael addition/Schiff base reaction of polydopamine modified reduced graphene oxide was first proposed. Inspired by the mussel adhesion proteins, 3,4-dihydroxyphenylalanine (DA) was selected as a reducing agent to simultaneously reduce graphene oxide and self-polymerize to obtain the polydopamine-reduced graphene oxide (PDA-rGO). The PDA-rGO was then functionalized with thiols and amines by the reaction of thiol/amino groups with quinine groups of PDA-rGO via the Michael addition/Schiff base reaction. Several typical compounds containing thiol and/or amino groups such as 1-[(4-amino)phenylethynyl] ferrocene (Fc-NH2), cysteine (cys), and glucose oxidase (GOx) were selected as the model molecules to anchor on the surface of PDA-rGO using the strategy for construction of multifunctional electrochemical platforms. The experiments revealed that the composite grafted with ferrocene derivative shows excellent catalysis activity toward many electroactive molecules and could be used for individual or simultaneous detection of dopamine hydrochloride (DA) and uric acid (UA), or hydroquinone (HQ) and catechol (CC), while, after grafting of cysteine on PDA-rGO, simultaneous discrimination detection of Pb(2+) and Cd(2+) was realized on the composite modified electrode. In addition, direct electron transfer of GOx can be observed when GOx-PDA-rGO was immobilized on glassy carbon electrode (GCE). When glucose was added into the system, the modified electrode showed excellent electric current response toward glucose. These results inferred that the proposed multifunctional electrochemical platforms could be simply, conveniently, and effectively regulated through changing the anchored recognition or reaction groups. This study would provide a versatile method to design more detection or biosensing platforms through a chemical reaction strategy in the future.

Self-assembled monolayer initiated electropolymerization: a route to thin-film materials with

enhanced photovoltaic performance.

https://www.ncbi.nlm.nih.gov/pubmed/18680323

Continuing progress in the field of organic polymer photovoltaic (PV) devices requires the development of new materials with better charge-transport efficiency. To improve this parameter, we have investigated surface-attached bilayer polymer PV thin films prepared starting from a covalently attached monolayer of an electroactive initiator using sequential electropolymerization of dithiophene and its derivatives. These systems were found to show significantly increased photocurrent generation quantum yields as compared to systems made through conventional approaches. In addition, the described PV thin films possess remarkable mechanical, air, and photostability. These properties likely arise from the more uniform and better ordered bulk layer morphologies as well as tighter covalently bonded contacts at the interfacial junctions, contributing to improved charge transport. While more studies on the fundamental reasons behind the discovered phenomenon are currently underway, this information can be readily applied to build more efficient organic polymer photovoltaics.

Photochromism and electrochemistry of a dithienylcyclopentene electroactive polymer.

https://www.ncbi.nlm.nih.gov/pubmed/18481876

A bifunctional substituted dithienylcyclopentene photochromic switch bearing electropolymerisable methoxystyryl units, which enable immobilization of the photochromic unit on conducting substrates, is reported. The spectroscopic, electrochemical, and photochemical properties of a monomer in solution are compared with those of the polymer formed through oxidative electropolymerization. The electroactive polymer films prepared on gold, platinum, glassy carbon, and indium titanium oxide (ITO) electrodes were characterized by cyclic voltammetry, X-ray photoelectron spectroscopy (XPS), and atomic force microscopy (AFM). The thickness of the films formed is found to be limited to several monolayer equivalents. The photochromic properties and stability of the polymer films have been investigated by UV/vis spectroscopy, electrochemistry, and XPS. Although the films are electrochemically and photochemically stable, their mechanical stability with respect to adhesion to the electrode was found to be sensitive to both the solvent and the electrode material employed, with more apolar solvents, glassy carbon, and ITO electrodes providing good adhesion of the polymer film. The polymer film is formed consistently as a thin film and can be switched both optically and electrochemically between the open and closed state of the photochromic dithienylethene moiety.

In situ synthesis of Ni(OH)2 nanobelt modified electroactive poly(vinylidene fluoride) thin films: remarkable improvement in dielectric properties.

https://www.ncbi.nlm.nih.gov/pubmed/25915166

A facile and low cost synthesis of Ni(OH)2 nanobelt (NB) modified electroactive poly(vinylidene fluoride) (PVDF) thin films with excellent dielectric properties has been reported via in situ formation of Ni(OH)2 NBs in the PVDF matrix. The formation and morphology of the NBs are confirmed by UV-visible spectroscopy and field emission scanning electron microscopy respectively. A remarkable improvement in electroactive Î² phase nucleation (âˆ¼82%) and the dielectric constant (Îµ âˆ¼ 3.1 Ã— 10(6) at 20 Hz) has been observed in the nanocomposites (NCs). The interface between the NBs and the polymer matrix plays a crucial role in the enhancement of the electroactive Î² phase and the dielectric properties of thin films. Strong interaction via hydrogen bonds between Ni(OH)2 NBs and the PVDF matrix is the main reason for enhancement in Î² phase crystallization and improved dielectric properties. The NC thin films can be utilized for potential applications as high energy storage devices like supercapacitors, solid electrolyte batteries, self-charging power cells, piezoelectric nanogenerators, and thin film transistors and sensors.

Directly-Grown Hierarchical Carbon Nanotube@Polypyrrole Core-Shell Hybrid for High-Performance Flexible Supercapacitors.

https://www.ncbi.nlm.nih.gov/pubmed/26791424

A hierarchical carbon nanotube-polypyrrole (CNT-PPy) core-shell composite was fabricated by growing CNTs directly on carbon cloth (CC) as a skeleton followed by electropolymerization of PPy with controlled polymerization time. Direct fabrication of electroactive (CNT-PPy) materials on the flexible CC electrode could reduce the interfacial resistance between the electrode and electrolyte and improve the ion diffusion. The supercapacitor electrode based on optimized PPy/CNT-CC exhibits excellent electrochemical performance, with the highest gravimetric capacitance being roughly 1038â€…Fâ€‰g(-1) per active mass of PPy and up to 486.1â€…Fâ€‰g(-1) per active mass of the PPy/CNT composite. Notably, excellent flexibility and cycle stability up to 10â€‰000â€…cycles with only 18â€‰% capacitance loss was achieved. At the same time, the fabricated asymmetric supercapacitor (PPy/CNT-CCâˆ¥CNT-CC) shows the maximum power density of 10â€‰962â€…Wâ€‰kg(-1) at an energy density of 3.9â€…Whâ€‰kg(-1) under the operating potential of 1.4â€…V. The overall high cycle stability and high performance of the fabricated PPy/CNT-CC flexible electrode is due to the novel binder-free direct growth process.

Fabrication of electrospun silk fibroin scaffolds coated with graphene oxide and reduced graphene for applications in biomedicine.

https://www.ncbi.nlm.nih.gov/pubmed/26717014

Silk fibroin and graphene are both promising biomaterials described in the bibliography. Hybrid scaffolds combining their properties could be attractive for tissue engineering applications. In this work, a new methodology to produce electrospun fibroin scaffolds coated with graphene materials is provided. The mechanical, electrical and electrochemical properties of the materials attained were characterised. The fibre diameters were measured (from 3.9 to 5.2 Î¼m). The samples coated with reduced grapheme were electronic conductors and electroactive in liquid electrolytes, showing maximum oxidation and reduction (aroundâˆ’0.4 V peak). The chronoamperometric responses showed a reduction shoulder, pointing to the entrance of balancing cations from the solution by nucleationâ€“relaxation: the reaction induced structural changes in the graphene. In order to check the biocompatibility of the materials, they were seeded with L929 fibroblasts. The excellent biocompatibility of silk fibroin meshes was maintained after coating with graphene, being the proliferation results equal in all the treatments 7 days after the seeding (Tukey, p N 0.05).The conductive and electroactive properties of meshes coated with reduced graphene allow the potential application of local electric fields or local ionic currents to cell cultures, biological interfaces or animal models without host response.

Ionic polymer-metal composite actuators obtained from radiation-grafted cation- and anion-exchange membranes.

https://www.ncbi.nlm.nih.gov/pubmed/25420910

Two series of ionic polymer-metal composites (IPMCs), one cationic and one anionic, are designed and prepared from radiation-grafted ion-exchange membranes. Through examination of the properties of the membranes synthesized from the two grafting monomers and the two base polymers, acrylic acid-grafted poly(vinylidene fluoride-co-hexafluoropropylene) and quarternized 4-vinylpyridine-grafted poly(ethylene-co-tetrafluoroethylene) with the appropriate amount of ionic groups are employed for the fabrication of cation and anion IPMCs, respectively. The bending displacement of the cation IPMC is comparable to Nafion-based IPMC under direct- and alternating-current voltage, but back-relaxation is not observed. The actuation performance of the anion IPMC is highly improved over those reported earlier in the literature for the other anion IPMCs.

A novel multicomponent redox polymer nanobead based high performance non-enzymatic glucose sensor.

https://www.ncbi.nlm.nih.gov/pubmed/26584775

The fabrication of a highly sensitive electrochemical non-enzymatic glucose sensor based on copper nanoparticles (Cu NPs) dispersed in a graphene (G)-ferrocene (Fc) redox polymer multicomponent nanobead (MCNB) is reported. The preparation of MCNB involves three major steps, namely: i) the preparation of a poly(aniline-co-anthranilic acid)-grafted graphene (G-PANI(COOH), ii) the covalent linking of ferrocene to G-PANI(COOH) via a polyethylene imine (PEI), and iii) the electrodeposition of Cu NPs. The prepared MCNB (designated as G-PANI(COOH)-PEI-Fc/Cu-MCNB), contains a conductive G-PANI(COOH), electron mediating Fc, and electrocatalytic Cu NPs that make it suitable for ultrasensitive non-enzymatic electrochemical sensing. The morphology, structure, and electro activities of MCNB were characterized. Electrochemical measurements showed that the G-PANI(COOH)-PEI-Fc/Cu-MCNB/GCE modified electrode exhibited good electrocatalytic behavior towards the detection of glucose in a wide linear range (0.50 to 15mM), with a low detection limit (0.16mM) and high sensitivity (14.3ÂµAmM(-1)cm(-2)). Besides, the G-PANI(COOH)-PEI-Fc/Cu-MCNB/GCE sensor electrode did not respond to the presence of electroactive interferrants (such as uric acid, ascorbic acid, and dopamine) and saccharides or carbohydrates (fructose, lactose, d-isoascorbic acid, and dextrin), demonstrating its selectivity towards glucose. The fabricated NEG sensor exhibited high precision for measuring glucose in serum samples, with an average RSD of 4.3% and results comparable to those of commercial glucose test strips. This reliability and stability of glucose sensing indicates that G-PANI(COOH)-PEI-Fc/Cu-MCNB/GCE would be a promising material for the non-enzymatic detection of glucose in physiological fluids.

Effective Electrochemistry of Human Sulfite Oxidase Immobilized on Quantum-Dots-Modified Indium Tin Oxide Electrode.

https://www.ncbi.nlm.nih.gov/pubmed/26357959

The bioelectrocatalytic sulfite oxidation by human sulfite oxidase (hSO) on indium tin oxide (ITO) is reported, which is facilitated by functionalizing of the electrode surface with polyethylenimine (PEI)-entrapped CdS nanoparticles and enzyme. hSO was assembled onto the electrode with a high surface loading of electroactive enzyme. In the presence of sulfite but without additional mediators, a high bioelectrocatalytic current was generated. Reference experiments with only PEI showed

direct electron transfer and catalytic activity of hSO, but these were less pronounced. The application of the polyelectrolyte-entrapped quantum dots (QDs) on ITO electrodes provides a compatible surface for enzyme binding with promotion of electron transfer. Variations of the buffer solution conditions, e.g., ionic strength, pH, viscosity, and the effect of oxygen, were studied in order to understand intramolecular and heterogeneous electron transfer from hSO to the electrode. The results are consistent with a model derived for the enzyme by using flash photolysis in solution and spectroelectrochemistry and molecular dynamic simulations of hSO on monolayer-modified gold electrodes. Moreover, for the first time a photoelectrochemical electrode involving immobilized hSO is demonstrated where photoexcitation of the CdS/hSO-modified electrode lead to an enhanced generation of bioelectrocatalytic currents upon sulfite addition. Oxidation starts already at the redox potential of the electron transfer domain of hSO and is greatly increased by application of a small overpotential to the CdS/hSO-modified ITO.

Potentiometric membrane sensor for the selective determination of pethidine in pharmaceutical preparations and biological fluids.

https://www.ncbi.nlm.nih.gov/pubmed/18154000

The construction and general performance characteristics of a novel potentiometric PVC membrane sensor based on pethidine-phosphomolybdate as electroactive material for the determination of pethidine are described. This sensor exhibits fast, stable and near-Nernstain response 55.24 +/- 0.1, over the concentration range 1.10(-2)-1.10(-5)M for pethidine-phosphomolybdate over pH 2-7. No interferences are caused by many organic, inorganic cations, alkaloids and amino acids. The sensor proved useful for determining pethidine in pure forms, pharmaceutical injections and monitoring the content uniformity assay of ampoules. The designed sensor also show good accuracy for the determination of pethidine in biological fluids.

Electronic plants.

https://www.ncbi.nlm.nih.gov/pubmed/26702448

The roots, stems, leaves, and vascular circuitry of higher plants are responsible for conveying the chemical signals that regulate growth and functions. From a certain perspective, these features are analogous to the contacts, interconnections, devices, and wires of discrete and integrated electronic circuits. Although many attempts have been made to augment plant function with electroactive materials, plants' "circuitry" has never been directly merged with electronics. We report analog and

digital organic electronic circuits and devices manufactured in living plants. The four key components of a circuit have been achieved using the xylem, leaves, veins, and signals of the plant as the template and integral part of the circuit elements and functions. With integrated and distributed electronics in plants, one can envisage a range of applications including precision recording and regulation of physiology, energy harvesting from photosynthesis, and alternatives to genetic modification for plant optimization.

Conducting polymer and its composite materials based electrochemical sensor for Nicotinamide Adenine Dinucleotide (NADH).

https://www.ncbi.nlm.nih.gov/pubmed/26774092

Nicotinamide Adenine Dinucleotide (NADH) is an important coenzyme in the human body that participates in many metabolic reactions. The impact of abnormal concentrations of NADH significantly causes different diseases in human body. Electrochemical detection of NADH using bare electrode is a challenging task especially in the presence of main electroactive interferences such as ascorbic acid (AA), uric acid (UA) and dopamine (DA). Modified electrodes have been widely explored to overcome the problems of poor sensitivity and selectivity occurred from bare electrodes. This review gives an overview on the progress of using conducting polymers, polyelectrolyte and its composites (co-polymer, carbonaceous, metal, metal oxide and clay) based modified electrodes for the sensing of NADH. In addition, developments on the fabrication of numerous conducting polymer composites based modified electrodes are clearly described.

Sensitive and selective determination of gallic acid in green tea samples based on an electrochemical platform of poly(melamine) film.

https://www.ncbi.nlm.nih.gov/pubmed/26614056

In this work, an electrochemical sensor coupled with an effective flow-injection amperometry (FIA) system is developed, targeting the determination of gallic acid (GA) in a mild neutral condition, in contrast to the existing electrochemical methods. The sensor is based on a thin electroactive poly(melamine) film immobilized on a pre-anodized screen-printed carbon electrode (SPCE*/PME). The characteristics of the sensing surface are well-characterized by field emission scanning electron microscopy (FE-SEM), X-ray photoelectron spectroscopy (XPS) and surface water contact angle experiments. The proposed assay exhibits a wide linear response to GA in both pH 3 and pH 7.0 phosphate buffer solutions (PBS) under the optimized flow-injection amperometry. The detection

limit (S/NÂ =Â 3) is 0.076Â Î¼M and 0.21Â Î¼M in the pH 3 and pH 7 solutions, respectively. A relative standard deviation (RSD) of 3.9% is obtained for 57 successive measurements of 50Â Î¼MÂ GA in pH 7 solutions. Interference studies indicate that some inorganic salts, catechol, caffeine and ascorbic acid do not interfere with the GA assay. The interference effects from some orthodiphenolic compounds are also investigated. The proposed method and a conventional Folin-Ciocalteu method are applied to detect GA in green tea samples using the standard addition method, and satisfactory spiked recoveries are obtained.

Biocompatible, Biodegradable, and Electroactive Polyurethane-Urea Elastomers with Tunable Hydrophilicity for Skeletal Muscle Tissue Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/26641320

It remains a challenge to develop electroactive and elastic biomaterials to mimic the elasticity of soft tissue and to regulate the cell behavior during tissue regeneration. We designed and synthesized a series of novel electroactive and biodegradable polyurethane-urea (PUU) copolymers with elastomeric property by combining the properties of polyurethanes and conducting polymers. The electroactive PUU copolymers were synthesized from amine capped aniline trimer (ACAT), dimethylol propionic acid (DMPA), polylactide, and hexamethylene diisocyanate. The electroactivity of the PUU copolymers were studied by UV-vis spectroscopy and cyclic voltammetry. Elasticity and Young's modulus were tailored by the polylactide segment length and ACAT content. Hydrophilicity of the copolymer films was tuned by changing DMPA content and doping of the copolymer. Cytotoxicity of the PUU copolymers was evaluated by mouse C2C12 myoblast cells. The myogenic differentiation of C2C12 myoblasts on copolymer films was also studied by analyzing the morphology of myotubes and relative gene expression during myogenic differentiation. The chemical structure, thermal properties, surface morphology, and processability of the PUU copolymers were characterized by NMR, FT-IR, gel permeation chromatography (GPC), thermogravimetric analysis (TGA), differential scanning calorimetry (DSC), X-ray diffraction (XRD), scanning electron microscopy (SEM), atomic force microscopy (AFM), and solubility testing, respectively. Those biodegradable electroactive elastic PUU copolymers are promising materials for repair of soft tissues such as skeletal muscle, cardiac muscle, and nerve.

Biocompatible xanthan/polypyrrole scaffolds for tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/25953548

Polypyrrole (PPy) was electropolymerized in xanthan hydrogels (XCA), resulting in electroactive XCAPPy scaffolds with (15 Â± 3) wt.% PPy and (40 Â± 10) Î¼m thick. The physicochemical characterization of hybrid XCAPPy scaffolds was performed by means of cyclic voltammetry, swelling tests, Fourier transform infrared spectroscopy (FTIR), differential scanning calorimetry (DSC), thermogravimetric analyses (TGA), scanning electron microscopy (SEM), atomic force microscopy (AFM) and tensile tests. XCAPPy swelled~80% less than XCA. FTIR spectra and thermal analyses did not evidence strong interaction between PPy and XCA matrix. XCAPPy presented a porous stratified structure resulting from the arrangement of PPy chains parallel to XCA surface. Under stress XCAPPy presented larger strain than neat XCA probably due to the sliding of planar PPy chains. The adhesion and proliferation of fibroblasts onto XCA and XCAPPy were evaluated in the absence and in the presence of external magnetic field (EMF) of 0.4T, after one day, 7 days, 14 days and 21 days. Fibroblast proliferation was more pronounced onto XCAPPy than onto XCA, due to its higher hydrophobicity and surface roughness. EMF stimulated cell proliferation onto both scaffolds.

A simulation study of the electrostriction effects in dielectric elastomer composites containing polarizable inclusions with different spatial distributions.

https://www.ncbi.nlm.nih.gov/pubmed/26592758

Controlled actuation of electroactive polymers with embedded high dielectric nanoparticles is theoretically analyzed. If the inclusions are placed randomly in the elastomer body, the composite always contracts along the direction of the applied field. For a simple cubic distribution of inclusions, contraction occurs if the applied field is directed along the [001] direction of the lattice. For inclusions occupying the sites of other lattice structures such as body-centered or face-centered cubic crystals, the composite elongates along the field direction if it is applied along the [001] direction. The stability of the elongation against the imperfectness of the lattice site positions and the distortion ratio of the initial structures are examined. Finite elongation windows show up for the initially distorted body-centered cubic and face-centered cubic crystals as a function of the distortion ratio of the initial structure. The existence of these elongation windows are also predicted from the analysis of the electrostatic energy of the distorted body-centered cubic and face-centered cubic lattice structures. Our results indicate that the electrostriction effect, which is the main contribution to the actuation of low aspect-ratio composites, strongly depends on the geometry of the spatial distribution of nanoparticles, and can thereby largely be tuned.

Multiple-stimuli responsive bioelectrocatalysis based on reduced graphene oxide/poly(N-isopropylacrylamide) composite films and its application in the fabrication of logic gates.

https://www.ncbi.nlm.nih.gov/pubmed/25686462

In the present work, reduced graphene oxide (rGO)/poly(N-isopropylacrylamide) (PNIPAA) composite films were electrodeposited onto the surface of Au electrodes in a fast and one-step manner from an aqueous mixture of a graphene oxide (GO) dispersion and N-isopropylacrylamide (NIPAA) monomer solutions. Reflection-absorption infrared (IR) and Raman spectroscopies were employed to characterize the successful construction of the rGO/PNIPAA composite films. The rGO/PNIPAA composite films exhibited reversible potential-, pH-, temperature-, and sulfate-sensitive cyclic voltammetric (CV) on-off behavior to the electroactive probe ferrocenedicarboxylic acid (Fc(COOH)2). For instance, after the composite films were treated at -0.7 V for 7 min, the CV responses of Fc(COOH)2 at the rGO/PNIPAA electrodes were quite large at pH 8.0, exhibiting the on state. However, after the films were treated at 0 V for 30 min, the CV peak currents became much smaller, demonstrating the off state. The mechanism of the multiple-stimuli switchable behaviors for the system was investigated not only by electrochemical methods but also by scanning electron microscopy and X-ray photoelectron spectroscopy. The potential-responsive behavior for this system was mainly attributed to the transformation between rGO and GO in the films at different potentials. The film system was further used to realize multiple-stimuli responsive bioelectrocatalysis of glucose catalyzed by the enzyme of glucose oxidase and mediated by the electroactive probe of Fc(COOH)2 in solution. On the basis of this, a four-input enabled OR (EnOR) logic gate network was established.

A Single-Step Synthesis of Electroactive Mesoporous ProDOT-Silica Structures.

https://www.ncbi.nlm.nih.gov/pubmed/26037244

The single-step preparation of highly ordered mesoporous silica hybrid nanocomposites with conjugated polymers was explored using a novel cationic 3,4-propylenedioxythiophene (ProDOT) surfactant (PrS). The method does not require high-temperature calcination or a washing procedure. The combination of self-assembly of the silica surfactant and inâ€…situ polymerization of the ProDOT tail is responsible for creation of the mesoporosity with ultralarge pores, large pore volume, and electroactivity. As this novel material exhibits excellent textural parameters together with electrical conductivity, we believe that this could find potential applications in various fields. This

novel concept of creating mesoporosity without a calcination process is a significant breakthrough in the field of mesoporous materials and the method can be further generalized as a rational preparation of various mesoporous hybrid materials having different structures and pore diameters.

Native and structurally modified gum arabic: exploring the effect of the gum's microstructure in obtaining electroactive nanoparticles.

https://www.ncbi.nlm.nih.gov/pubmed/25563942

Electroactive nanoparticles combining gum arabic (GA) and polyaniline (PANI) were prepared by chemical synthesis. The gum consists of highly branched anionic polysaccharides with some protein content. GA was structurally modified by Smith controlled degradation, in order to reduce its degree of branching (GAD), aiming the elucidation of the relationship between the structure and the properties of complex polysaccharides. The modification was studied by SEC, GC-MS, (13)C NMR and colorimetric methods. GAD has lower molecular mass, lower degree of branching and lower uronic acid content. Besides it is enriched in galactose and protein when compared with GA. The obtained composites (GA-PANI and GAD-PANI) were thoroughly characterized. Although the use of both polysaccharides (GA and GAD) produced highly stable electroactive nanoparticles, the best combination of properties was achieved for GA-PANI. The sample GAD was not able to prevent the occurrence of crosslinking between PANI chains, possibly due to its lower microstructural complexity which diminishes the occurrence of hydrogen bonds between the polymers.

Reagentless polyol detection by conductivity increase in the course of self-doping of boronate-substituted polyaniline.

https://www.ncbi.nlm.nih.gov/pubmed/25363870

We report on the novel reagentless and label-free detection principle based on electroactive (conducting) polymers considering sensors for polyols, particularly, saccharides and hydroxy acids. Unlike the majority of impedimetric and conductometric (bio)sensors, which specific and unspecific signals are directed in the same way (resistance increase), making doubtful their real applications, the response of the reported system results in resistance decrease, which is directed oppositely to the background. The mechanism of the resistance decrease is the polyaniline self-doping, i.e., as an alternative to proton doping, an appearance of the negatively charged aromatic ring substituents in polymer chain. Negative charge "freezing" at the boron atom is indeed a result of complex formation with di- and polyols, specific binding. Changes in Raman spectra of boronate-substituted polyaniline

after addition of glucose are similar to those caused by proton doping of the polymer. Thermodynamic data on interaction of the electropolymerized 3-aminophenylboronic acid with saccharides and hydroxy acids also confirm that the observed resistance decrease is due to polymer interaction with polyols. The first reported conductivity increase as a specific signal opens new horizons for reagentless affinity sensors, allowing the discrimination of specific affinity bindings from nonspecific interactions.

An Innovative Strategy for the Fabrication of Functional Cell Sheets Using an Electroactive Conducting Polymer.

https://www.ncbi.nlm.nih.gov/pubmed/26155317

Here, we report the development of an electric field-assisted methodology for constructing 3D C2C12 cell sheets with the potential for cell surface modification. In this method, a conducting polymer, polypyrrole (Ppy), is electrodeposited via biotin doping, and then chemical conjugation of biotinylated bone morphogenetic protein 2 (BMP2) is achieved using a biotin-streptavidin cross-linker. Subsequently, C2C12 cells are cultured on BMP2-immobilized Ppy surfaces to induce interactions between cell surface receptors and bound BMP2 ligands. Following these procedures, layers of BMP2-immobilized cells can be easily detached from the Ppy surface by applying an electrical potential. This novel method results in high affinity, ligand-bound cell sheets, which exhibit homogeneous coverage with membrane-bound proteins and signal activation that occurs via maximal receptor accessibility. Using this strategy to engineer the cell surface with desirable ligands results in structures that mimic in vivo tissues; thus, the method reported here has potential applications in regenerative medicine and tissue engineering.

Dynamic piezoelectric stimulation enhances osteogenic differentiation of human adipose stem cells.

https://www.ncbi.nlm.nih.gov/pubmed/25370596

This work reports on the influence of the substrate polarization of electroactive Î²-poly(vinylidene fluoride) (Î²-PVDF) on human adipose stem cells (hASCs) differentiation under static and dynamic conditions. hASCs were cultured on different Î²-PVDF surfaces (non-poled and "poled -") adsorbed with fibronectin and osteogenic differentiation was determined using a quantitative alkaline phosphatase assay. "Poled -" Î²-PVDF samples promote higher osteogenic differentiation, which is even higher under dynamic conditions. It is thus demonstrated that electroactive membranes can

provide the necessary electromechanical stimuli for the differentiation of specific cells and therefore will support the design of suitable tissue engineering strategies, such as bone tissue engineering.

Development of electroactive and elastic nanofibers that contain polyaniline and poly(L-lactide-co-epsilon-caprolactone) for the control of cell adhesion.

https://www.ncbi.nlm.nih.gov/pubmed/18401867

In this work, electrically conductive polyaniline (PAni) doped with camphorsulfonic acid (CPSA) is blended with poly(L-lactide-co-epsilon-caprolactone) (PLCL), and then electrospun to prepare uniform nanofibers. The CPSA-PAni/PLCL nanofibers show a smooth fiber structure without coarse lumps or beads and consistent fiber diameters (which range from 100 to 700 nm) even with an increase in the amount of CPSA-PAni (from 0 to 30 wt.-%). However, the elongation at break decreases from 391.54 +/- 9.20% to 207.85 +/- 6.74% when 30% of CPSA-PAni is incorporated. Analysis of the surface of the nanofibers demonstrates the presence of homogeneously blended CPSA-PAni. Most importantly, a four-point probe analysis reveals that electrical properties are maintained in the nanofibers where the conductivity is significantly increased from 0.0015 to 0.0138 S x cm(-1) when the nanofibers are prepared with 30% CPSA-PAni. The cell adhesion tests using human dermal fibroblasts, NIH-3T3 fibroblasts, and C2C12 myoblasts demonstrate significantly higher adhesion on the CPSA-PAni/PLCL nanofibers than pure PLCL nanofibers. In addition, the growth of NIH-3T3 fibroblasts is enhanced under the stimulation of various direct current flows. The CPSA-PAni/PLCL nanofibers with electrically conductive properties may potentially be used as a platform substrate to study the effect of electrical signals on cell activities and to direct desirable cell function for tissue engineering applications.

Optical and electrochemical methods for determining the effective area and charge density of conducting polymer modified electrodes for neural stimulation.

https://www.ncbi.nlm.nih.gov/pubmed/25495574

Neural stimulation is used in the cochlear implant, bionic eye, and deep brain stimulation, which involves implantation of an array of electrodes into a patient's brain. The current passed through the electrodes is used to provide sensory queues or reduce symptoms associated with movement disorders and increasingly for psychological and pain therapies. Poor control of electrode properties can lead to suboptimal performance; however, there are currently no standard methods to assess them, including the electrode area and charge density. Here we demonstrate optical and

electrochemical methods for measuring these electrode properties and show the charge density is dependent on electrode geometry. This technique highlights that materials can have widely different charge densities but also large variation in performance. Measurement of charge density from an electroactive area may result in new materials and electrode geometries that improve patient outcomes and reduce side effects.

In Vivo Electrochemical Analysis of a PEDOT/MWCNT Neural Electrode Coating.

https://www.ncbi.nlm.nih.gov/pubmed/26473938

Neural electrodes hold tremendous potential for improving understanding of brain function and restoring lost neurological functions. Multi-walled carbon nanotube (MWCNT) and dexamethasone (Dex)-doped poly(3,4-ethylenedioxythiophene) (PEDOT) coatings have shown promise to improve chronic neural electrode performance. Here, we employ electrochemical techniques to characterize the coating in vivo. Coated and uncoated electrode arrays were implanted into rat visual cortex and subjected to daily cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) for 11 days. Coated electrodes experienced a significant decrease in 1 kHz impedance within the first two days of implantation followed by an increase between days 4 and 7. Equivalent circuit analysis showed that the impedance increase is the result of surface capacitance reduction, likely due to protein and cellular processes encapsulating the porous coating. Coating's charge storage capacity remained consistently higher than uncoated electrodes, demonstrating its in vivo electrochemical stability. To decouple the PEDOT/MWCNT material property changes from the tissue response, in vitro characterization was conducted by soaking the coated electrodes in PBS for 11 days. Some coated electrodes exhibited steady impedance while others exhibiting large increases associated with large decreases in charge storage capacity suggesting delamination in PBS. This was not observed in vivo, as scanning electron microscopy of explants verified the integrity of the coating with no sign of delamination or cracking. Despite the impedance increase, coated electrodes successfully recorded neural activity throughout the implantation period.

An electrochromic painter's palette: color mixing via solution co-processing.

https://www.ncbi.nlm.nih.gov/pubmed/25580827

Electrochromic polymers (ECPs) have been shown to be synthetically tunable, producing a full palette of vibrantly colored to highly transmissive polymers. The development of these colored-to-transmissive ECPs employed synthetic design strategies for broad color targeting;

however, due to the subtleties of color perception and the intricacies of polymer structure and color relationships, fine color control is difficult. In contrast, color mixing is a well-established practice in the printing industry. We have identified three colored-to-transmissive switching electrochromic polymers, referred to as ECP-Cyan (ECP-C), ECP-Magenta (ECP-M), and ECP-Yellow (ECP-Y), which, via the co-processing of multicomponent ECP mixtures, follow the CMY color mixing model. The presented work qualitatively assesses the thin film characteristics of solution co-processed ECP mixtures. To quantitatively determine the predictability of the color properties of ECP mixtures, we estimated mass extinction coefficients (Îµmass) from solution spectra of the CMY ECPs and compared the estimated and experimentally observed color values of blends via a calculated color difference (Î”Eab). The values of Î”Eab range from 8 to 26 across all mixture compositions, with an average value of 15, representing a reasonable degree of agreement between predicted and observed color values. We demonstrate here the ability to co-process ECP mixtures into vibrantly colored, visually continuous films and the ability to estimate the color properties produced in these mixed ECP films.

Edge promoted ultrasensitive electrochemical detection of organic bio-molecules on epitaxial graphene nanowalls.

https://www.ncbi.nlm.nih.gov/pubmed/25801954

We report the simultaneous electrochemical detection of dopamine (DA), uric acid (UA) and ascorbic acid (AA) on three dimensional (3D) unmodified 'as-grown' epitaxial graphene nanowall arrays (EGNWs). The 3D few layer EGNWs, unlike the 2D planar graphene, offers an abundance of vertically oriented nano-graphitic-edges that exhibit fast electron-transfer kinetics and high electroactive surface area to geometrical area (EAA/GAâ‰ˆ134%), as evident from the Fe(CN)6(3-/4-) redox kinetic study. The hexagonal sp(2)-C domains, on the basal plane of the EGNWs, facilitate efficient adsorption via spontaneous Ï€-Ï€ interaction with the aromatic rings in DA and UA. Such affinity together with the fast electron kinetics enables simultaneous and unambiguous identification of individual AA, DA and UA from their mixture. The unique edge dominant EGNWs result in an unprecedented low limit of detection (experimental) of 0.033 nM and highest sensitivity of 476.2 ÂµA/ÂµM/cm(2), for UA, which are orders of magnitude higher than comparable existing reports. A reaction kinetics based modeling of the edge-oriented 3D EGNW system is proposed to illustrate the superior electro-activity for bio-sensing applications.

The effect of PVDF-TrFE scaffolds on stem cell derived cardiovascular cells.

https://www.ncbi.nlm.nih.gov/pubmed/26705272

Recently, electrospun polyvinylidene fluoride (PVDF) and polyvinylidene fluoride-trifluoroethylene (PVDF-TrFE) scaffolds have been developed for tissue engineering applications. These materials have piezoelectric activity, wherein they can generate electric charge with minute mechanical deformations. Since the myocardium is an electroactive tissue, the unique feature of a piezoelectric scaffold is attractive for cardiovascular tissue engineering applications. In this study, we examined the cytocompatibility and function of pluripotent stem cell derived cardiovascular cells including mouse embryonic stem cell-derived cardiomyocytes (mES-CM) and endothelial cells (mES-EC) on PVDF-TrFE scaffolds. MES-CM and mES-EC adhered well to PVDF-TrFE and became highly aligned along the fibers. When cultured on scaffolds, mES-CM spontaneously contracted, exhibited well-registered sarcomeres and expressed classic cardiac specific markers such as myosin heavy chain, cardiac troponin T, and connexin43. Moreover, mES-CM cultured on PVDF-TrFE scaffolds responded to exogenous electrical pacing and exhibited intracellular calcium handling behavior similar to that of mES-CM cultured in 2D. Similar to cardiomyocytes, mES-EC also demonstrated high viability and maintained a mature phenotype through uptake of low-density lipoprotein and expression of classic endothelial cell markers including platelet endothelial cell adhesion molecule, endothelial nitric oxide synthase, and the arterial specific marker, Notch-1. This study demonstrates the feasibility of PVDF-TrFE scaffold as a candidate material for developing engineered cardiovascular tissues utilizing stem cell-derived cells. Biotechnol. Bioeng. 2016;113: 1577-1585.

DNA-Assisted Î²-phase Nucleation and Alignment of Molecular Dipoles in PVDF Film: A Realization of Self-Poled Bioinspired Flexible Polymer Nanogenerator for Portable Electronic Devices.

https://www.ncbi.nlm.nih.gov/pubmed/26189605

A flexible nanogenerator (NG) is fabricated with a poly(vinylidene fluoride) (PVDF) film, where deoxyribonucleic acid (DNA) is the agent for the electroactive Î²-phase nucleation. Denatured DNA is co-operating to align the molecular -CH2/-CF2 dipoles of PVDF causing piezoelectricity without electrical poling. The NG is capable of harvesting energy from a variety of easily accessible mechanical stress such as human touch, machine vibration, football juggling, and walking. The NG exhibits high piezoelectric energy conversion efficiency facilitating the instant turn-on of several green or blue light-emitting diodes. The generated energy can be used to charge capacitors

providing a wide scope for the design of self-powered portable devices.

Novel bamboo leaf shaped CuO nanorod@hollow carbon fibers derived from plant biomass for efficient and nonenzymatic glucose detection.

https://www.ncbi.nlm.nih.gov/pubmed/26280029

The present paper reports on the preparation of novel bamboo leaf shaped CuO nanorod dispersed hollow carbon fibers (denoted as CuO NR@PCFs). Specially, the new-type hollow carbon fibers (containing abundant micro/meso/macropores and a large specific surface area) were prepared only by simple and fast pyrolysis of the natural product catkins without using any template or surfactant. Meanwhile, a facile method was used to prepare the bamboo leaf shaped CuO nanorod covered PCFs. Thanks to the abundant micro/meso/macropores, large specific surface area, and excellent electrical conduction efficiency of the PCF matrix, the as-prepared CuO NR@PCFs could also afford more catalytic sites, show more excellent reactant transport efficiency, and display more excellent electron transport rates compared with those for the pure CuO balls. Above all, these advantages will result in the excellent oxidation and detection efficiency of the CuO NR@PCF sample to glucose. Electrochemical measurements reveal that the CuO NR@PCF modified electrode can directly catalyze glucose oxidation and display an enhanced current response compared with the pure CuO balls (such as a response time within 4 s, wide linear ranges of 5 Ã— 10(-3)-0.8 mM and 0.8-8.5 mM, good reproducibility, considerable stability, and excellent anti-interference to electroactive molecules and Cl(-)). The superior catalytic activity and selectivity make the CuO NR@PCF catalyst very promising for application in direct detection of glucose.

Quantifying Molecular-Level Cell Adhesion on Electroactive Conducting Polymers using Electrochemical-Single Cell Force Spectroscopy.

https://www.ncbi.nlm.nih.gov/pubmed/26335299

Single Cell Force Spectroscopy was combined with Electrochemical-AFM to quantify the adhesion between live single cells and conducting polymers whilst simultaneously applying a voltage to electrically switch the polymer from oxidized to reduced states. The cell-conducting polymer adhesion represents the non-specific interaction between cell surface glycocalyx molecules and polymer groups such as sulfonate and dodecylbenzene groups, which rearrange their orientation during electrical switching. Single cell adhesion significantly increases as the polymer is switched from an oxidized to fully reduced state, indicating stronger cell binding to sulfonate groups as

opposed to hydrophobic groups. This increase in single cell adhesion is concomitant with an increase in surface hydrophilicity and uptake of cell media, driven by cation movement, into the polymer film during electrochemical reduction. Binding forces between the glycocalyx and polymer surface are indicative of molecular-level interactions and during electrical stimulation there is a decrease in both the binding force and stiffness of the adhesive bonds. The study provides insight into the effects of electrochemical switching on cell adhesion at the cell-conducting polymer interface and is more broadly applicable to elucidating the binding of cell adhesion molecules in the presence of electrical fields and directly at electrode interfaces.

MWCNTs-reinforced epoxidized linseed oil plasticized polylactic acid nanocomposite and its electroactive shape memory behaviour.

https://www.ncbi.nlm.nih.gov/pubmed/25365179

A novel electroactive shape memory polymer nanocomposite of epoxidized linseed oil plasticized polylactic acid and multi-walled carbon nanotubes (MWCNTs) was prepared by a combination of solution blending, solvent cast technique, and hydraulic hot press moulding. In this study, polylactic acid (PLA) was first plasticized by epoxidized linseed oil (ELO) in order to overcome the major limitations of PLA, such as high brittleness, low toughness, and low tensile elongation. Then, MWCNTs were incorporated into the ELO plasticized PLA matrix at three different loadings (2, 3 and 5 wt. %), with the aim of making the resulting nanocomposites electrically conductive. The addition of ELO decreased glass transition temperature, and increased the elongation and thermal degradability of PLA, as shown in the results of differential scanning calorimetry (DSC), tensile test, and thermo gravimetric analysis (TGA). Scanning electron microscopy (SEM) and atomic force microscopy (AFM) were used to observe surface morphology, topography, and the dispersion of MWCNTs in the nanocomposite. Finally, the electroactive-shape memory effect (electroactive-SME) in the resulting nanocomposite was investigated by a fold-deploy "U"-shape bending test. As per the results, the addition of both ELO and MWCNTs to PLA matrix seemed to enhance its overall properties with a great deal of potential in improved shape memory. The 3 wt. % MWCNTs-reinforced nanocomposite system, which showed 95% shape recovery within 45 s at 40 DC voltage, is expected to be used as a preferential polymeric nanocomposite material in various actuators, sensors and deployable devices.

Surface exploration of a room-temperature ionic liquid-chitin composite film decorated with

electrochemically deposited PdFeNi trimetallic alloy nanoparticles by pattern recognition: an elegant approach to developing a novel biotin biosensor.

https://www.ncbi.nlm.nih.gov/pubmed/25281100

In this study, a novel biosensing system for the determination of biotin (BTN) based on electrodeposition of palladium-iron-nickel (PdFeNi) trimetallic alloy nanoparticles (NPs) onto a glassy carbon electrode (GCE) modified with a room-temperature ionic liquid (RTIL)-chitin (Ch) composite film (PdFeNi/ChRTIL/GCE) is established. NPs have a wide range of applications in science and technology and their sizes are often measured using transmission electron microscopy (TEM) or X-ray diffraction. Here, we used a pattern recognition method (digital image processing, DIP) for measuring particle size distributions (PSDs) from scanning electron microscopic (SEM) images in the presence of an uneven background. Different depositions were performed by varying the number of cyclic potential scans (N) during electroreduction step. It was observed that the physicochemical properties of the deposits were correlated to the performance of the PdFeNi/ChRTIL/GCE with respect to BTN assay. The best results were obtained for eight electrodeposition cyclic scans, where small-sized particles (19.54 Â± 6.27 nm) with high density (682 particles Âµm(-2)) were obtained. Under optimized conditions, a linear range from 2.0 to 44.0 Ã— 10(-9) mol L(-1) and a limit of detection (LOD) of 0.6 Ã— 10(-9) mol L(-1) were obtained. The PdFeNi/ChRTIL nanocomposite showed excellent compatibility, enhanced electron transfer kinetics, large electroactive surface area, and was highly sensitive, selective, and stable toward BTN determination. Finally, the PdFeNi/ChRTIL/GCE was satisfactorily applied to the determination of BTN in infant milk powder, liver, and egg yolk samples.

Ionic electroactive polymer artificial muscles in space applications.

https://www.ncbi.nlm.nih.gov/pubmed/25372857

A large-scale effort was carried out to test the performance of seven types of ionic electroactive polymer (IEAP) actuators in space-hazardous environmental factors in laboratory conditions. The results substantiate that the IEAP materials are tolerant to long-term freezing and vacuum environments as well as ionizing Gamma-, X-ray, and UV radiation at the levels corresponding to low Earth orbit (LEO) conditions. The main aim of this material behaviour investigation is to understand and predict device service time for prolonged exposure to space environment.

Electroactive Tissue Scaffolds with Aligned Pores as Instructive Platforms for Biomimetic

Tissue Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/28955011

Tissues in the body are hierarchically structured composite materials with tissue-specific chemical and topographical properties. Here we report the preparation of tissue scaffolds with macroscopic pores generated via the dissolution of a sacrificial supramolecular polymer-based crystal template (urea) from a biodegradable polymer-based scaffold (polycaprolactone, PCL). Furthermore, we report a method of aligning the supramolecular polymer-based crystals within the PCL, and that the dissolution of the sacrificial urea yields scaffolds with macroscopic pores that are aligned over long, clinically-relevant distances (i.e., centimeter scale). The pores act as topographical cues to which rat Schwann cells respond by aligning with the long axis of the pores. Generation of an interpenetrating network of polypyrrole (PPy) and poly(styrene sulfonate) (PSS) in the scaffolds yields electroactive tissue scaffolds that allow the electrical stimulation of Schwann cells cultured on the scaffolds which increases the production of nerve growth factor (NGF).

Correlation of the impedance and effective electrode area of doped PEDOT modified electrodes for brain-machine interfaces.

https://www.ncbi.nlm.nih.gov/pubmed/25773879

Electrode impedance is used to assess the thermal noise and signal-to-noise ratio for brain-machine interfaces. An intermediate frequency of 1 kHz is typically measured, although other frequencies may be better predictors of device performance. PEDOT-PSS, PEDOT-DBSA and PEDOT-pTs conducting polymer modified electrodes have reduced impedance at 1 kHz compared to bare metal electrodes, but have no correlation with the effective electrode area. Analytical solutions to impedance indicate that all low-intermediate frequencies can be used to compare the electrode area at a series RC circuit, typical of an ideal metal electrode in a conductive solution. More complex equivalent circuits can be used for the modified electrodes, with a simplified Randles circuit applied to PEDOT-PSS and PEDOT-pTs and a Randles circuit including a Warburg impedance element for PEDOT-DBSA at 0 V. The impedance and phase angle at low frequencies using both equivalent circuit models is dependent on the electrode area. Low frequencies may therefore provide better predictions of the thermal noise and signal-to-noise ratio at modified electrodes. The coefficient of variation of the PEDOT-pTs impedance at low frequencies was lower than the other conducting polymers, consistent with linear and steady-state electroactive area measurements. There are poor correlations between the impedance and the charge density as they are not ideal metal electrodes.

Flexible 3D porous CuO nanowire arrays for enzymeless glucose sensing: in situ engineered versus ex situ piled.

https://www.ncbi.nlm.nih.gov/pubmed/25415769

Convenient determination of glucose in a sensitive, reliable and cost-effective way has aroused sustained research passion, bringing along assiduous investigation of high-performance electroactive nanomaterials to build enzymeless sensors. In addition to the intrinsic electrocatalytic capability of the sensing materials, electrode architecture at the microscale is also crucial for fully enhancing the performance. In this work, free-standing porous CuO nanowire (NW) was taken as a model sensing material to illustrate this point, where an in situ formed 3D CuO nanowire array (NWA) and CuO nanowires pile (NWP) immobilized with polymer binder by conventional drop-casting technique were both studied for enzymeless glucose sensing. The NWA electrode exhibited greatly promoted electrochemistry characterized by decreased overpotential for electro-oxidation of glucose and over 5-fold higher sensitivity compared to the NWP counterpart, benefiting from the binder-free nanoarray structure. Besides, its sensing performance was also satisfying in terms of rapidness, selectivity and durability. Further, the CuO NWA was utilized to fabricate a flexible sensor which showed excellent performance stability against mechanical bending. Thanks to its favorable electrode architecture, the CuO NWA is believed to offer opportunities for building high-efficiency flexible electrochemical devices.

Electroactive polypyrrole nanowire arrays: synergistic effect of cancer treatment by on-demand drug release and photothermal therapy.

https://www.ncbi.nlm.nih.gov/pubmed/25815804

An electroresponsive drug release system based on polypyrrole (Ppy) nanowires was developed to induce the local delivery of anticancer drug, doxorubicin (DOX), according to the applied electric field. DOX-conjugated Ppy nanowire (NW) (DOX/Ppy NW) array was initially prepared by electrochemical deposition of a mixture of pyrrole monomers and biotin as dopants in the anodic alumina oxide membrane as a sacrificial template. Morphological observation by scanning electron microscopy revealed free-standing and 3D nanotopographical features with large surface area and high density. In addition, we investigated the antitumor efficacy of DOX released from DOX/Ppy NW array in response to the external electric field using two kinds of cancer cell lines, human oral squamous carcinoma cells (KB cells) and human breast cancer cells (MCF7 cells). Meanwhile, strong photothermal effect as a result of a near-infrared absorbing ability of Ppy synergistically

maximizes the chemotherapeutic efficacy. Our results suggested that the proposed multifunctional Ppy platform possessing several beneficial features is very promising for many therapeutic applications including cancer.

Unusual Fe(CN)â‚†Â³â•»/â•´â•» capture induced by synergic effect of electropolymeric cationic surfactant and graphene: characterization and biosensing application.

https://www.ncbi.nlm.nih.gov/pubmed/25409412

Herein, a special microheterogeneous system for Fe(CN)6(3-/4-) capture was constructed based on graphene (GN) and the electropolymeric cationic surfactant, an amphiphilic pyrrole derivative, (11-pyrrolyl-1-yl-undecyl) triethylammonium tetrafluoroborate (A2). The morphology of the system was characterized by scanning electron microscope. The redox properties of the entrapped Fe(CN)6(3-/4-) were investigated by cyclic voltammetry and UV-visible spectrometry. The entrapped Fe(CN)6(3-/4-) exhibited highly electroactive with stable and symmetrical cyclic voltammetric signal. A dramatic negative shift in the half wave potential can be obtained due to the unusual Fe(CN)6(3-/4-) partitioning in in this microheterogeneous system based on poly(A2+GN). Finally, the entrapped Fe(CN)6(3-/4-) was applied in the construction of the enhanced biosensors to hydrogen peroxide and sulfide.

Electroactive Film of Myoglobin Incorporated in a 3D-porous Calcium Alginate Film with Polyvinyl Alcohol, Glycerin and Gelatin.

https://www.ncbi.nlm.nih.gov/pubmed/26656812

In this work, an electroactive porous Mb-CA's composite film was fabricated by incorporating myoglobin (Mb) in a three-dimension (3D) porous calcium alginate (CA) film with polyvinyl alcohol, glycerol, and gelatin. The porous Mb-CA's film modified electrodes exhibited a pair of well-defined, quasi-reversible cyclic voltammetric (CV) peaks at about -0.37 V vs. SCE in pH 7.0 buffers, characteristic of Mb heme Fe((III))/Fe((II)) redox couples. The electrochemical parameters, such as formal potentials (E(o')) and apparent heterogeneous electron-transfer rate constants (ks), were estimated by square-wave voltammetry with nonlinear regression analysis. The porous CA's composite film could form hydrogel in aqueous solution. The positions of the Soret absorbance band suggest that Mb in the CA's composite film kept its native states in the medium pH range. Hydrogen peroxide, oxygen, and nitrite were electrochemically catalyzed by the Mb-CA's composite film with significant lowering of the reduction overpotential.

Electrically controlled release of benzoic acid from poly(3,4-ethylenedioxythiophene)/alginate matrix: effect of conductive poly(3,4-ethylenedioxythiophene) morphology.

https://www.ncbi.nlm.nih.gov/pubmed/25059579

A drug-loaded conductive polymer/hydrogel blend, benzoic acid-loaded poly(3,4-ethylenedioxythiophene/alginate (BA-loaded PEDOT/Alg) hydrogel, was used as a carrier/matrix for an electrical stimuli transdermal drug delivery system (TDDS). The effects of cross-linking ratio, PEDOT particle size, and electric field strength on the release mechanism and the diffusion coefficient (D) of BA were examined by using a modified Franz-diffusion cell. The diffusion scaling exponent value of BA is close to 0.5 which refers to the diffusion controlled mechanism, or the Fickian diffusion as the BA release mechanism. The D increased when there was a decrease in the cross-linking ratio due to the mesh size-hindering effect. When increasing electric field strength, the D of BA-loaded PEDOT/Alg hydrogel increased because the cathode-BA(-) electrorepulsion, electroinduced alginate expansion, and PEDOT electroneutralization simultaneously occurred. The highest D belonged to a blend with the smallest PEDOT particle and highest electrical conductivity. The D of BA was a function of the matrix mesh size except when drug size/mesh size was lower than 2.38 Ã— 10(-3), where D of BA became mesh size independent as the matrix mesh size was extremely large. Thus, the fabricated conductive polymer hydrogel blends have a great potential to be used in TDDS under electrical stimulation.

High-Resolution, Large-Area Fabrication of Compliant Electrodes via Laser Ablation for Robust, Stretchable Dielectric Elastomer Actuators and Sensors.

https://www.ncbi.nlm.nih.gov/pubmed/26197865

A key element in stretchable actuators, sensors, and systems based on elastomer materials are compliant electrodes. While there exist many methodologies for fabricating electrodes on dielectric elastomers, very few succeed in achieving high-resolution patterning over large areas. We present a novel approach for the production of mechanically robust, high-resolution compliant electrodes for stretchable silicone elastomer actuators and sensors. Cast, 2-50 Î¼m thick poly(dimethylsiloxane) (PDMS)-carbon composite layers are patterned by laser ablation and subsequently bonded to a PDMS membrane by oxygen plasma activation. The technique affords great design flexibility and high resolution and readily scales to large-area arrays of devices. We validate our methodology by producing arrays of actuators and sensors on up to A4-size substrates, reporting on microscale dielectric elastomer actuators (DEA) generating area strains of over 25%, and interdigitated

capacitive touch sensors with high sensitivity yet insensitivity to substrate stretching. We demonstrate the ability to cofabricate highly integrated multifunctional transducers using the same process flow, showing the methodology's promise in realizing sophisticated and reliable complex stretchable devices with fine features over large areas.

Synthesis and polymerization of substituted ammonium sulfonate monomers for advanced materials applications.

https://www.ncbi.nlm.nih.gov/pubmed/22201255

Sulfonated polymers have found use as ion-exchange membranes for use in fuel cells, water purification, electroactive devices, and inorganic materials templating and synthesis. Improving the materials for these applications and opening up new applications requires the ability to synthesis targeted or more complex sulfonated polymers, which includes tailoring the chemistry (copolymerization across a wider range of solubility) and/or polymer architecture (block, graft, nanoparticle). This article will summarize the recent work using sulfonated monomers with substituted ammonium counterions as a versatile route for enabling this goal. Two main benefits of these monomers are as follows. First, they are useful for preparing amphiphilic copolymers, which is a challenge using traditional acidic or alkali salt forms of sulfonated monomers. Second, sulfonated polymers with substituted ammonium counterions are useful polymers for obtaining unique material properties, such as organo-gelation of low polarity solvents or obtaining ionic liquid polymers for the fabrication of solid polymer electrolytes.

Polymeric matrix membrane sensors for stability-indicating potentiometric determination of oxybutynin hydrochloride and flavoxate hydrochloride urogenital system drugs.

https://www.ncbi.nlm.nih.gov/pubmed/19202792

Four polyvinyl chloride (PVC) matrix membrane electrodes responsive to 2 drugs affecting the urogenital system--oxybutynin hydrochloride (OX) and flavoxate hydrochloride (FX)--were developed, described, and characterized. A precipitation-based technique with tungstophosphate (TP) and ammonium reineckate (R) anions as electroactive materials in a PVC matrix with an OX cation was used for electrode 1 and 2 fabrication, respectively. Electrode 3 and 4 fabrication was based on use of the precipitation technique of FX cation with tetrakis (4-chlorophenyl) borate and R anions as electroactive materials. Fast and stable Nernstian responses in the range 1 x 10(-2)-1 x 10(-6) M for the 2 drugs over the pH range 5-8 revealed the performance characteristics of these

electrodes, which were evaluated according to International Union of Pure and Applied Chemistry recommendations. The method was applied to FX and OX in their pharmaceutical formulations and in human plasma samples. The 4 proposed sensors were found to be specific for the drugs in the presence of up to 60% of their degradation products. Validation of the method according to the quality assurance standards showed suitability of the proposed electrodes for use in the quality control assessment of these drugs. The recoveries for determination of the drugs by the 4 proposed selective electrodes were 99.5 +/- 0.5, 100.0 +/- 0.4, 99.9 +/- 0.4, and 100.1 +/- 0.4% for sensors 1-4, respectively. Statistical comparison between the results obtained by this method and the official method of the drugs was done, and no significant difference found.

Electropolymerized phenol derivatives as permselective polymers for biosensor applications.

https://www.ncbi.nlm.nih.gov/pubmed/25857616

Amperometric biosensors are often coated with a polymeric permselective film to avoid electroactive interference by reducing agents present in the target medium. Phenylenediamine and phenol monomers are commonly used to form these permselective films in the design of microsensors and biosensors. This paper aims to evaluate the permselectivity, stability and lifetime of polymers electrosynthesized using either constant potential amperometry (CPA) or cyclic voltammetry (CV) from naturally occurring phenylpropanoids in monomeric and dimeric forms (eugenol, isoeugenol, dehydrodieugenol and magnolol). Sensors were characterized by scanning electron microscopy and permselectivity analysis. Magnolol formed an electro-deposited polymer with a more defined three-dimensional texture in comparison with the other films. The phenol-derived films showed different permselectivity towards H2O2 over ascorbic acid and dopamine, likely to be related to the thickness and compactness of the polymer. The CV-derived films had a better permselectivity compared to the CPA-corresponding polymers. Based on these results, the permselectivity, stability and lifetime of a biosensor for glucose were studied when a magnolol coating was electro-deposited. The structural principles governing the permselectivity of the magnolol-derived film are suggested to be mainly related to the conformational flexibility of this monomer. Newly designed biosensors, coated with electropolymerized natural phenol derivatives, may represent promising analytical devices for different application fields.

Imidazolium-Containing ABA Triblock Copolymers as Electroactive Devices.

https://www.ncbi.nlm.nih.gov/pubmed/26699795

Two-step reversible addition-fragmentation chain transfer (RAFT) polymerization and two subsequent postpolymerization modification steps afforded well-defined ABA triblock copolymers featuring mechanically reinforcing polystyrene outer blocks and 1-methylimidazole-neutralized poly(acrylic acid)-based central blocks. Size exclusion chromatography and (1)H NMR spectroscopy confirmed predictable molecular weights and narrow distributions. The ionic liquid (IL) 1-ethyl-3-methylimidazolium trifluoromethanesulfonate ([EMIm][OTf]) was incorporated at 30 wt % into polymeric films. Thermogravimetric analysis, differential scanning calorimetry, and dynamic mechanical analysis determined the thermomechanical properties of the polymers and polymer-IL composites. Atomic force microscopy, small-angle X-ray scattering (SAXS), and transmission electron microscopy (TEM) determined surface and bulk morphologies, and poly(Sty-b-AA(MeIm)-b-Sty) exhibited a change from packed cylindrical to lamellar morphology in SAXS upon IL incorporation. Electrochemical impedance spectroscopy determined the in-plane ionic conductivities of the polymer-IL membranes (Ïƒ âˆ¼ 10(-4) S/cm). A device fabricated from poly(Sty-b-AA(MeIm)-b-Sty) with 30 wt % incorporated IL demonstrated mechanical actuation under a low applied voltage of 4 V.

Electrical stimulation using conductive polymer polypyrrole promotes differentiation of human neural stem cells: a biocompatible platform for translational neural tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/25296166

Conductive polymers (CPs) are organic materials that hold great promise for biomedicine. Potential applications include in vitro or implantable electrodes for excitable cell recording and stimulation and conductive scaffolds for cell support and tissue engineering. In this study, we demonstrate the utility of electroactive CP polypyrrole (PPy) containing the anionic dopant dodecylbenzenesulfonate (DBS) to differentiate novel clinically relevant human neural stem cells (hNSCs). Electrical stimulation of PPy(DBS) induced hNSCs to predominantly Î²-III Tubulin (Tuj1) expressing neurons, with lower induction of glial fibrillary acidic protein (GFAP) expressing glial cells. In addition, stimulated cultures comprised nodes or clusters of neurons with longer neurites and greater branching than unstimulated cultures. Cell clusters showed a similar spatial distribution to regions of higher conductivity on the film surface. Our findings support the use of electrical stimulation to promote neuronal induction and the biocompatibility of PPy(DBS) with hNSCs and opens up the possibility of identifying novel mechanisms of fate determination of differentiating human stem cells for advanced

in vitro modeling, translational drug discovery, and regenerative medicine.

Novel neural interface for implant electrodes: improving electroactivity of polypyrrole through MWNT incorporation.

https://www.ncbi.nlm.nih.gov/pubmed/18214647

Multi-walled carbon nanotubes (MWNTs) can be incorporated into conductive polymers to produce superior materials for neural interfaces with high interfacial areas, conductivity and electrochemical stability. This paper explores the addition of MWNTs to polypyrrole (PPy) through two methods, layering and codeposition. Conductivity of PPy doped with polystyrene sulfonate (PSS), a commonly used dopant, was improved by 50% when MWNTs were layered with PPy/PSS. The film electrochemical stability was improved from 38% activity to 66% activity after 400 cycles of oxidation and reduction. Growth inhibition assays indicated that MWNTs are not growth inhibitory. The electroactive polymer-MWNT composites produced demonstrate properties that suggest they are promising candidates for biomedical electrode coatings.

Polypyrrole-Based Implantable Electroactive Pump for Controlled Drug Microinjection.

https://www.ncbi.nlm.nih.gov/pubmed/26134590

Implantable devices for long-lasting controlled insulin microinjection are of great value to diabetic patients. To address this need, we develop a flexible electroactive pump based on a biocompatible polypyrrole composite film that comprises a polypyrrole matrix and a macromolecular dopant of polycaprolactone-block-polytetrahydrofuran-block-polycaprolactone. Using phosphate-buffered saline as the electrolyte, this film demonstrates much higher electroactivity and reproducibility than conventional Cl--doped polypyrrole, making it an excellent actuator for driving an implantable pump. At a driving current density of 1 mA/cm2, the pump demonstrates a consistent output capacity of 10.5 at 0.35 Î¼L/s over 20 cycles. This work paves the way for the development of an implantable electroactive pump to improve the quality of life of diabetics.

Synthesis, characterization and antioxidant activity of a novel electroactive and biodegradable polyurethane for cardiac tissue engineering application.

https://www.ncbi.nlm.nih.gov/pubmed/25280676

There has been a growing trend towards applying conducting polymers for electrically excitable cells

to increase electrical signal propagation within the cell-loaded substrates. A novel biodegradable electroactive polyurethane containing aniline pentamer (AP-PU) was synthesized and fully characterized by spectroscopic methods. To tune the physico-chemical properties and biocompatibility, the AP-PU was blended with polycaprolactone (PCL). The presence of electroactive moieties and the electroactivity behavior of the prepared films were confirmed by UV-visible spectroscopy and cyclic voltammetry. A conventional four probe analysis demonstrated the electrical conductivity of the films in the semiconductor range (~10(-5)S/cm). MTT assays using L929 mouse fibroblast and human umbilical vein endothelial cells (HUVECs) showed that the prepared blend (PB) displayed more cytocompatibility compared with AP-PU due to the introduction of a biocompatible PCL moiety. The in vitro cell culture also confirmed that PB was as supportive as tissue culture plate. The antioxidant activity of the AP-PU was proved using 1,1-diphenyl-2-picrylhydrazyl (DPPH) scavenging assay by employing UV-vis spectroscopy. In vitro degradation tests conducted in phosphate-buffered saline, pH7.4 and pH5.5, proved that the films were also biodegradable. The results of this study have highlighted the potential application of this bioelectroactive polyurethane as a platform substrate to study the effect of electrical signals on cell activities and to direct desirable cell function for tissue engineering applications.

In vitro characterization of an electroactive carbon-nanotube-based nanofiber scaffold for tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/21728234

In an effort to reduce organ replacement and enhance tissue repair, there has been a tremendous effort to create biomechanically optimized scaffolds for tissue engineering applications. In contrast, the development and characterization of electroactive scaffolds has attracted little attention. Consequently, the creation and characterization of a carbon nanotube based poly(lactic acid) nanofiber scaffold is described herein. After 28 d in physiological solution at 37â€‰Â°C, a change in the mass, chemical properties and polymer morphology is seen, while the mechanical properties and physical integrity are unaltered. No adverse cytotoxic affects are seen when mesenchymal stem cells are cultured in the presence of the scaffold. Taken together, these data auger well for electroactive tissue engineering.

Direct patterning of organic conductors on knitted textiles for long-term electrocardiography.

https://www.ncbi.nlm.nih.gov/pubmed/26446346

Wearable sensors are receiving a great deal of attention as they offer the potential to become a key technological tool for healthcare. In order for this potential to come to fruition, new electroactive materials endowing high performance need to be integrated with textiles. Here we present a simple and reliable technique that allows the patterning of conducting polymers on textiles. Electrodes fabricated using this technique showed a low impedance contact with human skin, were able to record high quality electrocardiograms at rest, and determine heart rate even when the wearer was in motion. This work paves the way towards imperceptible electrophysiology sensors for human health monitoring.

Superfast-response and ultrahigh-power-density electromechanical actuators based on hierarchal carbon nanotube electrodes and chitosan.

https://www.ncbi.nlm.nih.gov/pubmed/21972899

Here we report a novel single-walled carbon nanotube (SWNT) based bimorph electromechanical actuator, which consists of unique as-grown SWNT films as double electrode layers separated by a chitosan electrolyte layer consisting of an ionic liquid. By taking advantage of the special hierarchical structure and the outstanding electrical and mechanical properties of the SWNT film electrodes, our actuators show orders-of-magnitude improvements in many aspects compared to previous ionic electroactive polymer (i-EAP) actuators, including superfast response (19 ms), quite wide available frequency range (dozens to hundreds of Hz), incredible large stress generating rate (1080 MPa/s), and ultrahigh mechanical output power density (244 W/kg). These remarkable achievements together with their facile fabrication, low driving voltage, flexibility, and long durability enable the SWNT-based actuators many applications such as artificial muscles for biomimetic flying insects or robots and flexible deployable reflectors.

Conducting polymers for neural interfaces: challenges in developing an effective long-term implant.

https://www.ncbi.nlm.nih.gov/pubmed/18501423

Metal electrode materials used in active implantable devices are often associated with poor long-term stimulation and recording performance. Modification of these materials with conducting polymer coatings has been suggested as an approach for improving the neural tissue-electrode interface and increasing the effective lifetime of these implants. Neural interfaces ideally have intimate contact between the excitable tissue and the electrode to maintain signal quality and

activation of neural cells. The outcomes of current research into conducting polymers as coatings has potential to enhance this tissue-material contact by increasing the electrode surface area and roughness as well as allowing delivery of bioactive signals to neural cells. However, challenges facing conducting polymers include poor electroactive stability and mechanical properties as well as control of the mobility, concentration and presentation of bioactive molecules. The impact of biological inclusions on polymer properties and their ongoing performance in neural prosthetics requires a greater understanding with future research aimed at controlling and optimising film characteristics for long-term performance. Optimising the electrode interface will require a trade-off between desired electrical, mechanical, chemical and biological properties.

Electrodeposition and characterisation of polypyrroles containing sulfonated carbon nanotubes.

https://www.ncbi.nlm.nih.gov/pubmed/18330162

Using facile diazonium chemistry, sulfonate groups have been covalently attached to single wall carbon nanotubes. The resulting sulfonated tubes form a stable aqueous dispersion in the presence of pyrrole monomer. Subsequent electropolymerisation results in a conductive, electroactive polypyrrole doped with sulfonated tubes being formed at unusually low potentials. The potential of this material as a host matrix for biomolecules has been demonstrated by entrapping horse-radish peroxidase directly in the polypyrrole during composite formation.

Thermo- and sulfate-controllable bioelectrocatalysis of glucose based on horseradish peroxidase and glucose oxidase embedded in poly(N,N-diethylacrylamide) hydrogel films.

https://www.ncbi.nlm.nih.gov/pubmed/24888410

Dual-responsive poly(N,N-diethylacrylamide) (PDEA) hydrogel films with entrapped horseradish peroxidase (HRP) and glucose oxidase (GOD) were successfully prepared on electrode surface with a simple one-step polymerization procedure under mild conditions, designated as PDEA-HRP-GOD. Cyclic voltammetric (CV) response of electroactive probe K3Fe(CN)6 at the film electrodes displayed reversible thermo- and sulfate-responsive switching behavior. For example, at 25Â Â°C, the K3Fe(CN)6 demonstrated a well-defined CV peak pair with large peak currents for the films, showing the on state, while at 40Â Â°C, the CV response was greatly suppressed and the system was at the off state. The influence of temperature and Na2SO4 concentration on the switching behavior of the film system was not independent or separated, but was synergetic. The responsive

mechanism of the system was ascribed to the structure change of PDEA component in the films with temperature and sulfate concentration. This switching property of the PDEA-HRP-GOD films could be further used to realize dual-responsive catalytic oxidation of glucose sequentially by HRP and GOD entrapped in the films with Fe(CN)6 (3-) as the mediator through changing the surrounding temperature and Na2SO4 concentration. This system may establish a foundation for fabricating a new type of multi-switchable electrochemical biosensors based on bienzyme electrocatalysis.

[Construction and characterization of a selective membrane electrode for tenoxicam determination].

https://www.ncbi.nlm.nih.gov/pubmed/21243822

This paper describes the construction and characterization of a selective membrane electrode which can be used for determination of tenoxicam.

Three-Dimensional BC/PEDOT Composite Nanofibers with High Performance for Electrode-Cell Interface.

https://www.ncbi.nlm.nih.gov/pubmed/26550840

There is an increasing need to synthesize biocompatible nanofibers with excellent mechanical and electrical performance for electrochemical and biomedical applications. Here we report a facile approach to prepare electroactive and flexible 3D nanostructured biomaterials with high performance based on bacterial cellulose (BC) nanofibers. Our approach can coat BC nanofibers with poly(3,4-ethylenedioxythiophene) (PEDOT) by in situ interfacial polymerization in a controllable manner. The PEDOT coating thickness is adjustable by the monomer concentration or reaction time during polymerization, producing nanofibers with a total diameter ranging from 30 to 200 nm. This fabrication process also provides a convenient method to tune different parameters such as the average pore size and electrical conductivity on the demands of actual applications. Our experiments have demonstrated that the 3D BC/PEDOT nanofibers exhibit high specific surface area, excellent mechanical properties, electroactive stability, and low cell cytotoxicity. With electrical stimulation, calcium imaging of PC12 neural cells on BC/PEDOT nanofibers has revealed a significant increase in the percentage of cells with higher action potentials, suggesting an enhanced capacitance effect of charge injection. As an attractive solution to the challenge of designing better electrode-cell interfaces, 3D BC/PEDOT nanofibers promise many important applications such as biosensing devices, smart drug delivery systems, and implantable electrodes for tissue engineering.

Enhancement of adhesion and promotion of osteogenic differentiation of human adipose stem cells by poled electroactive poly(vinylidene fluoride).

https://www.ncbi.nlm.nih.gov/pubmed/24838756

Poly(vinylidene fluoride) (PVDF) is a biocompatible material with excellent electroactive properties. Nonelectroactive Î±-PVDF and electroactive Î²-PVDF were used to investigate the substrate polarization and polarity influence on the focal adhesion (FA) size and number as well as on human adipose stem cells (hASCs) differentiation. hASCs were cultured on different PVDF surfaces adsorbed with fibronectin and FA size and number, total adhesion area, cell size, cell aspect ratio and FA density were estimated using cells expressing vinculin fused to enhanced green fluorescent protein. Osteogenic differentiation was also determined using a quantitative alkaline phosphatase assay. The surface charge of the poled PVDF films (positive or negative) influenced the hydrophobicity of the samples, leading to variations in the conformation of adsorbed extracellular matrix proteins, which ultimately modulated the stem cell adhesion on the films and induced their osteogenic differentiation.

Simultaneous measurement and quantitation of 4-hydroxyphenylacetic acid and dopamine with fast-scan cyclic voltammetry.

https://www.ncbi.nlm.nih.gov/pubmed/25785694

Caged compounds have been used extensively to investigate neuronal function in a variety of preparations, including cell culture, ex vivo tissue samples, and in vivo. As a first step toward electrochemically measuring the extent of caged compound photoactivation while also measuring the release of the catecholamine neurotransmitter, dopamine, fast-scan cyclic voltammetry at carbon-fiber microelectrodes (FSCV) was used to electrochemically characterize 4-hydroxyphenylacetic acid (4HPAA) in the absence and presence of dopamine. 4HPAA is a by-product formed during the process of photoactivation of p-hydroxyphenacyl-based caged compounds, such as p-hydroxyphenylglutamate (pHP-Glu). Our data suggest that the oxidation of 4HPAA occurs through the formation of a conjugated species. Moreover, we found that a triangular waveform of -0.4 V to +1.3 V to -0.4 V at 600 V s(-1), repeated every 100 ms, provided an oxidation current of 4HPAA that was enhanced with a limit of detection of 100 nM, while also allowing the detection and quantitation of dopamine within the same scan. Along with quantifying 4HPAA in biological preparations, the results from this work will allow the electrochemical measurement of photoactivation reactions that generate 4HPAA as a by-product as well as provide a framework for

measuring the photorelease of electroactive by-products from caged compounds that incorporate other chromophores.

Electrochemically Induced Synthesis of Poly(2,6-carbazole).

https://www.ncbi.nlm.nih.gov/pubmed/26218573

The formation of a poly(2,6-carbazole) derivative during an electrochemical polymerization process is shown. Comparison of 3,5-bis(9-octyl-9H-carbazol-2-yl)pyridine and 3,5-bis(9-octyl-9H-carbazol-3-yl)pyridine by electrochemical and UV-Vis-NIR spectroelectrochemical measurements and DFT (density functional theory) calculation prove the formation of a poly(2,6-carbazole) derivative. Both of the compounds form stable and electroactive conjugated polymers.

Electrospun polyamide 6/poly(allylamine hydrochloride) nanofibers functionalized with carbon nanotubes for electrochemical detection of dopamine.

https://www.ncbi.nlm.nih.gov/pubmed/25644325

The use of nanomaterials as an electroactive medium has improved the performance of bio/chemical sensors, particularly when synergy is reached upon combining distinct materials. In this paper, we report on a novel architecture comprising electrospun polyamide 6/poly(allylamine hydrochloride) (PA6/PAH) nanofibers functionalized with multiwalled carbon nanotubes, used to detect the neurotransmitter dopamine (DA). Miscibility of PA6 and PAH was sufficient to form a single phase material, as indicated by thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC), leading to nanofibers with no beads onto which the nanotubes could adsorb strongly. Differential pulse voltammetry was employed with indium tin oxide (ITO) electrodes coated with the functionalized nanofibers for the selective electrochemical detection of dopamine (DA), with no interference from uric acid (UA) and ascorbic acid (AA) that are normally present in biological fluids. The response was linear for a DA concentration range from 1 to 70 Î¼mol L(-1), with detection limit of 0.15 Î¼mol L(-1) (S/N = 3). The concepts behind the novel architecture to modify electrodes can be potentially harnessed in other electrochemical sensors and biosensors.

Electroactive Polymer Nanoparticles Exhibiting Photothermal Properties.

https://www.ncbi.nlm.nih.gov/pubmed/26780244

A method for the synthesis of electroactive polymers is demonstrated, starting with the synthesis of extended conjugation monomers using a three-step process that finishes with Negishi coupling. Negishi coupling is a cross-coupling process in which a chemical precursor is first lithiated, followed by transmetallation with ZnCl2. The resultant organozinc compound can be coupled to a dibrominated aromatic precursor to give the conjugated monomer. Polymer films can be prepared via electropolymerization of the monomer and characterized using cyclic voltammetry and ultraviolet-visible-near infrared (UV-Vis-NIR) spectroscopy. Nanoparticles (NPs) are prepared via emulsion polymerization of the monomer using a two-surfactant system to yield an aqueous dispersion of the polymer NPs. The NPs are characterized using dynamic light scattering, electron microscopy, and UV-Vis-NIR-spectroscopy. Cytocompatibility of NPs is investigated using the cell viability assay. Finally, the NP suspensions are irradiated with a NIR laser to determine their effectiveness as potential materials for photothermal therapy (PTT).

Rational design and application of molecularly imprinted sol-gel polymer for the electrochemically selective and sensitive determination of Sudan I.

https://www.ncbi.nlm.nih.gov/pubmed/21376972

An electrochemical strategy on the basis of rationally designed molecularly imprinted sol-gel polymer embedded with gold nanoparticles (AuNPs) is developed for the specific and sensitive determination of Sudan I. The rationally designed sensing Sudan I imprinted sol-gel was prepared by mixing Sudan I with 3-aminopropyltriethoxysilane, tetraethoxysilane, chitosan, and AuNPs, followed by copolymerization and extraction of the template molecules. The hybrid forming membrane was characterized by SEM and FTIR-ATR, and used for the linear sweep voltammetric (LSV) determination of Sudan I in water/ethanol solutions. The LSV responses exhibited high sensitivity and selectivity, as discriminated from Sudan I analogues. Under optimal experimental conditions, LSV peak currents were linearly proportional to the concentrations of Sudan I in the range from 0.1 Ã— 10(-7) to 1.0 Ã— 10(-5)M, with a detection limit of 2.0 Ã— 10(-9)M. The strategy is generally applicable in developing sensitive, selective, and moreover, reusable electrochemical sensors for quantitative determination of electroactive species.

Compliant silver nanowire-polymer composite electrodes for bistable large strain actuation.

https://www.ncbi.nlm.nih.gov/pubmed/22302290

A new compliant electrode-based on silver nanowire-polymer composite has been developed. The

composite electrode has low sheet resistance (as low as 10 Î©/sq), remains conductive (10(2) -10(3) Î©/sq) at strains as high as 140%, and can support Joule heating. The combination of the composite and a bistable electroactive polymer produces electrically-induced, large-strain actuation and relaxation, reversibly without the need of mechanical programming.

Ductile electroactive biodegradable hyperbranched polylactide copolymers enhancing myoblast differentiation.

https://www.ncbi.nlm.nih.gov/pubmed/26335860

Myotube formation is crucial to restoring muscular functions, and biomaterials that enhance the myoblast differentiation into myotubes are highly desirable for muscular repair. Here, we report the synthesis of electroactive, ductile, and degradable copolymers and their application in enhancing the differentiation of myoblasts to myotubes. A hyperbranched ductile polylactide (HPLA) was synthesized and then copolymerized with aniline tetramer (AT) to produce a series of electroactive, ductile and degradable copolymers (HPLAAT). The HPLA and HPLAAT showed excellent ductility with strain to failure from 158.9% to 42.7% and modulus from 265.2 to 758.2Â MPa. The high electroactivity of the HPLAAT was confirmed by UV spectrometer and cyclic voltammogram measurements. These HPLAAT polymers also showed improved thermal stability and controlled biodegradation rate compared to HPLA. Importantly, when applying these polymers for myotube formation, the HPLAAT significantly improved the proliferation of C2C12 myoblasts inÂ vitro compared to HPLA. Furthermore, these polymers greatly promoted myogenic differentiation of C2C12Â cells as measured by quantitative analysis of myotube number, length, diameter, maturation index, and gene expression of MyoD and TNNT. Together, our study shows that these electroactive, ductile and degradable HPLAAT copolymers represent significantly improved biomaterials for muscle tissue engineering compared to HPLA.

Electromechanical response of silk fibroin hydrogel and conductive polycarbazole/silk fibroin hydrogel composites as actuator material.

https://www.ncbi.nlm.nih.gov/pubmed/26249559

Pure silk fibroin (SF) hydrogel and polycarbazole/silk fibroin (SF/PCZ) hydrogels were fabricated by solvent casting technique to evaluate electromechanical responses, dielectric properties, and cantilever deflection properties as functions of electric field strength, SF concentration, glutaraldehyde concentration, and PCZ concentration in the blends. Electromechanical properties

were characterized in oscillatory shear mode at electric field strengths ranging from 0 to 600V/mm and at a temperature of 27Â°C. For both the pristine SF and SF/PCZ hydrogels, the storage modulus response (Î”G') and the storage modulus sensitivity (Î”G'/G'0) increased dramatically with increasing electric field strength. The pristine hydrogel possessed the highest storage modulus sensitivity value of 5.87, a relatively high value when compared with other previously studied electroactive polymers. With the addition of conductive PCZ in SF hydrogel, the storage modulus sensitivity and the relative dielectric constant decreased; the conductive polymer thus provided the softening effect under electric field. In the deflection response, the dielectrophoresis force and deflection distance increased monotonically with electric field strength, where the pure SF hydrogel showed the highest deflection distance and dielectrophoresis force.

Nanomechanical and electrical characterization of a new cellular electret sensor-actuator.

https://www.ncbi.nlm.nih.gov/pubmed/21817574

Electrically charged cellular polymers are known to display pseudo-piezoelectric effects that endow them with interesting mechano-electrical characteristics. When a film of such a polymer is compressed, charge is generated across its thickness, and conversely, applying an oscillatory or static potential elicits mechanical motions. This dual sensor-actuator behaviour can be embedded in one material and presents distinct advantages of functional integration. A novel electroactive foam is presented here that embeds such a sensor-actuator function. The foam has a sensitivity constant (d(33)) of 330Â pCÂ N(-1). Interestingly, the resonant behaviour of the cellular film can be altered by variation in the DC offset across the material. Such adaptive capacity could be of great advantage for tuning polymer-based mechanical devices to be either efficient sound radiators and mechanical actuators, or sensitive and coherent sensors. Possible applications in microfluidics are also discussed.

Formation of electroactive colloids via in situ coprecipitation under electric field: erbium chloride alkaline aqueous pseudocapacitor.

https://www.ncbi.nlm.nih.gov/pubmed/24973700

For the first time, a new ErCl3 alkaline aqueous pseudocapacitor system was demonstrated by designing commercial ErCl3 salt electrode in alkaline aqueous electrolyte, where the materials synthesis and subsequently integrating into practical electrode structures occur at the same spatial and temporal scale. Highly electroactive ErOOH colloids were in-situ crystallized via electric field

assisted chemical coprecipitation of ErCl3 in KOH aqueous electrolyte. These electroactive ErOOH colloids absorbed by carbon black and PVDF matrix were highly redox-reactive with higher cation utilization ratio of 86 % and specific capacitance values of 1811F/g, exceeding the one-electron redox theoretical capacitance (Er(3+)â†”Er(2+)). We believe that additional two-electron (Er(2+)â†”Er) or three-electron (Er(3+)â†”Er) reactions can occur in our designed ErCl3 alkaline aqueous pseudocapacitor system. The specific electrode configuration with ErOOH colloids grown among the carbon black/PVDF matrix can create short ion diffusion and electron transfer length to enable the fast and reversible Faradaic reactions. This work shows promising for finding high-performance electrical energy storage systems via designing the colloidal state of electroactive cations with the utilization of in-situ crystallization route.

Strong electroactive biodegradable shape memory polymer networks based on star-shaped polylactide and aniline trimer for bone tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/25742188

Preparation of functional shape memory polymer (SMP) for tissue engineering remains a challenge. Here the synthesis of strong electroactive shape memory polymer (ESMP) networks based on star-shaped polylactide (PLA) and aniline trimer (AT) is reported. Six-armed PLAs with various chain lengths were chemically cross-linked to synthesize SMP. After addition of an electroactive AT segment into the SMP, ESMP was obtained. The polymers were characterized by (1)H NMR, GPC, FT-IR, CV, DSC, DMA, tensile test, and degradation test. The SMP and ESMP exhibited strong mechanical properties (modulus higher than GPa) and excellent shape memory performance: short recovery time (several seconds), high recovery ratio (over 94%), and high fixity ratio (almost 100%). Moreover, cyclic voltammetry test confirmed the electroactivity of the ESMP. The ESMP significantly enhanced the proliferation of C2C12 cells compared to SMP and linear PLA (control). In addition, the ESMP greatly improved the osteogenic differentiation of C2C12 myoblast cells compared to PH10 and PLA in terms of ALP enzyme activity, immunofluorescence staining, and relative gene expression by quantitative real-time polymerase chain reaction (qRT-PCR). These intelligent SMPs and electroactive SMP with strong mechanical properties, tunable degradability, good electroactivity, biocompatibility, and enhanced osteogenic differentiation of C2C12 cells show great potential for bone regeneration.

Mesoporous silica particle-PLA-PANI hybrid scaffolds for cell-directed intracellular drug

delivery and tissue vascularization.

https://www.ncbi.nlm.nih.gov/pubmed/26252158

Instructive materials are expected to revolutionize stem cell based tissue engineering. As many stem cell cues have adverse effects on normal tissue homeostasis, there is a need to develop bioactive scaffolds which offer locally retained and cell-targeted drug delivery for intracellular release in targeted cell populations. Further, the scaffolds need to support vascularization to promote tissue growth and function. We have developed an electrospun PLA-PANI fiber scaffold, and incorporated mesoporous silica nanoparticles within the scaffold matrix to obtain cell-targeted and localized drug delivery. The isotropy of the scaffold can be tuned to find the optimal morphology for a given application and the scaffold is electroactive to support differentiation of contractile tissues. We demonstrate that there is no premature drug release from particles under physiological conditions over a period of one week and that the drug is released upon internalization of particles by cells within the scaffold. The scaffold is biocompatible, supports muscle stem cell differentiation and cell-seeded scaffolds are vascularized in vivo upon transplantation on the chorioallantoic membrane of chicken embryos. The scaffold is a step towards instructive biomaterials for local control of stem cell differentiation, and tissue formation supported by vascularization and without adverse effects on the homeostasis of adjacent tissues due to diffusion of biological cues.

Fabrication of novel coated pyrolytic graphite electrodes for the selective nano-level monitoring of CdÂ²â•º ions in biological and environmental samples using polymeric membrane of newly synthesized macrocycle.

https://www.ncbi.nlm.nih.gov/pubmed/25682247

Novel 5-amino-1,3,4-thiadiazole-2-thiol unit based macrocyclic ionophore 5,11,17-trithia-1,3,7,9,13,15,19,20,21-nonaazatetracyclo[14.2.1.1(4,7).1(10,13)]henicosa-4(20),10(21),16(19)-triene-6,12,18-trithione (M1), was synthesized and characterized. Preliminary studies on M1 have showed that it has more the affinity toward Cd(2+) ion. Thus, the macrocyclic ionophore (M1) was used as electroactive material in the fabrication of PVC-membrane electrodes such as polymeric membrane electrode (PME), coated graphite electrode (CGE) and coated pyrolytic graphite electrode (CPGE) were prepared and its performance characteristic were compared with. The electroanalytical studies performed on PME, CGE and CPGE revealed that CPGE having membrane composition M1:PVC:1-CN:NaTPB in the ratio of 7:37:54:2 exhibits the best potentiometric characteristics in terms of detection limit of 7.58Ã—10(-9) mol L(-1), Nernstian slope

of 29.6 mV decade(-1) of activity. The sensor was found to be independent of pH in the range 2.5-8.5. The sensor showed a fast response time of 10s and could be used over a period of 4 months without any significant divergence in its potentiometric characteristics. The sensor has been employed for monitoring of the Cd(2+) ion in real samples and also used as an indicator electrode in the potentiometric titration of Cd(2+) ion with EDTA.

A label-free electrochemical DNA biosensor based on a Zr(IV)-coordinated DNA duplex immobilised on a carbon nanofibre|chitosan layer.

https://www.ncbi.nlm.nih.gov/pubmed/22297858

A label-free electrochemical biosensor for detecting DNA hybridisation was developed by monitoring the change in the voltammetric activity of ferrocenecarboxylic acid at the biosensorâ€“solution interface. The biosensor was constructed by initially immobilising on a glassy carbon electrode an anchoring layer consisting of chitosan, carboxyl group functionalised carbon nanofibres and glutaraldehye. Chitosan acted as an adhering agent and carbon nanofibres were strategically used to provide a large surface area with binding points for DNA immobilisation, while glutaraldehye was a linker for DNA probes on the electrode surface. Based on a two-factorial design, cyclic voltammetry of [Fe(CN)(6)](3-/4-) was performed to optimise the composition of the anchoring layer.Next, a 17-base pair DNA probe was attached to the anchoring layer, followed by its complementary target. Zr(IV) ion, known to exhibit affinity for oxygen-containing electroactive markers, for example, ferrocenecarboxylic acid, was then coordinated in the DNA duplex. In this way, ferrocenecarboxylic acid was attracted towards the biosensor for oxidation. A change in the voltammetric oxidation current of ferrocenecarboxylic acid pre- and post-hybridisation was used to provide an indication of hybridisation. A linear dynamic range between 0.5 and 40 nM and a detection limit of 88 pM of DNA target were then achieved. In addition, the biosensor exhibited good selectivity, repeatability and stability for the determination of DNA sequences.

Large-Deformation Curling Actuators Based on Carbon Nanotube Composite: Advanced-Structure Design and Biomimetic Application.

https://www.ncbi.nlm.nih.gov/pubmed/26512734

In recent years, electroactive polymers have been developed as actuator materials. As an important branch of electroactive polymers, electrothermal actuators (ETAs) demonstrate potential applications in the fields of artificial muscles, biomimetic devices, robotics, and so on. Large-shape

deformation, low-voltage-driven actuation, and ultrafast fabrication are critical to the development of ETA. However, a simultaneous optimization of all of these advantages has not been realized yet. Practical biomimetic applications are also rare. In this work, we introduce an ultrafast approach to fabricate a curling actuator based on a newly designed carbon nanotube and polymer composite, which completely realizes all of the above required advantages. The actuator shows an ultralarge curling actuation with a curvature greater than 1.0 cm(-1) and bending angle larger than 360Â°, even curling into a tubular structure. The driving voltage is down to a low voltage of 5 V. The remarkable actuation is attributed not only to the mismatch in the coefficients of thermal expansion but also to the mechanical property changes of materials during temperature change. We also construct an S-shape actuator to show the possibility of building advanced-structure actuators. A weightlifting walking robot is further designed that exhibits a fast-moving motion while lifting a sample heavier than itself, demonstrating promising biomimetic applications.

Fabrication of Amperometric Glucose Sensor Using Glucose Oxidase-Cellulose Nanofiber Aqueous Solution.

https://www.ncbi.nlm.nih.gov/pubmed/26561252

Cellulose nanofiber aqueous solution, which remained virtually transparent for more than one week, was prepared by using the clear upper layer of diluted cellulose nanofiber solution produced by wet jet milling. Glucose oxidase (GOx) was easily dissolved in this solution and GOx-immobilized electrode was easily fabricated by simple repetitious drops of GOx-cellulose solution on the surface of a platinum-iridium electrode. Glucose sensor properties of the obtained electrodes were examined in phosphate buffer solution of pH 7.4 at 40Â°C. The obtained electrode provided a glucose sensor response with significantly high response speed and good linear relationship between glucose concentration and response current. After an initial decrease of response sensitivity for a few days, relatively constant sensitivity was obtained for about 20 days. Nevertheless, the influence of electroactive compounds such as ascorbic acid, uric acid and acetoaminophen were not negletable.

Antibacterial and conductive injectable hydrogels based on quaternized chitosan-graft-polyaniline/oxidized dextran for tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/26272777

Biomaterials with injectability, conductivity and antibacterial effect simultaneously have been rarely

reported. Herein, we developed a new series of in situ forming antibacterial conductive degradable hydrogels using quaternized chitosan (QCS) grafted polyaniline with oxidized dextran as crosslinker. The chemical structures, morphologies, electrochemical property, conductivity, swelling ratio, rheological property, in vitro biodegradation and gelation time of hydrogels were characterized. Injectability was verified by in vivo subcutaneous injection on a Sprague Dawley rat. The antibacterial activity of the hydrogels was firstly evaluated employing antibacterial assay using Escherichia coli and Staphylococcus aureus in vitro. The hydrogels containing polyaniline showed enhanced antibacterial activity compared to QCS hydrogel, especially for hydrogels with 3 wt% polyaniline showing 95 kill% and 90kill% for E. coli and S. aureus, respectively. Compared with QCS hydrogel, the hydrogels with 3 wt% polyaniline still showed enhanced antibacterial activity for E. coli in vivo. The adipose-derived mesenchymal stem cells (ADMSCs) were used to evaluate the cytotoxicity of the hydrogels and hydrogels with polyaniline showed better cytocompatibility than QCS hydrogel. The electroactive hydrogels could significantly enhance the proliferation of C2C12 myoblasts compared to QCS hydrogel. This work opens the way to fabricate in situ forming antibacterial and electroactive degradable hydrogels as a new class of bioactive scaffolds for tissue regeneration applications.

Structures and packing of ferrocenylmethyl methacrylate and ferrocene-1,1'-diylbis(methylene) dimethacrylate.

https://www.ncbi.nlm.nih.gov/pubmed/26632839

Electroactive metallocene polymers are of interest due to the possibility that they offer a muscle-like response, and in gel systems very large volume changes are possible. The ferrocenyl moiety exhibits physical and electrochemical stability of the neutral and oxidized forms and could be a candidate for use as the redox-active group in these materials. The title compounds, [Fe(C5H5)(C10H11O2)], (I), and [Fe(C10H11O2)2], (II), comprise a typical ferrocene core with coplanar and approximately eclipsed cyclopentadienyl (Cp) rings. In (I), there is a single methyl methacrylate substituent, with the other Cp ring unsubstituted. In (II), a methyl methacrylate substituent on each Cp ring completes the structure. In both compounds, there is an s-trans geometry of the vinyl and carbonyl components of the methacrylate group. Inversion dimers formed through C-H...O contacts dominate the crystal packing of both molecules. Weak C-H...Ï€(ring) contacts and, in the case of (I), an unusual C-H...Ï€(alkene) contact further stabilize the structures.

An Electrolyte-Free Conducting Polymer Actuator that Displays Electrothermal Bending and Flapping Wing Motions under a Magnetic Field.

https://www.ncbi.nlm.nih.gov/pubmed/26717199

Electroactive materials that change shape in response to electrical stimulation can serve as actuators. Electroactive actuators of this type have great utility in a variety of technologies, including biomimetic artificial muscles, robotics, and sensors. Electroactive actuators developed to date often suffer from problems associated with the need to use electrolytes, slow response times, high driving voltages, and short cycle lifetimes. Herein, we report an electrolyte-free, single component, polymer electroactive actuator, which has a fast response time, high durability, and requires a low driving voltage (<5 V). The process employed for production of this material involves wet-spinning of a preorganized camphorsulfonic acid (CSA)-doped polyaniline (PANI) gel, which generates long, flexible, and conductive (âˆ¼270 S/cm) microfibers. Reversible bending motions take place upon application of an alternating current (AC) to the PANI polymer. This motion, promoted by a significantly low driving voltage (<0.5 V) in the presence of an external magnetic field, has a very large swinging speed (9000 swings/min) that lies in the range of those of flies and bees (1000-15000 swings/min) and is fatigue-resistant (>1000000 cycles).

Enzyme immobilisation on electroactive nanostructured membranes (ENM): optimised architectures for biosensing.

https://www.ncbi.nlm.nih.gov/pubmed/18656679

Electroactive nanostructured membranes have been produced by the layer-by-layer (LbL) technique, and used to make electrochemical enzyme biosensors for glucose by modification with cobalt hexacyanoferrate redox mediator and immobilisation of glucose oxidase enzyme. Indium tin oxide (ITO) glass electrodes were modified with up to three bilayers of polyamidoamine (PAMAM) dendrimers containing gold nanoparticles and poly(vinylsulfonate) (PVS). The gold nanoparticles were covered with cobalt hexacyanoferrate that functioned as a redox mediator, allowing the modified electrode to be used to detect H(2)O(2), the product of the oxidase enzymatic reaction, at 0.0 V vs. SCE. Enzyme was then immobilised by cross-linking with glutaraldehyde. Several parameters for optimisation of the glucose biosensor were investigated, including the number of deposited bilayers, the enzyme immobilisation protocol and the concentrations of immobilised enzyme and of the protein that was crosslinked with PAMAM. The latter was used to provide glucose oxidase with a friendly environment, in order to preserve its bioactivity. The optimised

biosensor, with three bilayers, has high sensitivity and operational stability, with a detection limit of 6.1 microM and an apparent Michaelis-Menten constant of 0.20mM. It showed good selectivity against interferents and is suitable for glucose measurements in natural samples.

Amperometry and cyclic voltammetry with carbon fiber microelectrodes at single cells.

https://www.ncbi.nlm.nih.gov/pubmed/18428562

Amperometry and cyclic voltammetry are two electrochemical techniques that enable the detection of electroactive neurotransmitters that are released from single cells. These techniques have provided the first chemical view of the events that occur during exocytosis. This unit describes the isolation of several cell types known for their exocytotic properties, the fabrication and calibration of carbon fiber microelectrodes, as well as some of the equipment and software requirements for obtaining electrochemically generated data.

Voltammetric behaviors of wheat-germ agglutinin on a chitin-modified carbon-paste electrode.

https://www.ncbi.nlm.nih.gov/pubmed/18469462

The voltammetric behavior of wheat-germ agglutinin (WGA) on a chitin-modified carbon-paste electrode (CPE) was investigated using glucose labeled with an electroactive compound. WGA usually consists of two subunits, each with two binding sites for sugars. WGA was immobilized on the electrode surface by selective binding to a N-acetylglucosamine residue of chitin. Because glucose also combines with WGA, the glucose was coupled with electroactive daunomycin to evaluate the binding. When a WGA-labeled glucose complex was formed, the electroactive moiety became electroinactive. The binding caused a decrease in the peak current of the labeled glucose. In a measurement of only daunomycin used as a label, the peak current in a solution with WGA was similar to that in a solution without WGA. Therefore, it is clear that the labeled glucose was held in the remaining binding site of WGA on the electrode surface. Thus, a CPE modified with chitin would be powerful as a reaction field between sugar and lectin.

pH-dependent behaviors of electroactive myoglobin loaded into layer-by-layer films assembled with alginate and hydroxyethyl cellulose ethoxylate.

https://www.ncbi.nlm.nih.gov/pubmed/18616316

In the present work, strong polybase quaternized hydroxyethyl cellulose ethoxylate (HECE) and weak polyacid alginate (AA) were assembled into {HECE/AA} n layer-by-layer (LBL) films on electrodes by electrostatic interaction between them, and the films were then immersed in myoglobin (Mb) solution to load Mb into the films, designated as {HECE/AA}n-Mb. The {HECE/AA}n-Mb films showed a nearly reversible cyclic voltammetric (CV) peak pair at about -0.34 V vs SCE in pH 7.0 buffers for Mb heme Fe(III)/Fe(II) redox couple, and the surface concentration of electroactive Mb in the films (Gamma*) was affected significantly by the pH of Mb loading solution and testing solution. The amount of Mb loaded from pH 5.0 solution was much larger than that from pH 9.0 solution, which is mainly attributed to the higher degree of swelling, porosity, and permeability of {HECE/AA}n films at pH 5.0 than at pH 9.0. In addition, the electrostatic interaction between Mb and the AA component in the films might also play an important role in Mb loading. The pH of the testing solution where {HECE/AA}n-Mb films were tested by CV also influenced the Gamma* value, showing that the fraction of electroactive Mb among the total Mb loaded into the films increased remarkably as the pH of the testing solution decreased. This result is rationalized in terms of the pH-dependent film permeability toward counterions and the electron-hopping mechanism in electron transfer of redox proteins in the film phase. This model system may provide a general and effective approach to control the electroactivity of immobilized redox proteins in the multilayer assembly containing weak polyions by adjusting pH and may guide us to develop the new kind of controllable electrochemical biosensors based on the direct electrochemistry of enzymes.

Sheath-flow microfluidic approach for combined surface enhanced Raman scattering and electrochemical detection.

https://www.ncbi.nlm.nih.gov/pubmed/25815795

The combination of hydrodynamic focusing with embedded capillaries in a microfluidic device is shown to enable both surface enhanced Raman scattering (SERS) and electrochemical characterization of analytes at nanomolar concentrations in flow. The approach utilizes a versatile polystyrene device that contains an encapsulated microelectrode and fluidic tubing, which is shown to enable straightforward hydrodynamic focusing onto the electrode surface to improve detection. A polydimethyslsiloxane (PDMS) microchannel positioned over both the embedded tubing and SERS active electrode (aligned âˆ¼200 Î¼m from each other) generates a sheath flow that confines the analyte molecules eluting from the embedded tubing over the SERS electrode, increasing the interaction between the Riboflavin (vitamin B2) and the SERS active electrode. The microfluidic

device was characterized using finite element simulations, amperometry, and Raman experiments. This device shows a SERS and amperometric detection limit near 1 and 100 nM, respectively. This combination of SERS and amperometry in a single device provides an improved method to identify and quantify electroactive analytes over either technique independently.

Electroactive chitosan nanoparticles for the detection of single-nucleotide polymorphisms using peptide nucleic acids.

https://www.ncbi.nlm.nih.gov/pubmed/18566805

Here we report an electrochemical biosensor that would allow for simple and rapid analysis of nucleic acids in combination with nuclease activity on nucleic acids and electroactive bionanoparticles. The detection of single-nucleotide polymorphisms (SNPs) using PNA probes takes advantage of the significant structural and physicochemical differences between the full hybrids and SNPs in PNA/DNA and DNA/DNA duplexes. Ferrocene-conjugated chitosan nanoparticles (Chi-Fc) were used as the electroactive indicator of hybridization. Chi-Fc had no affinity towards the neutral PNA probe immobilized on a gold electrode (AuE) surface. When the PNA probe on the electrode surface hybridized with a full-complementary target DNA, Chi-Fc electrostatically attached to the negatively-charged phosphate backbone of DNA on the surface and gave rise to a high electrochemical oxidation signal from ferrocene at approximately 0.30 V. Exposing the surface to a single-stranded DNA specific nuclease, Nuclease S1, was found to be very effective for removing the nonspecifically adsorbed SNP DNA. An SNP in the target DNA to PNA made it susceptible to the enzymatic digestion. After the enzymatic digestion and subsequent exposure to Chi-Fc, the presence of SNPs was determined by monitoring the changes in the electrical current response of Chi-Fc. The method provided a detection limit of 1 fM (S/N = 3) for the target DNA oligonucleotide. Additionally, asymmetric PCR was employed to detect the presence of genetically modified organism (GMO) in standard Roundup Ready soybean samples. PNA-mediated PCR amplification of real DNA samples was performed to detect SNPs related to alcohol dehydrogenase (ALDH). Chitosan nanoparticles are promising biomaterials for various analytical and pharmaceutical applications.

Reversible shape memory of nanoscale deformations in inherently conducting polymers without reprogramming.

https://www.ncbi.nlm.nih.gov/pubmed/21401135

By using inherently conducting polymers, we introduce new shape memory functionality for stimuli-responsive polymers. The shape memory process is unique in that it utilizes electrochemical control of the polymer redox state to conceal, and temporarily store, preformed nanoscale surface patterns, which can later be recalled. Unlike classical thermoset and thermoplastic shape memory polymers, the electrochemical control does not completely perturb the low entropy state of the deformed polymer chains, thus enabling the concept of reversible transition between the permanent and temporary shapes. This is demonstrated using electrochemical-atomic force microscopy/quartz crystal microbalance to characterize the modulation of nanoscale deformations in electroactive polybithiophene films. Experimental results reveal that cation/solvent exchange with the electrolyte and its effect on reconfiguration of the film structure is the mechanism behind the process. In addition to incorporating conductive properties into shape-memory polymers, the ability to reversibly modulate surface nanopatterns in a liquid environment is also of significant interest in tribology and biointerface applications.

Improved single nucleotide polymorphisms detection using conjugated polymer/surfactant system and peptide nucleic acid.

https://www.ncbi.nlm.nih.gov/pubmed/18296040

An improved assay for the detection of single nucleotide polymorphisms (SNP) of mutant DNA using a combination of peptide nucleic acid (PNA) probes, a cationic conjugated polymer (CCP) and non-ionic surfactant is reported. A comparison between CCP/surfactant and CCP alone shows enhancement in the discrimination between mutant and wild type DNA by a factor of two. A discrimination factor of 70% and 92% was calculated for single and five bases mismatched mutants, respectively when using CCP/surfactant. Furthermore, CCP/surfactant provides a strong emissive donor which increases signal to noise ratio and prevents fluctuation in the output signal caused by the suspension nature of the CCP (due to polymer aggregation) in water. The fluorescence resonance energy transfer (FRET) ratio which defined as the ratio of PL emission of the acceptor to that of the donor, was found to be 20% better when the location of the mutation is five bases away from the duplex terminal compared to that in the centre of the duplex. The enhance discrimination referred to the difference in the FRET and reabsorption rates in different types of duplex. The FRET ratio can be very sensitive to the sample excitation strength, emission collection and spectrometer setting.

Piezoelectric polymers as biomaterials for tissue engineering applications.

https://www.ncbi.nlm.nih.gov/pubmed/26355812

Tissue engineering often rely on scaffolds for supporting cell differentiation and growth. Novel paradigms for tissue engineering include the need of active or smart scaffolds in order to properly regenerate specific tissues. In particular, as electrical and electromechanical clues are among the most relevant ones in determining tissue functionality in tissues such as muscle and bone, among others, electroactive materials and, in particular, piezoelectric ones, show strong potential for novel tissue engineering strategies, in particular taking also into account the existence of these phenomena within some specific tissues, indicating their requirement also during tissue regeneration. This referee reports on piezoelectric materials used for tissue engineering applications. The most used materials for tissue engineering strategies are reported together with the main achievements, challenges and future needs for research and actual therapies. This review provides thus a compilation of the most relevant results and strategies and a start point for novel research pathways in the most relevant and challenging open questions.

Aligned Electroactive TMV Nanofibers as Enabling Scaffold for Neural Tissue Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/26390383

Electroactive nanofibers were fabricated by in situ polymerization of aniline on the surface of tobacco mosaic virus (TMV) using sodium poly(styrenesulfonate) (PSS) as dopant. These electroactive TMV/PANi/PSS nanofibers were employed to support growth of neuronal cells, resulting in augmentation of the length of neurites. In addition, the percentage of cells with neurites was increased in comparison to cells cultured on TMV-derived nonconductive nanofibers. The TMV-based electroactive nanofibers could be aligned in capillaries that could guide the outgrowth direction of neurites, increase the percentage of cells with neurites, and lead to a bipolar cellular morphology. Our results demonstrate that the electroactivity and topographical cues provided by TMV/PANi/PSS nanofibers can synergistically stimulate neural cells differentiation and neurites outgrowth, which make it a promising scaffolding material for neural tissue engineering.

Shape-Memory PVDF Exhibiting Switchable Piezoelectricity.

https://www.ncbi.nlm.nih.gov/pubmed/26332996

In this study, a material is designed which combines the properties of shape-memory and electroactive polymers. This is achieved by covalent cross-linking of polyvinylidene fluoride. The

resulting polymer network exhibits excellent shape-memory properties with a storable strain of 200%, and fixity as well as recovery values of 100%. Programming upon rolling induces the transformation from the nonelectroactive Î±-phase to the piezoelectric Î²-phase. The highest Î²-phase content is found to be 83% for a programming strain of 200% affording a d33 value of -30 pm V(-1). This is in good accordance with literature known values for piezoelectric properties. Thermal triggering this material does not only result in a shape change but also renders the material nonelectroactive.

Electroactive SWNT/PEGDA hybrid hydrogel coating for bio-electrode interface.

https://www.ncbi.nlm.nih.gov/pubmed/21676598

Electric interface between neural tissue and electrode plays a significant role in the development of implanted devices for continuous monitoring and functional stimulation of central nervous system in terms of electroactivity, biocompatibility and long-term stability. To engineer an interface that possesses these merits, a polymeric hydrogel based on poly(ethylene glycol) diacrylate (PEGDA) and single-walled carbon nanotubes (SWNTs) were employed to fabricate a hybrid hydrogel via covalent anchoring strategy, i.e., self-assembly of cysteamine (Cys) followed by Michael addition between Cys and PEGDA. XPS characterization proves that the Cys molecules are linked to gold surface via the strong S-Au bond and that the PEGDA macromers are covalently bonded to Cys. FTIR spectra indicate the formation of hybrid hydrogel coating during photopolymerization. Electrochemical measurements using cyclic voltammetry (CV) and impedance spectrum clearly show the enhancement of electric properties to the hydrogel by the SWNTs. The charge transfer of the hybrid hydrogel-based electrode is quasi-reversible and charge transfer resistance decreases to the tenth of that of the pure hydrogel due to electron hopping along the SWNTs. Additionally, this hybrid hydrogel provides a favorable biomimetic microenvironment for cell attachment and growth due to its inherent biocompatibility. Combination of these merits yields hybrid hydrogels that can be good candidates for application to biosensors and biomedical devices. More importantly, the hybrid hydrogel coatings fabricated via the current strategy have good adhesion to the electrode substrate which is highly desired for chronically implantable devices.

Optical detection of DNA and proteins with cationic polythiophenes.

https://www.ncbi.nlm.nih.gov/pubmed/18198841

In recent years, intense research has been carried out worldwide with the goal of developing simple,

sensitive, and specific detection tools for biomedical applications. Along these lines, we reported in 2002 on cationic polythiophene derivatives able to provide ultrasensitive detection levels and the capability to distinguish perfect matches from oligonucleotides having as little as a single base mismatch. It was shown that the intrinsic fluorescence of the random-coil polymers quenches as a result of the planar, highly conjugated conformation adopted by the polymers when complexed with a single-strand DNA (ssDNA) capture probe but increases again after hybridization with the perfectly matched complementary strand. This change in fluorescence intensity is mainly due to a modification in the delocalization of pi electrons along the carbon chain backbone that occurs when switching between the two conformations. Thus, by monitoring, via the change in fluorescence intensity, the hybridization of the complementary ssDNA target with the "duplex", one could detect as little as 220 complementary target molecules in a 150 microL sample volume (0.36 zmol) in less than 1 hour. Building on this initial concept, we then reported that tagging the DNA probe with a suitable fluorophore dramatically increases the detection sensitivity. This novel molecular system involves the self-assembly of aggregates of duplexes in solution, prior to the introduction of the target, which allows a highly efficient resonance energy transfer (RET) between a "donor" (being the complex formed of the DNA double helix and the polymer chain wrapped around it) and a large number of neighboring "acceptors" (the fluorophores attached to the DNA probes). The massive intrinsic signal amplification (fluorescence chain reaction or FCR) provided by this novel integrated molecular system allows the specific detection of as little as five dsDNA copies in a 3 mL sample volume in only 5 minutes, without the need for prior amplification of the target. Clearly, direct and reliable detection of DNA hybridization without prior PCR amplification or chemical tagging of the genetic target is now possible with this methodology. We have also shown that proteins can be detected following a similar strategy. Impressive results have also been reported by direct and specific staining of targeted proteins. All these features have recently allowed the development of responsive polymeric supports for the detection of DNA and proteins. All these assays that do not require any chemical manipulation of the biological targets or sophisticated experimental procedures should soon lead to major advances in genomics and proteomics.

Investigations on mixed micelles of binary mixtures of zwitterionic surfactants and triblock polymers: a cyclic voltammetric study.

https://www.ncbi.nlm.nih.gov/pubmed/18701114

Cyclic voltammetry has been employed to investigate the mixed micellar behavior of the binary

mixtures of different zwitterionic surfactants such as 3-(N,N-dimethylhexadecylammonio)propane sulfonate (HPS), 3-(N,N-dimethyltetradecylammonio)propane sulfonate (TPS) and 3-(N,N-dimethyldodecylammonio)propane sulfonate (DPS) with three triblock polymers (L64, F127 and P65) by using 2,2,6,6-tetramethyl-1-piperidinyloxy (TEMPO) as an electroactive probe at 25 degrees C. Critical micellar concentration (cmc) has been determined from the plots of variation in peak current (i(p)) versus the total concentration of surfactant/triblock polymer. Diffusion coefficient of the electroactive species has also been reported. The regular solution theory approximation has been used to determine various micellar parameters of ideal systems. The variation in micellar mole fraction (X(1)) of the zwitterionic surfactant supports the formation of mixed micelles, which are rich in triblock polymer component in the surfactant rich region of the mixture and vice versa. The regular solution interaction parameter (beta) suggests the formation of mixed micelles due to the synergistic interactions in case of HPS/TPS/DPS+F127/P65 systems and gets affected by EO/PO ratio of triblock polymers.

Electrochemical selective determination of ascorbic acid at redox active polymer modified electrode derived from direct blue 71.

https://www.ncbi.nlm.nih.gov/pubmed/18586483

A simple selective method for determination of ascorbic acid using polymerized direct blue 71 (DB71) is described. Anodic polymerization of the azo dye DB71 on glassy carbon (GC) electrode in 0.1M H(2)SO(4) acidic medium was found to yield thin and stable polymeric films. The poly(DB71) films were electroactive in wide pH range (1-13). A pair of symmetrical redox peaks at a formal redox potential, E('0)=-0.02V vs. Ag/AgCl (pH 7.0) was observed with a Nernstian slope -0.058V, is attributed to a 1:1 proton+electron involving polymer redox reactions at the modified electrode. Scanning electron microscope (SEM), atomic force microscope (AFM) and electrochemical impedance spectroscopy (EIS) measurements were used for surface studies of polymer modified electrode. Poly(DB71) modified GC electrode showed excellent electrocatalytic activity towards ascorbic acid in neutral buffer solution. Using amperometric method, linear range (1x10(-6)-2x10(-3)M), dynamic range (1x10(-6)-0.01M) and detection limit (1x10(-6)M, S/N=3) were estimated for measurement of ascorbic acid in pH 7.0 buffer solution. Major interferences such as dopamine and uric acid are tested at this modified electrode and found that selective detection of ascorbic acid can be achieved. This new method successfully applied for determination of ascorbic acid in commercial tablets with satisfactory results.

Electrokinetic microfluidic devices for rapid, low power drug delivery in autonomous microsystems.

https://www.ncbi.nlm.nih.gov/pubmed/18231674

In this work, a low power and robust electroactive microwell-based implantable drug delivery system, intended for use with autonomous microsystems, is presented. The device comprises of an upper silicon based structure in which the drug storage sites are defined and a lower electrically functionalized PDMS (polydimethylsiloxane) backing. The drug ejection mechanism developed here exploits localized electrokinetic effects to control both the release time and release rate of chemicals stored in independent well sites. It is shown how this can reduce the dosage time from hours to seconds over previous diffusion based approaches, using as little as 20 mJ of energy per dose. This paper focuses on presenting the design and characterizing the electrokinetic transport mechanics which govern the release time and dispersal pattern of the well contents using a series of experimental and numerical techniques.

Linear and hyperbranched electron-acceptor supramolecular oligomers.

https://www.ncbi.nlm.nih.gov/pubmed/21374825

The nanometric organization of p-type and n-type materials is expected to facilitate charge mobility in OSCs, thereby preventing recombination and enhancing efficiency. Herein, the synthesis and self-assembly of monomers comprising one or two units of a TCAQ tweezer covalently connected to a fullerene derivative is reported. Such molecules self-assemble in solution (NMR) and on surfaces (AFM) to form linear and hyperbranched supramolecular oligomers, respectively. The self-assembly process was also found to have very little influence on the electronic properties of the electroactive units of the monomers (CV and UV/Vis), as was expected from their matching character. These polymers constitute two of the first examples of n-type supramolecular polymers reported to date.

Electronic interactions within composites of polyanilines formed under acidic and alkaline conditions. Conductivity, ESR, Raman, UV-vis and fluorescence studies.

https://www.ncbi.nlm.nih.gov/pubmed/21206949

The properties of two forms of polyaniline (PAni) synthesised under acidic and basic conditions have been investigated both individually and as combined complexes. The PAni polymerised within alkaline media was redox inactive and non-conducting while the PAni emeraldine salt (ES) was electroactive and conducting. Raman, electron spin resonance, UV-Vis and fluorescence

spectroscopies were used to monitor the changes in electronic properties of these conducting polymer composites. Solution cast films of alkaline synthesised (A-PAni) with the PAni ES resulted in an increase in the high spin polaron population suggesting that it acts as a pseudodopant. The ability of the A-PAni to increase and maintain the population of the polaron charge carrier was confirmed by UV-vis and Raman spectroscopy. Significantly, the presence of the A-PAni in PAni ES helped to sustain higher electrical conductivities at loading levels that were well below the percolation threshold of an insulating polystyrene sulfonate polymeric oligomer model. Fluorescence studies indicated that the A-PAni was fluorescent. However, mixtures of A-PAni with the PAni ES resulted in quenching of the A-PAni emission. The quenching process was observed to involve both static and dynamic processes, with the static quenching being dominant. These results suggest that the two polymers are strongly associated with each other when in the solid state. In stark contrast, the alkaline synthesized PAni did not influence the electrochemical properties of the emeraldine salt. These results deviate significantly from the expected outcome of the addition of an insulating A-PAni additive and highlight the unusual interactions occurring between PAni and its alkaline analogue.

Application of stochastic system identification to the study of the compliance of electroactive polymers.

https://www.ncbi.nlm.nih.gov/pubmed/21361629

Electroactive polymers have shown promising applications as transducers that can mimic biological muscle. The modulus or the compliance of many of these devices can change significantly as they are actuated making these materials attractive for applications that require tunable stiffness. We have developed a dynamic mechanical analyzer that is capable of making in situ measurements of the dynamic compliance transfer function of conducting polymers as a function of an electrochemical stimulus. We do this by simultaneously applying a stochastic stress waveform over a potential waveform and calculating the compliance as it changes over the course of electrochemical excitation. Using these signals we can calculate the compliance transfer function between 0.1 and 100 Hz and the impulse response function with up to 3% variation in its parameters. These functions are then computed as charge is injected into the polymer and it is shown that the low frequency gain of the transfer function can change by 30%-40% in the electrochemical system tested.

A comparative study of graphene-hydrogel hybrid bionanocomposites for biosensing.

https://www.ncbi.nlm.nih.gov/pubmed/25612313

Hydrogels have become increasingly popular as immobilization materials for cells, enzymes and proteins for biosensing applications. Enzymatic biosensors that utilize hydrogel as an encapsulant have shown improvements over other immobilization techniques such as cross linking and covalent bonding. However, to date there are no studies which directly compare multiple hydrogel-graphene nanocomposites using the same enzyme and test conditions. This study compares the performance of four different hydrogels used as protein encapsulants in a mediator-free biosensor based on graphene-nanometal-enzyme composites. Alcohol oxidase (AOx) was encapsulated in chitosan poly-N-isopropylacrylamide (PNIPAAM), silk fibroin or cellulose nanocrystals (CNC) hydrogels, and then spin coated onto a nanoplatinum-graphene modified electrode. The transduction mechanism for the biosensor was based on AOx-catalyzed oxidation of methanol to produce hydrogen peroxide. To isolate the effect(s) of stimulus response on biosensor behavior, all experiments were conducted at 25 Â°C and pH 7.10. Electroactive surface area (ESA), electrochemical impedance spectroscopy (EIS), sensitivity to methanol, response time, limit of detection, and shelf life were measured for each bionanocomposite. Chitosan and PNIPAAM had the highest sensitivity (0.46 Â± 0.2 and 0.3 Â± 0.1 Î¼A mM(-1), respectively) and electroactive surface area (0.2 Â± 0.06 and 0.2 Â± 0.02 cm(2), respectively), as well as the fastest response time (4.3 Â± 0.8 and 4.8 Â± 1.1 s, respectively). Silk and CNC demonstrated lower sensitivity (0.09 Â± 0.02 and 0.15 Â± 0.03 Î¼A mM(-1), respectively), lower electroactive surface area (0.12 Â± 0.02 and 0.09 Â± 0.03 cm(2), respectively), and longer response time (8.9 Â± 2.1 and 6.3 Â± 0.8 s, respectively). The high porosity of chitosan, PNIPAAM, and silk gels led to excellent transport, which was significantly better than CNC bionanocomposites. Electrochemical performance of CNC bionanocomposites were relatively poor, which may be linked to poor gel stability. The differences between the Chitosan/PNIPAAM group and the Silk/CNC group were statistically significant ($p < 0.05$) based on ANOVA. Each of these composites was within the range of other published devices in the literature, while some attributes were significantly improved (namely response time and shelf life). The main advantages of these hydrogel composites over other devices is that only one enzyme is required, all materials are non-toxic, the sensor does not require mediators/cofactors, and the shelf life and response time are significantly improved over other devices.

Nanostructured liquid crystals combining ionic and electronic functions.

https://www.ncbi.nlm.nih.gov/pubmed/20465261

New molecular materials combining ionic and electronic functions have been prepared by using

liquid crystals consisting of terthiophene-based mesogens and terminal imidazolium groups. These liquid crystals show thermotropic smectic A phases. Nanosegregation of the pi-conjugated mesogens and the ionic imidazolium moieties leads to the formation of layered liquid-crystalline (LC) structures consisting of 2D alternating pathways for electronic charges and ionic species. These nanostructured materials act as efficient electrochromic redox systems that exhibit coupled electrochemical reduction and oxidation in the ordered bulk states. For example, compound 1 having the terthienylphenylcyanoethylene mesogen and the imidazolium triflate moiety forms the smectic LC nanostructure. Distinct reversible electrochromic responses are observed for compound 1 without additional electrolyte solution on the application of double-potential steps between 0 and 2.5 V in the smectic A phase at 160 degrees C. In contrast, compound 2 having a tetrafluorophenylterthiophene moiety and compound 3 having a phenylterthiophene moiety exhibit irreversible cathodic reduction and reversible anodic oxidation in the smectic A phases. The use of poly(3,4-ethylenedioxythiophene)-poly(4-styrene sulfonate) (PEDOT-PSS) as an electron-accepting layer on the cathode leads to the distinct electrochromic responses for 2 and 3. These results show that new self-organized molecular redox systems can be built by nanosegregated pi-conjugated liquid crystals containing imidazolium moieties with and without electroactive thin layers on the electrodes.

Completing the color palette with spray-processable polymer electrochromics.

https://www.ncbi.nlm.nih.gov/pubmed/21495668

The field of electrochromic polymers has now reached an important milestone with the availability of a yellow to fully transmissive, cathodically coloring, solution-processable electroactive polymer. This is in addition to previously published electrochromic polymers that have neutral state colors that span from orange, red, magenta, blue, cyan, green, and black, that also attain highly transmissive states upon switching. With this, the full color palette is now complete allowing the largest variety of colors for transmissive and reflective electrochromic display applications. Here, we report on how we have been able to obtain this full color palette through synthetic modifications and color tuning utilizing electron rich and donor-acceptor repeat units, electron-donating substituents, and steric interactions with our 3,4-alkylenedioxythiophene family of polymers. Additionally, using solubilizing pendant groups for both organic and aqueous compatibility, we have been able to create this color palette with fully solution processable materials, paving the way for materials patterning, printing, and incorporation into devices for display and window applications.

A novel strategy to improve the sensitivity of antibiotics determination based on bioelectrocatalysis at molecularly imprinted polymer film electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/26079673

A new strategy for the sensitive detection of kanamycin (KA) and other antibiotics based on molecularly imprinted polymer (MIP) and bioelectrocatalysis was developed in the present study. The KA-polypyrrole MIP films were electropolymerized on the surface of pyrolytic graphite (PG) electrodes, with pyrrole (PY) serving as the monomer and KA as the template. Because KA is electro-inactive, electroactive K3[Fe(CN)6] was used as the probe in the cyclic voltammetric (CV) measurements. The difference of the CV reduction peaks of K3[Fe(CN)6] at electrodes between the MIP films after KA removal and KA-rebinding MIP films could thus be used to determine KA quantitatively. When horseradish peroxidase (HRP) and H2O2 were added into the testing solution, the detection sensitivity of the system was greatly amplified because the electrochemical reduction of H2O2 could be catalyzed by HRP and mediated by K3[Fe(CN)6]. With the bioelectrocatalysis amplification, the limit of detection (LOD) for KA fell as low as 28 nM, approximately two orders of magnitude lower than that for the MIP films in the absence of enzymatic catalysis. The strategy demonstrated the generality. Not only KA but also other antibiotics, such as oxytetracycline (OTC), could be determined by this method. More significantly, in addition to the K3[Fe(CN)6]-HRP-H2O2 system, other bioelectrocatalysis systems, such as Fc(COOH)2-GOD-glucose (Fc(COOH)2=ferrocenedicarboxylic acid, GOD=glucose oxidase), could also be used to amplify the CV signal and realize the sensitive detection of KA for the MIP film system, thereby illustrating the great potential and prospects of the strategy.

A novel ionic polymer metal ZnO composite (IPMZC).

https://www.ncbi.nlm.nih.gov/pubmed/22163869

The presented research introduces a new Ionic Polymer-Metal-ZnO Composite (IPMZC) demonstrating photoluminescence (PL)-quenching on mechanical bending or application of an electric field. The newly fabricated IPMZC integrates the optical properties of ZnO and the electroactive nature of Ionic Polymer Metal Composites (IPMC) to enable a non-contact read-out of IPMC response. The electro-mechano-optical response of the IPMZC was measured by observing the PL spectra under mechanical bending and electrical regimes. The working range was measured to be 375-475 nm. It was noted that the PL-quenching increased proportionally with the increase in curvature and applied field at 384 and 468 nm. The maximum quenching of 53.4% was achieved

with the membrane curvature of 78.74/m and 3.01% when electric field (12.5 Ã— 10(3) V/m) is applied. Coating IPMC with crystalline ZnO was observed to improve IPMC transduction.

A tetrathiafulvalene-based electroactive covalent organic framework.

https://www.ncbi.nlm.nih.gov/pubmed/25266337

Two-dimensional covalent organic frameworks (2D COFs) provide a unique platform for the molecular design of electronic and optoelectronic materials. Here, the synthesis and characterization of an electroactive COF containing the well-known tetrathiafulvalene (TTF) unit is reported. The TTF-COF crystallizes into 2D sheets with an eclipsed AA stacking motif, and shows high thermal stability and permanent porosity. The presence of TTF units endows the TTF-COF with electron-donating ability, which is characterized by cyclic voltammetry. In addition, the open frameworks of TTF-COF are amenable to doping with electron acceptors (e.g., iodine), and the conductivity of TTF-COF bulk samples can be improved by doping. Our results open up a reliable route for the preparation of well-ordered conjugated TTF polymers, which hold great potential for applications in fields from molecular electronics to energy storage.

Electroactive polymer actuators as artificial muscles: are they ready for bioinspired applications?

https://www.ncbi.nlm.nih.gov/pubmed/22126909

Electroactive polymer (EAP) actuators are electrically responsive materials that have several characteristics in common with natural muscles. Thus, they are being studied as 'artificial muscles' for a variety of biomimetic motion applications. EAP materials are commonly classified into two major families: ionic EAPs, activated by an electrically induced transport of ions and/or solvent, and electronic EAPs, activated by electrostatic forces. Although several EAP materials and their properties have been known for many decades, they have found very limited applications. Such a trend has changed recently as a result of an effective synergy of at least three main factors: key scientific breakthroughs being achieved in some of the existing EAP technologies; unprecedented electromechanical properties being discovered in materials previously developed for different purposes; and higher concentration of efforts for industrial exploitation. As an outcome, after several years of basic research, today the EAP field is just starting to undergo transition from academia into commercialization, with significant investments from large companies. This paper presents a brief overview on the full range of EAP actuator types and the most significant areas of interest for

applications. It is hoped that this overview can instruct the reader on how EAPs can enable bioinspired motion systems.

Electro-active shape memory properties of poly(Îµ-caprolactone)/functionalized multiwalled carbon nanotube nanocomposite.

https://www.ncbi.nlm.nih.gov/pubmed/21090574

One type of electroactive shape memory nanocomposite was fabricated, including cross-linked poly(Îµ-caprolactone) (cPCL) and conductive multiwalled carbon nanotubes (MWNTs). The cross-linking reaction of the pristine poly(Îµ-caprolactone) (PCL) was realized by using benzoyl peroxide (BPO) as an initiator. The raw MWNTs (Raw-M) were prefunctionalized by acid-oxidation process and covalent grafting with poly (ethylene glycol) (PEG), respectively. Three kinds of nanocomposites containing cPCL/Raw-M, cPCL/acid-oxidation MWNTs (AO-M) and cPCL/PEG grafted MWNTs (PEG-M) were obtained, and the mechanical, electrical and shape memory properties were further investigated. The influence of in vitro degradation on their shape memory and mechanical properties was also evaluated. The methyl thiazolyl tetrazolium (MTT) assay was performed to estimate their biocompatibility. The results displayed that these nanocomposites could perform favorable shape memory recovery both in hot water at 55 Â°C and in electric field with 50 V applied voltage. In addition, compared with cPCL/Raw-M and cPCL/AO-M, cPCL/PEG-M composite possessed more favorable properties such as mechanical, biocompatible, and electroactive shape memory functions. Therefore, the nanocomposite may be potential for application as smart bioactuators in biomedical field.

Synthesis of biodegradable and electroactive multiblock polylactide and aniline pentamer copolymer for tissue engineering applications.

https://www.ncbi.nlm.nih.gov/pubmed/18260636

To obtain one biodegradable and electroactive polymer as the scaffold for tissue engineering, the multiblock copolymer PLAAP was designed and synthesized with the condensation polymerization of hydroxyl-capped poly(l-lactide) (PLA) and carboxyl-capped aniline pentamer (AP). The PLAAP copolymer exhibited excellent electroactivity, solubility, and biodegradability. At the same time, as one scaffold material, PLAAP copolymer possesses certain mechanical properties with the tensile strength of 3 MPa, tensile Young 's modulus of 32 MPa, and breaking elongation rate of 95%. We systematically studied the compatibility of PLAAP copolymer in vitro and proved that the

electroactive PLAAP copolymer was innocuous, biocompatible, and helpful for the adhesion and proliferation of rat C6 cells. Moreover, the PLAAP copolymer stimulated by electrical signals was demonstrated as accelerating the differentiation of rat neuronal pheochromocytoma PC-12 cells. This biodegradable and electroactive PLAAP copolymer thus possessed the properties in favor of the long-time application in vivo as nerve repair scaffold materials in tissue engineering.

One-step synthesis of potassium ferricyanide-doped polyaniline nanoparticles for label-free immunosensor.

https://www.ncbi.nlm.nih.gov/pubmed/25618379

A novel, label-free and inherent electroactive redox immunosensor for ultrasensitive detection of carcinoembryonic antigen (CEA) was proposed based on gold nanoparticles (AuNPs) and potassium ferricyanide-doped polyaniline (FC-PANI) nanoparticles. FC-PANI composite was synthesized via oxidative polymerization of aniline, using potassium ferricyanide (K3[Fe(CN)6]) as both oxidant and dopant. FC-PANI acting as the signal indicator was first fixed on a gold electrode (GE) to be the signal layer. Subsequently, the negatively charged AuNPs could be adsorbed on the positively charged FC-PANI modified GE surface by electrostatic adsorption, and then to immobilize CEA antibody (anti-CEA) for the assay of CEA. The CEA concentration was measured through the decrease of amperometric signals in the corresponding specific binding of antigen and antibody. The wide linear range of the immunosensor was from 1.0 pg mL(-1) to 500.0 ng mL(-1) with a low detection limit of 0.1 pg mL(-1) (S/N=3). The proposed method would have a potential application in clinical immunoassays with the properties of facile procedure, stability, high sensitivity and selectivity.

Comparison of electrode materials for the detection of rapid hydrogen peroxide fluctuations using background-subtracted fast scan cyclic voltammetry.

https://www.ncbi.nlm.nih.gov/pubmed/21727955

Hydrogen peroxide (H(2)O(2)) is a critically important signaling molecule. Endogenous H(2)O(2) mediates diverse physiological processes both intra- and intercellularly; and enzymatically generated H(2)O(2) is a widely used reporter molecule at biosensors that rely on enzymes to detect non-electroactive species. However, the development and application of electroanalytical methods for the direct detection of this molecule has been challenging because the electron transfer kinetics for the irreversible oxidation of H(2)O(2) are slow. We comparatively characterize the

electrochemical oxidation of H(2)O(2) on bare and Nafion(Â®)-coated platinum and carbon-fiber microdisc electrodes using fast-scan cyclic voltammetry (FSCV). Using a waveform ranging from +0.2 to +1.3 V at 400 V s(-1), the electrocatalytic properties of the platinum surface were not readily apparent, and the carbon-fiber microelectrode demonstrated greater sensitivity and selectivity toward H(2)O(2). Nafion(Â®)-coating further enhanced detection on carbon electrodes. These results confirm that platinum electrodes, with or without Nafion(Â®), will not work acceptably with this approach, and confirm the value of carbon-fiber microelectrodes relative to more traditionally used platinum electrodes in the direct detection of rapid H(2)O(2) fluctuations using FSCV.

Carbon nanoparticles-assisted mediator-less microbial fuel cells using Proteus vulgaris.

https://www.ncbi.nlm.nih.gov/pubmed/21764289

Recently mediator-less microbial fuel cells (MFCs) are attracting great interest among researchers due to their potential applications to electricity generation as well as wastewater treatment. Common mediator-less MFCs employ electroactive bacteria called exoelectrogens to directly transfer electrons to the anode from the bacteria. However, exoelectrogens are rather limited in number and thus may not find general use for practical purposes. Here we showed our results in which mediator-less MFCs could be developed from Gram-negative non-exoelectrogens. By using carbon nanoparticles as a conductive medium to immobilize bacteria, it was possible to generate appreciable electricity from Proteus vulgaris without exogenous mediators. Maximum power density of 269 mW m(-2) and cell voltage of ca. 400 mV were obtained using glucose as a substrate. Power generation was attributed to direct electron transfer and to self-produced mediators, both of which were assisted by carbon nanoparticles. Bacillus subtilis, a Gram-positive bacterium, in the meantime, did not produce appreciable electricity.

Electrospinning of aniline pentamer-graft-gelatin/PLLA nanofibers for bone tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/25200841

Blends of aniline pentamer-graft-gelatin (AP-g-GA) and poly(l-lactide) (PLLA) were electrospun to prepare uniform nanofibers as biomimetic scaffolds. The nanofibers exhibited good electroactivity, thermal stability and biodegradability. The biocompatibility of the nanofibers in vitro was evaluated by the adhesion and proliferation of mouse preosteoblastic MC3T3-E1 cells. The cellular elongation was significantly greater on electroactive AP-g-GA/PLLA nanofibers than on PLLA nanofibers.

Moreover, the AP-g-GA/PLLA nanofibers stimulated by an electrical pulsed signal could promote the differentiation of MC3T3-E1 cells compared with pure PLLA nanofibers. Our results demonstrated that the biodegradable and electroactive AP-g-GA/PLLA nanofibers had potential application in vivo as bone repair scaffold materials in tissue engineering.

Development of artificial muscles based on electroactive ionomeric polymer-metal composites.

https://www.ncbi.nlm.nih.gov/pubmed/21595715

This work contextualizes the research of materials that can be applied as artificial muscles. The main motivation of this research is the importance of the development of mechatronic systems for the replacement of traditional devices of actuation and motion based on rotational electrical motors by other devices that reproduce biological muscle movements. Electroactive polymers (EAPs) are materials that respond to electric stimuli with shape and/or dimension changes, and accomplish movements that are smooth enough to mimic biological muscles. Among EAPs, the ionomeric polymer-metal composites (IPMCs) are an interesting alternative to biomimetic devices due to large displacements when submitted to low applied voltage. This article presents a brief review of IPMCs, a sample preparation procedure, and some electromechanical experimental results. We also discuss the applicability of this technology in medical devices and as artificial muscles.

Greatly enhanced energy density and patterned films induced by photo cross-linking of poly(vinylidene fluoride-chlorotrifluoroethylene).

https://www.ncbi.nlm.nih.gov/pubmed/21432976

Greatly enhanced energy density in poly(vinylidene fluoride-chlorotrifluoroethylene) [P(VDF-CTFE)] is realized through interface effects induced by a photo cross-linking method. Being different from nanocomposites with lowered dielectric strength, the cross-linked P(VDF-CTFE)s possess a high breakdown field as well as remarkably elevated polarization, both of which contribute to the enhanced energy density as high as 22.5 Jâ€‰Â·â€‰cm(-3). Moreover, patterned thin films with various shapes and sizes are fabricated by photolithography, which sheds new light on the integration of PVDF-based electroactive polymers into organic microelectronic devices such as flexible pyroelectric/piezoelectric sensor arrays or non-volatile ferroelectric memory devices.

Fullerene derived molecularly imprinted polymer for chemosensing of

adenosine-5'-triphosphate (ATP).

https://www.ncbi.nlm.nih.gov/pubmed/25172817

For molecular imprinting of oxidatively electroactive analytes by electropolymerization, we used herein reductively electroactive functional monomers. As a proof of concept, we applied C60 fullerene adducts as such for the first time. For that, we derivatized C60 to bear either an uracil or an amide, or a carboxy addend for recognition of the adenosine-5'-triphosphate (ATP) oxidizable analyte with the ATP-templated molecularly imprinted polymer (MIP-ATP). Accordingly, the ATP complex with all of the functional monomers formed in solution was potentiodynamically electropolymerized to deposit an MIP-ATP film either on an Au electrode of the quartz crystal resonator or on a Pt disk electrode for the piezoelectric microgravimetry (PM) or capacitive impedimetry (CI) determination of ATP, respectively, under the flow-injection analysis (FIA) conditions. The apparent imprinting factor for ATP was âˆ¼4.0. After extraction of the ATP template, analytical performance of the resulting chemosensors, including detectability, sensitivity, and selectivity, was characterized. The limit of detection was 0.3 and 0.03mM ATP for the PM and CI chemosensor, respectively. The MIP-ATP film discriminated structural analogues of ATP quite well. The Langmuir, Freundlich, and Langmuir-Freundlich isotherms were fitted to the experimental data of the ATP sorption and sorption stability constants appeared to be nearly independent of the adopted sorption model.

Artificial antibodies for troponin T by its imprinting on the surface of multiwalled carbon nanotubes: its use as sensory surfaces.

https://www.ncbi.nlm.nih.gov/pubmed/21816602

A novel artificial antibody for troponin T (TnT) was synthesized by molecular imprint (MI) on the surface of multiwalled carbon nanotubes (MWCNT). This was done by attaching TnT to the MWCNT surface, and filling the vacant spaces by polymerizing under mild conditions acrylamide (monomer) in N,N'-methylenebisacrylamide (cross-linker) and ammonium persulphate (initiator). After removing the template, the obtained biomaterial was able to rebind TnT and discriminate it among other interfering species. Stereochemical recognition of TnT was confirmed by the non-rebinding ability displayed by non-imprinted (NI) materials, obtained by imprinting without a template. SEM and FTIR analysis confirmed the surface modification of the MWCNT. The ability of this biomaterial to rebind TnT was confirmed by including it as electroactive compound in a PVC/plasticizer mixture coating a wire of silver, gold or titanium. Anionic slopes of 50 mV decade(-1) were obtained for the gold wire

coated with MI-based membranes dipped in HEPES buffer of pH 7. The limit of detection was 0.16 Î¼g mL(-1). Neither the NI-MWCNT nor the MWCNT showed the ability to recognize the template. Good selectivity was observed against creatinine, sucrose, fructose, myoglobin, sodium glutamate, thiamine and urea. The sensor was tested successfully on serum samples. It is expected that this work opens new horizons on the design of new artificial antibodies for complex protein structures.

Electrochemical sensors based on molecularly imprinted polymers grafted onto gold electrodes using click chemistry.

https://www.ncbi.nlm.nih.gov/pubmed/22093342

We have developed a three-step method to graft molecularly imprinted polymer (MIP) thin films onto Au electrodes. In the first step, propargyl acrylate is clicked onto an azidoundecanethiol (N(3)(CH(2))(11)SH)/decanethiol mixed self-assembled monolayer (SAM). Then, by applying UV light (365 nm) in the presence of N,N'-methylenebis(acrylamide) (MAAM) and azobisisobutyronitrile (AIBN) as the radical initiator, polymerization was carried out directly on the electrode surface in the presence of an electroactive template molecule, hydroquinone (HQ). Detection of HQ using the clicked-on MIP sensor was studied using chronoamperometry and its behavior was compared to that of a sensor prepared by drop-coating MIPs onto Au. The detection limit of the clicked-on MIP sensor for HQ was found to be 1.21Â±0.56 Î¼M, about four times lower than what was observed using the coated-on MIP sensor. In addition, the sensitivity of the clicked-on MIP sensor was found to be approximately three times greater than the coated-on MIP sensor. Apparent diffusion coefficients determined using chronoamperometry suggest that the improved performance is likely due to the favorable mass transfer characteristics of the clicked-on MIP sensing membrane.

Glucose biosensor based on electrodeposition of platinum nanoparticles onto carbon nanotubes and immobilizing enzyme with chitosan-SiO(2) sol-gel.

https://www.ncbi.nlm.nih.gov/pubmed/18054479

A novel amperometric biosensor, based on electrodeposition of platinum nanoparticles onto multi-walled carbon nanotube (MWNTs) and immobilizing enzyme with chitosan-SiO(2) sol-gel, is presented in this article. MWNTs were cast on the glass carbon (GC) substrate directly. An extra Nafion coating was used to eliminate common interferents such as acetaminophen and ascorbic acids. The morphologies and electrochemical performance of the modified electrodes have been investigated by scanning electron microscopy (SEM) and amperometric methods, respectively. The

synergistic action of Pt and MWNTs and the biocompatibility of chitosan-SiO(2) sol-gel made the biosensor have excellent electrocatalytic activity and high stability. The resulting biosensor exhibits good response performance to glucose with a wide linear range from 1 microM to 23 mM and a low detection limit 1 microM. The biosensor also shows a short response time (within 5s), and a high sensitivity (58.9 microAm M(-1)cm(-2)). In addition, effects of pH value, applied potential, rotating rate, electrode construction and electroactive interferents on the amperometric response of the sensor were investigated and discussed in detail.

Cluster synthesis of monodisperse rutile-TiO2 nanoparticles and dielectric TiO2-vinylidene fluoride oligomer nanocomposites.

https://www.ncbi.nlm.nih.gov/pubmed/21911930

The embedding of oxide nanoparticles in polymer matrices produces a greatly enhanced dielectric response by combining the high dielectric strength and low loss of suitable host polymers with the high electric polarizability of nanoparticles. The fabrication of oxide-polymer nanocomposites with well-controlled distributions of nanoparticles is, however, challenging due to the thermodynamic and kinetic barriers between the polymer matrix and nanoparticle fillers. In the present study, monodisperse TiO(2) nanoparticles having an average particle size of 14.4Â nm and predominant rutile phase were produced using a cluster-deposition technique without high-temperature thermal annealing and subsequently coated with uniform vinylidene fluoride oligomer (VDFO) molecules using a thermal evaporation source, prior to deposition as TiO(2)-VDFO nanocomposite films on suitable substrates. The molecular coatings on TiO(2) nanoparticles serve two purposes, namely to prevent the TiO(2) nanoparticles from contacting each other and to couple the nanoparticle polarization to the matrix. Parallel-plate capacitors made of TiO(2)-VDFO nanocomposite film as the dielectric exhibit minimum dielectric dispersion and low dielectric loss. Dielectric measurements also show an enhanced effective dielectric constant in TiO(2)-VDFO nanocomposites as compared to that of pure VDFO. This study demonstrates for the first time a unique electroactive particle coating in the form of a ferroelectric VDFO that has high-temperature stability as compared to conventionally used polymers for fabricating dielectric oxide-polymer nanocomposites.

Swelling and contraction of ferrocyanide-containing polyelectrolyte multilayers upon application of an electric potential.

https://www.ncbi.nlm.nih.gov/pubmed/18973314

We developed a new platform at the interface of polyelectrolyte multilayers (PEMs) and electroactive polymers (EAPs) by combining the easy buildup of PEM thin films and the deformation characteristics of the EAPs. The PEM films were made of poly(L-glutamic acid) (PGA) and poly(allylamine hydrochloride) (PAH). After [Fe(CN)6]4- ions (FCIV) were added, cyclic voltammetry (CV) was performed, resulting in a reversible expansion and contraction of the film. The shape change as well as the film buildup prior to the cycling were monitored in situ using the electrochemical quartz crystal microbalance with dissipation monitoring (EC-QCM-D). Electrochemical atomic force microscopy (EC-AFM) images confirmed the rapid shape deformation. The process takes place in an aqueous environment under mild conditions (maximum potential of 600 mV and no pH change), which makes it a promising tool for biomedical applications. In addition, the electrochemically active films are produced using the layer-by-layer (LbL) method that is already established in biotechnology and biomaterials science; therefore, the presented approach can be readily adapted in these areas, bringing about a new possibility for the nanoscale dynamic control of coating thickness in various applications.

Electrochemically synthesized polymers in molecular imprinting for chemical sensing.

https://www.ncbi.nlm.nih.gov/pubmed/22302165

This critical review describes a class of polymers prepared by electrochemical polymerization that employs the concept of molecular imprinting for chemical sensing. The principal focus is on both conducting and nonconducting polymers prepared by electropolymerization of electroactive functional monomers, such as pristine and derivatized pyrrole, aminophenylboronic acid, thiophene, porphyrin, aniline, phenylenediamine, phenol, and thiophenol. A critical evaluation of the literature on electrosynthesized molecularly imprinted polymers (MIPs) applied as recognition elements of chemical sensors is presented. The aim of this review is to highlight recent achievements in analytical applications of these MIPs, including present strategies of determination of different analytes as well as identification and solutions for problems encountered.

Manipulating location, polarity, and outgrowth length of neuron-like pheochromocytoma (PC-12) cells on patterned organic electrode arrays.

https://www.ncbi.nlm.nih.gov/pubmed/21922117

In this manuscript, we describe a biocompatible organic electrode system, comprising poly(3,4-ethylenedioxythiophene) (PEDOT) microelectrode arrays on indium tin oxide (ITO) glass,

that can be used to regulate the neuron type, location, polarity, and outgrown length of neuron-like cells (PC-12). We fabricated a PEDOT microelectrode array with four different sizes (flat; 20, 50, and 100 Î¼m) through electrochemical polymerization. Extracellular matrix proteins absorbed well on these organic electrodes; cells absorbed selectively on the organic electrodes when we used polyethylene oxide/polypropylene oxide/polyethylene oxide triblock copolymers (PEO/PPO/PEO, Pluronicâ„¢ F108) as the anti-adhesive coating. In this system, the neurite polarities and neuron types could be manipulated by varying the width of the PEDOT microelectrode arrays. On the unpatterned PEDOT electrode, PC-12 cells were randomly polarized, with approximately 80% having multi-polar cell types. In contrast, when we cultured PC-12 cells on the 20 Î¼m wide PEDOT line array, the neurites aligned along the direction of the organic electrodes, with the percentage of uni- and bipolar PC-12 cells increasing to greater than 90%. The outgrowth of neurites on the microelectrodes was promoted by ~60% with an applied electrical stimulation. Therefore, these electroactive PEDOT microelectrode arrays have potential for use in tissue engineering related to the development and regeneration of mammalian nervous systems.

Amplification strategy using aggregates of ferrocene-containing cationic polythiophene for sensitive and specific electrochemical detection of DNA.

https://www.ncbi.nlm.nih.gov/pubmed/21932839

We report a new electrochemical amplification strategy for an ultrasensitive electrochemical detection of DNA sequences using aggregates composed of a water-soluble, ferrocene-functionalized polythiophene. A two-step hybridization is performed at one addressing surface with PNA capture probes whereas the electrochemical detection is done on an electrode nearby. Specific and quantitative detection of DNA targets with a detection limit of 4 Ã— 10(-16) M (about 4 zeptomoles or about 2500 copies of oligonucleotides) was achieved.

Direct electrochemistry and electrocatalysis of myoglobin-based nanocomposite membrane electrode.

https://www.ncbi.nlm.nih.gov/pubmed/21745763

The direct electron transfer of myoglobin (Mb) was achieved based on the immobilization of Mb/Silver nanoparticles (AgNPs) on glassy carbon electrode by multi-wall carbon nanotubes (MWNTs)-chitosan(Chit) film. The immobilized Mb displayed a pair of well-defined and reversible redox peaks with a formal potential (E(Î¸')) of -24 mV (vs. Ag/AgCl) in 0.1 M pH 7.0 phosphate buffer

solution. The apparent heterogeneous electron transfer rate constants (k(s)) of Mb confined to Chit-MWNTs film was evaluated as 5.47 s(-1) according to Laviron's equation. The surface concentration (Î“(*)) of the electroactive Mb in the Chit-MWNTs film was estimated to be (4.16Â±0.35)Ã—10(-9) mol cm(-2). Meanwhile, the catalytic ability of Mb toward the reduction of H(2)O(2) was studied. Its apparent Michaelis-Menten constant for H(2)O(2) was 0.024 mM, showing a good affinity. The linear range for H(2)O(2) determination was from 2.5Ã—10(-5) M to 2.0Ã—10(-4) M with a detection limit of 1.02Ã—10(-6) M (S/N=3). Moreover, the biosensor displays rapid response to H(2)O(2) and good stability and reproducibility.

Electrospun fullerenol-cellulose biocompatible actuators.

https://www.ncbi.nlm.nih.gov/pubmed/21517072

Though there are many stimuli-responsive polymer actuators based on synthetic polymers, electroactive natural biopolymer actuators are very rare. We developed an electrospun fullernol-cellulose biocompatible actuator with much lower power consumption and larger electromechanical displacement in comparison with a pure cellulose acetate actuator. Morphology of the electrospun membranes resembles the nanoporous structure of extracellular matrix in natural muscles. Presence of minute concentrations of fullerenol leads to sharp increase in the degree of crystallinity and substantial increase in tensile strength of membranes. Chemical interactions between cellulose acetate and fullerenols are confirmed by three shifts in carboxylate, carboxy, and carbonyl linkages from the Fourier-transform infrared spectrometry. Much larger tip displacement, nearly 3-fold even at 0.5 wt % fullerenol content, was observed with much lower power consumption under both alternating and direct current conditions.

Synthesis and optoelectronic characterization of some star-shaped oligomers with benzene and triphenylamine cores.

https://www.ncbi.nlm.nih.gov/pubmed/24052859

Six star-shaped oligomers containing triphenylamine (D1-D3) and benzene unit (D4-D6) as cores have been synthesized by Wittig condensation or Heck coupling reaction using aromatic aldehydes and triphenylphosphonium salts or aromatic halogenated compounds with vinyl triphenylamine. All oligomers have well-defined molecular structure and high purity. Characterization of the oligomers was made by FT-IR, (1)H-NMR spectroscopy, UV-Vis, and fluorescence spectroscopy. The electrochemical behavior was studied by cyclic voltammetry (CV). The cyclic voltammograms have

revealed that oligomers undergo quasireversible or irreversible redox processes. The irreversible process is associated with electrochemical polymerization of oligomers by dimerization of unsubstituted triphenylamine groups. Thermal characterization was accomplished by TGA and DSC methods and evidenced that all oligomers were stable materials until 250Â°C and have formed stable molecular glasses after first heating scan.

Triply responsive films in bioelectrocatalysis with a binary architecture: combined layer-by-layer assembly and hydrogel polymerization.

https://www.ncbi.nlm.nih.gov/pubmed/21534632

In this work, triply responsive films with a specific binary architecture combining layer-by-layer assembly (LbL) and hydrogel polymerization were successfully prepared. First, concanavalin A (Con A) and dextran (Dex) were assembled into {Con A/Dex}(5) LbL layers on electrode surface by the lectin-sugar biospecific interaction between them. The poly(N,N-diethylacrylamide) (PDEA) hydrogels with entrapped horseradish peroxidase (HRP) were then synthesized by polymerization on the surface of LbL inner layers, forming {Con A/Dex}(5)-(PDEA-HRP) films. The films demonstrated reversible pH-, thermo-, and salt-responsive on-off behavior toward electroactive probe Fe(CN)(6)(3-) in its cyclic voltammetric responses. This multiple stimuli-responsive films could be further used to realize triply switchable electrochemical reduction of H(2)O(2) catalyzed by HRP immobilized in the films and mediated by Fe(CN)(6)(3-) in solution. The responsive mechanism of the films was explored and discussed. The pH-sensitive property of the system was attributed to the electrostatic interaction between the {Con A/Dex}(5) inner layers and the probe at different pH, and the thermo- and salt-responsive behaviors should be ascribed to the structure change of PDEA hydrogels for the PDEA-HRP outermost layers under different conditions. The concept of binary architecture was also used to fabricate {Con A/Dex}(5)-(PDEA-GOD) films on electrodes, where GOD = glucose oxidase, which was applied to realize the triply switchable bioelectrocatalysis of glucose by GOD in the films with ferrocenedicarboxylic acid as the mediator in solution. This film system with the unique binary architecture may establish a foundation for fabricating a novel type of multicontrollable biosensors based on bioelectrocatalysis with immobilized enzymes.

Electroactive electrospun polyaniline/poly[(L-lactide)-co-(Îµ-caprolactone)] fibers for control of neural cell function.

https://www.ncbi.nlm.nih.gov/pubmed/22213547

Blends of PAni and PLCL are electrospun to prepare uniform fibers for the development of electrically conductive, engineered nerve grafts. PC12 cell viability is significantly higher on RPACL fibers than on PLCL-only fibers, and the electrical conductivity of the fibers affects the differentiation of PC12 cells; the number of cells positively-stained and their expression level are significantly higher on RPACL fibers. PC12 cell bodies display an oriented morphology with outgrowing neurites. On RPACL fibers, the expression level of paxillin, cdc-42, and rac is positively affected and proteins including RhoA and ERK exist as more activated state. These results suggest that electroactive fibers may hold promise as a guidance scaffold for neuronal tissue engineering.

A low-energy-consumption electroactive valveless hydrogel micropump for long-term biomedical applications.

https://www.ncbi.nlm.nih.gov/pubmed/21761057

Stimuli-responsive hydrogels have attracted considerable interest in the field of microfluidics due to their ability to transform electrical energy directly into mechanical work through swelling, bending, and other deformations. In particular, electroactive hydrogels hold great promise for biomedical micropumping applications such as implantable drug delivery systems. In such applications, energy consumption rate and durability are key properties. Here, we developed a valveless micropump system that utilizes a hydrogel as the main actuator, and tested its performance over 6 months of continuous operation. The proposed micropump system, powered by a single 1.5 V commercial battery, expended very little energy (less than 750 Î¼Ws per stroke) while pumping 0.9 wt% saline solution under a low voltage (less than 1 V), and remained fully functional after 6 months. CFD simulations were conducted to improve the microchannel geometry so as to minimize the backflow caused by the valveless mechanism of the system. Based on the simulation results, an asymmetric geometry and a stop post were introduced to enhance the pumping performance. To demonstrate the feasibility of the proposed system as a drug delivery pump, an anti-cancer drug (adriamycin) was perfused to human breast cancer cells (MCF-7) using the pump. The present study showed that the proposed system can operate continuously for long periods with low energy consumption, powered by a single 1.5 V battery, making it a promising candidate for an implantable drug delivery system.

Fullerenol-based electroactive artificial muscles utilizing biocompatible polyetherimide.

https://www.ncbi.nlm.nih.gov/pubmed/21332175

Two essential functional requirements for electroactive artificial muscles, which can be used for

biomedical active devices, are biocompatibility and sufficient range of motion. Fullerenol nanoparticles and their derivatives have been validated as potential candidates to be used for nanobiomaterials and biomedical applications because of their excellent proton conductivity, hydrophilicity, and biocompatibility. We developed fullerenol-based electroactive artificial muscles utilizing biocompatible polyetherimide. By using a solvent recasting method, present ionic networking membranes have been successfully synthesized with homogeneous dispersion of polyhydroxylated fullerene (PHF) nanoparticles into a sulfonated polyetherimide (SPEI) matrix. In comparison with pure SPEI membranes, the PHF-SPEI nanocomposite membranes show much higher water uptake and proton conductivity, which are both essential characteristics for high-performance ionic polymer actuators. The developed PHF-SPEI actuator shows over three times larger motion ranges and two times higher blocking forces than the pure SPEI actuator. The excellent biocompatibility of PHF and SPEI makes these actuators promising candidate materials for biomedical devices such as active stents and catheters.

Wearable wireless tactile display for virtual interactions with soft bodies.

https://www.ncbi.nlm.nih.gov/pubmed/25225636

We describe here a wearable, wireless, compact, and lightweight tactile display, able to mechanically stimulate the fingertip of users, so as to simulate contact with soft bodies in virtual environments. The device was based on dielectric elastomer actuators, as high-performance electromechanically active polymers. The actuator was arranged at the user's fingertip, integrated within a plastic case, which also hosted a compact high-voltage circuitry. A custom-made wireless control unit was arranged on the forearm and connected to the display via low-voltage leads. We present the structure of the device and a characterization of it, in terms of electromechanical response and stress relaxation. Furthermore, we present results of a psychophysical test aimed at assessing the ability of the system to generate different levels of force that can be perceived by users.

Tissue engineering of electrically responsive tissues using polyaniline based polymers: a review.

https://www.ncbi.nlm.nih.gov/pubmed/25112936

Conducting polymers have found numerous applications as biomaterial components serving to effectively deliver electrical signals from an external source to the seeded cells. Several cell types

including cardiomyocytes, neurons, and osteoblasts respond to electrical signals by improving their functional outcomes. Although a wide variety of conducting polymers are available, polyaniline (PANI) has emerged as a popular choice due to its attractive properties such as ease of synthesis, tunable conductivity, environmental stability, and biocompatibility. PANI in its pure form has exhibited biocompatibility both inÂ vitro and inÂ vivo, and has been combined with a host of biodegradable polymers to form composites having a range of mechanical, electrical, and surface properties. Moreover, recent studies in literature report on the functionalization of polyaniline oligomers with end segments that make it biodegradable and improve its biocompatibility, two properties which make these materials highly desirable for applications in tissue engineering. This review will discuss the features and properties of PANI based composites that make them effective biomaterials, and it provides a comprehensive summary of studies where the use of PANI as a biomaterial component has enhanced cellular function and behavior. We also discuss recent studies utilizing functionalized PANI oligomers, and conclude that electroactive PANI and its derivatives show great promise in eliciting favorable responses from various cell lines that respond to electrical stimuli, and are therefore effective biomaterials for the engineering of electrically responsive biological tissues and organs.

A Solution-Processable (Tetraaniline-b-Polyethylene Glycol)3 Star-Shaped Rod-Coil Block Copolymer with Enhanced Electrochromic Properties.

https://www.ncbi.nlm.nih.gov/pubmed/26663524

A novel electroactive star-shaped rod-coil copolymer composed of a benzene core and three symmetrically positioned tetraaniline-b-poly(ethylene glycol) arms, (TAni-b-PEG)3 rod-coil block copolymer, is synthesized successfully and characterized using Fourier transform infrared spectroscopy (FTIR), UV-vis, (1)H NMR, and matrix-assisted laser desorption/ionization (MALDI) mass spectrometry. Uniform and high-quality (TAni-b-PEG)3 thin films onto indium tin oxide-coated glass surface are fabricated simply from its DMF solution. Resulting (TAni-b-PEG)3 copolymer thin films possess excellent electrochromic properties with a high optical contrast of 73.3%, superb coloration efficiency of 318.5 cm(2) C(-1) at 750 nm. Very short switching times, that is, 2.11 s and 2.14 s for coloring and bleaching times, respectively, are observed as well. The mechanism of these impressive electrochromic properties of (TAni-b-PEG)3 thin films possessed is proposed based on the atomic force microscopy investigation, star-shaped molecular geometry, synergetic electronic and ionic conductivity and amphiphilic self-assembly feature of (TAni-b-PEG)3 copolymer, which can

self-assemble to form cylinder pattern consisting of quick pathways for electronic charges and ionic species, respectively.

Electroactive porous tubular scaffolds with degradability and non-cytotoxicity for neural tissue regeneration.

https://www.ncbi.nlm.nih.gov/pubmed/21985870

Electroactive degradable porous tubular scaffolds were fabricated from the blends of polycaprolactone and a hyperbranched degradable conducting copolymer at different feed ratios by a solution-casting/salt-leaching method. Scaning electron microscopy (SEM) and microcomputed tomography tests indicated that these scaffolds had homogeneously distributed interconnected pores on the cross-section and surface. The electrical conductivity of films with the same composition as the scaffolds was between 3.4Ã—10(-6) and 3.1Ã—10(-7) S cm(-1), depending on the ratio of hyperbranched degradable conducting copolymer to polycaprolactone. A hydrophilic surface with a contact angle of water about 30Â° was achieved by doping the films with (Â±)-10-camphorsulfonic acid. The mechanical properties of the films were investigated by tensile tests, and the morphology of the films was studied by SEM. The scaffolds were subjected to the WST test (a cell proliferation and cytotoxicity assay using water-soluble tetrazolium salts) with HaCaT keratinocyte cells, and the results show that these scaffolds are non-cytotoxic. These degradable electroactive tubular scaffolds are good candidates for neural tissue engineering application.

Insulated gold scanning tunneling microscopy probes for recognition tunneling in an aqueous environment.

https://www.ncbi.nlm.nih.gov/pubmed/22299981

Chemically functionalized probes are required for tunneling measurements made via chemical contacts ("Recognition Tunneling"). Here, we describe the etching of gold STM probes suitable for chemical functionalization with moieties bearing thiol groups. Insulated with high density polyethylene, these probes may be used in aqueous electrolytes with sub pA leakage currents. The area of the exposed probe surface was characterized via the saturation current in an electroactive solution (0.1 M K(3)Fe(CN)(6)). Twenty five percent of the probes had an exposed region of 10 nm radius or less.

Electrochemical detection of natural DNA damage induced by in situ peroxidase-generated reactive nitrogen species in DNA layer-by-layer films.

https://www.ncbi.nlm.nih.gov/pubmed/22387104

The NO(2)â€¢ radical is one kind of reactive nitrogen species and can be generated by horseradish peroxidase (HRP)-catalyzed oxidation of nitrite (NO(2)(-)) in the presence of hydrogen peroxide (H(2)O(2)) and may cause DNA damage in living system. In the present work, {PDDA/DNA}(4) layer-by-layer (LBL) films assembled with poly(diallyldimethylammonium chloride) (PDDA) and natural double-stranded DNA on electrodes were used to detect DNA damage induced by NO(2)â€¢ radicals generated from the HRP+H(2)O(2)+NO(2)(-) incubation system using cyclic voltammetry with Ru(bpy)(3)(2+) as the electroactive catalyst in solution. HRP and DNA were then further assembled into PDDA/DNA/{HRP/DNA}(2) LBL films, and the damage of DNA in the films caused by the NO(2)â€¢ radicals produced in situ by incubation of the films with H(2)O(2)+NO(2)(-) solutions was detected electrochemically. When catalase layers were assembled on the surface of PDDA/DNA/{HRP/DNA}(2) films, the DNA damage induced by the H(2)O(2)+NO(2)(-) system was inhibited since the catalase in the films could effectively decompose H(2)O(2), and the NO(2)â€¢ radicals could not be generated. This work not only provides a foundation for fabricating electrochemical biosensors in detecting NO(2)â€¢-induced DNA damage, but also offers an in vitro model to simulate the pathway of DNA damage and protection in living process.

Redox targeting of DNA anchored to MWCNTs and TiO2 nanoparticles dispersed in poly dialyldimethylammonium chloride and chitosan.

https://www.ncbi.nlm.nih.gov/pubmed/24952239

A key issue associated with electrochemical DNA-based biosensors is how to enhance DNA immobilization on the substrates. In order to improve the immobilization of DNA and to optimize DNA interaction efficiency, different kinds of strategies have been developed. In this regard, nanomaterials have attracted a great deal of attention in electrode surface modification for DNA biosensor fabrication. In this study, nanostructured films were deposited at the surface of a pencil graphite electrode (PGE) as a working electrode. For the present purpose, common polyelectrolytes are used for surface modification with double-stranded DNA. Two positively charged polyelectrolyte, namely poly dialyldimethylammonium chloride (PDDA) and chitosan, are initially compared for DNA immobilization at the surface of MWCNTs and TiO2 nanoparticles (TiO2NPs). In a second step, the basic electrochemical properties of the sensors are investigated using voltammetric methods. The

modified electrodes are also characterized by scanning electron microscopy and electrochemical impedance measurements. It will be shown that electrode modification with DNA and the nanostructure that disperses in PDDA leads to an enhanced sensitivity of the DNA voltammetric detection mechanism. In a previous study, a comparison was done between MWCNTs and TiO2NPs for determining the effect of nanoparticle effect on DNA immobilization on the electrode surface. In order to compare the efficiency of the prepared DNA-based biosensors, methylene blue is chosen as an electroactive probe. It will be shown that the stability of the immobilized DNA within several days will be much higher when MWCNTs rather than TiO2NPs are used.

Preparation and characterization of biodegradable and electroactive polymer blend materials based on mPEG/tetraaniline and PLLA.

https://www.ncbi.nlm.nih.gov/pubmed/21384553

A novel PGTA diblock copolymer containing electroactive TEA and mPEG is described. Biodegradable PLLA/PGTA polymer blends are shown to be electroactive. Nanopores of different sizes can be formed on the surface of the polymer blends. An MTT assay shows that the PLLA/PGTA blends exhibited reduced cytotoxicity as compared to TEA due to the introduction of the biocompatible PLLA moiety. Cell culture results show that the cells grow better when they were adhered to the surface of the PLLA/PGTA blends. The 80/20 wt.-% PLLA/PGTA blend shows the best biocompatibility and an electroactivity that accelerates the differentiation of rat C6 glioma cells.

Electrochemical measurement of endogenous serotonin release from human blood platelets.

https://www.ncbi.nlm.nih.gov/pubmed/21384903

Platelet aggregation in the bloodstream is tightly associated with the secretory function of platelets based on several types of cytoplasmic secretory granules, each sequestering distinct chemical messenger species. Dense-body granules are one prominent type of secretory granule responsible for storing small molecule chemical messengers. Upon platelet activation, the timely and rapid release of these small molecules is critical in facilitating platelet aggregation. Therefore, techniques capable of measuring real-time granule content release are needed to understand the fundamental properties of platelet secretion and aggregation. Existing techniques lack adequate time resolution or require potentially toxic exogenous reagents for real-time measurement of granule content release. Herein, we demonstrate a label-free electrochemical method based on the endogenous electroactive chemical messenger serotonin (5-hydroxytryptamine or 5-HT) for the real-time

measurement of dense-body granule secretion from platelet suspensions; fast-scan cyclic voltammetry (FSCV) using carbon-fiber microelectrodes was chosen on the basis of its excellent temporal resolution, high sensitivity, and the ability to provide the electrochemical signature cyclic voltammograms for molecular identification. Real-time serotonin release from thrombin-stimulated human platelet suspensions was successfully measured, and the amount and time course of the bulk serotonin release were found to agree well with data obtained from single platelet measurements, thus confirming accurate characterization of granular secretion. Furthermore, this electrochemical method was applied to study the stimulation-secretion coupling in platelets, serotonin storage and release dynamics with applied pharmacological agents, and chemical messenger storage deficiency in Hermansky-Pudlak Syndrome (HPS) platelets, and the potential of this method to reveal secretion behavior in both normal and diseased platelets has clearly been demonstrated.

Preparation of a porous composite film for the fabrication of a hydrogen peroxide sensor.

https://www.ncbi.nlm.nih.gov/pubmed/22163932

A series of dopant-type polyaniline-polyacrylic acid composite (PAn-PAA) films with porous structures were prepared and developed for an enzyme-free hydrogen peroxide (H(2)O(2)) sensor. The composite films were highly electroactive in a neutral environment as compared to polyaniline (PAn). In addition, the carboxyl group of the PAA was found to react with H(2)O(2) to form peroxy acid groups, and the peroxy acid could further oxidize the imine structure of PAn to form N-oxides. The N-oxides reverted to their original form via electrochemical reduction and increased the reduction current. Based on this result, PAn-PAA was used to modify a gold electrode (PAn-PAA/Au) as a working electrode for the non-enzymatic detection of H(2)O(2). The characteristics of the proposed sensors could be tuned by the PAA/PAn molar ratio. Blending PAA with PAn enhanced the surface area, electrocatalytic activity, and conductivity of these sensors. Under optimal conditions, the linear concentration range of the H(2)O(2) sensor was 0.04 to 12 mM with a sensitivity of 417.5 Î¼A/mM-cm(2). This enzyme-free H(2)O(2) sensor also exhibited a rapid response time, excellent stability, and high selectivity.

Synthesis and characterization of new electroactive polypyrrole-chondroitin sulphate A substrates.

https://www.ncbi.nlm.nih.gov/pubmed/18155969

Novel composite polypyrrole/chondroitin-4-sulphate films with cation-exchange properties were synthesized by the electrochemical polymerization of pyrrole in the presence of chondroitin-4-sulphate (CSA) sodium salt, acting as dopant anion at neutral pH. The negatively charged biomolecule was found to be permanently entrapped in the polypyrrole (PPy) membrane which resulted, as expected, facilitated in the mass transport by mobile cationic counterions. The porous nature of the substrates was identified as the most influential factor controlling the morphology. The morphology, in turn, affects the interaction between the material surface and the tissues on a cellular level. In this work in vitro analyses of human fibroblast response to polypyrrole/chondroitin-4-sulphate films were performed to focus on the different steps of cell reactions towards defined surface properties.

Characteristics of new composite- and classical potentiometric sensors for the determination of pioglitazone in some pharmaceutical formulations.

https://www.ncbi.nlm.nih.gov/pubmed/18555633

The construction and electrochemical response characteristics of poly(vinyl chloride) membrane sensors for pioglitazone HCl (PG) are described. The sensing membranes incorporate ion association complexes of pioglitazone cation and sodium tetraphenylborate (NaTPB) (sensor 1) or phosphomolybdic acid (PMA) (sensor 2) or phosphotungstic acid (PTA) (sensor 3) as electroactive materials. The sensors display a fast, stable and near-Nernstian response over a relative wide pioglitazone concentration range (1x10(-2) to 10(-6) M), with cationic slopes of 55.0+/-0.5, 58.0+/-0.5 and 53.0+/-0.5 mV per concentration decade over a pH range of 1.0-5.0. The sensors show good discrimination of pioglitazone from several inorganic and organic compounds. The direct determination of 2.5-3900.0 microg/ml of pioglitazone show an average recovery of 98.5, 99.0 and 98.4% and a mean relative standard deviation of 1.6, 1.5 and 1.7% at 100.0 microg/ml for sensors 1, 2 and 3, respectively. The proposed sensors have been applied for direct determination of pioglitazone in some pharmaceutical preparations. The results obtained by determination of pioglitazone in tablets using the proposed sensors are comparable favorably with those obtained using the HPLC method. The sensors have been used as indicator electrodes for potentiometric titration of pioglitazone.

Highly selective needle-type glucose sensors prepared by the immobilization of glucose oxidase on Î³-polyglutamic acid film.

https://www.ncbi.nlm.nih.gov/pubmed/21415521

Fine needle-type glucose sensors with an outer diameter of less that 0.2 mm were fabricated using a low-cost biodegradable Î³-polyglutamic acid (PGA) not only as a glucose oxidase (GOx) immobilizing material, but also as a permselective inner membrane. PGA film was prepared on a cellulose acetate-coated Pt-Ir wire electrode, and GOx was covalently immobilized on its surface using water-soluble carbodiimide. The obtained electrode was practically not affected by the existence of electroactive compounds, and provided long-term stability for approximately one month. It also functioned in horse serum with a good linear relationship between the current and glucose concentrations within the range of 2.8 to 22.4 mM.

Natural electroactive hydrogel from soy protein isolation.

https://www.ncbi.nlm.nih.gov/pubmed/21086983

A natural electroactive protein hydrogel was prepared from soy protein isolate (SPI) solution by cross-linking with epichlorohydrin. Under electrical stimulus, such SPI hydrogel quickly bends toward one electrode, showing a good electroactivity. Because of its amphoteric nature, the SPI hydrogel bends either toward the anode (pH < 6) or cathode (pH > 6), depending on the pH of the electrolyte solution. Other factors, such as electric field strength, ionic strength and gel thickness also influence the electromechanical behavior of the SPI hydrogels. Moreover, this SPI hydrogel exhibits a good electroactive behavior under strong acidic (pH = 2 - 3) or basic (pH = 11 - 12) solutions, which is a significant improvement over two other kinds of natural electroactive hydrogels, i.e., chitosan/carboxymethylcellulose and chitosan/carboxymethylchitosan hydrogel, which we reported previously. The wide pH range and good electroactivity of this natural protein hydrogel suggests its great potential for microsensor and actuator applications, especially in the biomedical field, and also to increase the scope of natural polymer-based electroactive hydrogels.

Thermoplastic polyurethane:polythiophene nanomembranes for biomedical and biotechnological applications.

https://www.ncbi.nlm.nih.gov/pubmed/24857815

Nanomembranes have been prepared by spin-coating mixtures of a polythiophene (P3TMA) derivative and thermoplastic polyurethane (TPU) using 20:80, 40:60, and 60:40 TPU:P3TMA weight ratios. After structural, topographical, electrochemical, and thermal characterization, properties typically related with biomedical applications have been investigated: swelling, resistance to both

hydrolytic and enzymatic degradation, biocompatibility, and adsorption of type I collagen, which is an extra cellular matrix protein that binds fibronectin favoring cell adhesion processes. The swelling ability and the hydrolytic and enzymatic degradability of TPU:P3TMA membranes increases with the concentration of P3TMA. Moreover, the degradation of the blends is considerably promoted by the presence of enzymes in the hydrolytic medium, TPU:P3TMA blends behaving as biodegradable materials. On the other hand, TPU:P3TMA nanomembranes behave as bioactive platforms stimulating cell adhesion and, especially, cell viability. Type I collagen adsorption largely depends on the substrate employed to support the nanomembrane, whereas it is practically independent of the chemical nature of the polymeric material used to fabricate the nanomembrane. However, detailed microscopy study of the morphology and topography of adsorbed collagen evidence the formation of different organizations, which range from fibrils to pseudoregular honeycomb networks depending on the composition of the nanomembrane that is in contact with the protein. Scaffolds made of electroactive TPU:P3TMA nanomembranes are potential candidates for tissue engineering biomedical applications.

Membrane electrodes for determination of two antihypertensive drugs in pharmaceutical formulations of either single or binary mixtures and in biological fluids.

https://www.ncbi.nlm.nih.gov/pubmed/22491186

Membrane-selective electrodes were used to determine benazepril hydrochloride (BZ) and trandolapril (TR) in their binary mixtures with hydrochlorothiazide (HZ) and verapamil (VR), respectively. This method involves construction of four water insoluble ion-association complexes: benazepril-tetraphenyl borate (BZ-TPB), benazepril-reineckate (BZ-R), trandolapril-tetraphenyl borate (TR-TPB), and trandolapril-reineckate (TR-R). These complexes were used as electroactive materials in polyvinyl chloride (PVC) matrix membrane sensors in order to determine the two aforementioned drugs in their pharmaceutical formulations and in plasma. The performance characteristics of these sensors, evaluated according to IUPAC recommendations, revealed a fast, stable, and linear response for BZ and TR. The suggested procedures were checked using laboratory-prepared mixtures and were successfully used to analyze their pharmaceutical preparations. The results obtained using the proposed method were statistically analyzed and compared with those obtained using previously reported methods.

A highly sensitive NADH sensor based on a mycelium-like nanocomposite using graphene

oxide and multi-walled carbon nanotubes to co-immobilize poly(luminol) and poly(neutral red) hybrid films.

https://www.ncbi.nlm.nih.gov/pubmed/24922539

Hybridization of poly(luminol) (PLM) and poly(neutral red) (PNR) has been successfully performed and further enhanced by a conductive and steric hybrid nanotemplate using graphene oxide (GO) and multi-walled carbon nanotubes (MWCNTs). The morphology of the PLM-PNR-MWCNT-GO mycelium-like nanocomposite is studied by SEM and AFM and it is found to be electroactive, pH-dependent, and stable in the electrochemical system. It shows electrocatalytic activity towards NADH with a high current response and low overpotential. Using amperometry, it has been shown to have a high sensitivity of 288.9 Î¼A mM(-1) cm(-2) to NADH (Eapp. = +0.1 V). Linearity is estimated in a concentration range of 1.33 Ã— 10(-8) to 1.95 Ã— 10(-4) M with a detection limit of 1.33 Ã— 10(-8) M (S/N = 3). Particularly, it also shows another linear range of 2.08 Ã— 10(-4) to 5.81 Ã— 10(-4) M with a sensitivity of 151.3 Î¼A mM(-1) cm(-2). The hybridization and activity of PLM and PNR can be effectively enhanced by MWCNTs and GO, resulting in an active hybrid nanocomposite for determination of NADH.

Semicylindrical acoustic transducer from a dielectric elastomer film with compliant electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/21877790

A semicylindrical acoustic transducer was constructed using a dielectric elastomer film with compliant electrodes that is an electroactive polymer composed of a polyurethane elastomer base and polyethylene dioxythiophene/polystyrene sulfonate electrodes. The use of this dielectric elastomer is advantageous because polyurethane is a common material that keeps its shape without any rigid frame. Because the dielectric elastomer films are essentially incompressible, electric-field-induced thickness changes are usually translated into much larger changes of the film area and side length. Here it is proposed that this change in side length can be utilized for sound generation when the film is bent into a semicylindrical shape. Accordingly, a semicylindrical acoustic transducer was fabricated using a film of thickness of 300 Î¼m and its acoustic characteristics were investigated. The transducer can be operated at low applied voltages by reducing the film thickness, as long as the film is thick enough to generate sufficient force to overcome sound radiation impedance. The second harmonic distortion of the transducer was also investigated as a function of the ratio of the direct current bias voltage to the alternating current audio signal amplitude.

Nanothorn electrodes for ionic polymer-metal composite artificial muscles.

https://www.ncbi.nlm.nih.gov/pubmed/25146561

Ionic polymer-metal composites (IPMCs) have recently received tremendous interest as soft biomimetic actuators and sensors in various bioengineering and human affinity applications, such as artificial muscles and actuators, aquatic propulsors, robotic end-effectors, and active catheters. Main challenges in developing biomimetic actuators are the attainment of high strain and actuation force at low operating voltage. Here we first report a nanostructured electrode surface design for IPMC comprising platinum nanothorn assemblies with multiple sharp tips. The newly developed actuator with the nanostructured electrodes shows a new way to achieve highly enhanced electromechanical performance over existing flat-surfaced electrodes. We demonstrate that the formation and growth of the nanothorn assemblies at the electrode interface lead to a dramatic improvement (3- to 5-fold increase) in both actuation range and blocking force at low driving voltage (1-3â€…V). These advances are related to the highly capacitive properties of nanothorn assemblies, increasing significantly the charge transport during the actuation process.

Utilization of highly purified single wall carbon nanotubes dispersed in polymer thin films for an improved performance of an electrochemical glucose sensor.

https://www.ncbi.nlm.nih.gov/pubmed/24857497

In this work we report the improved performance an electrochemical glucose sensor based on a glassy carbon electrode (GCE) that has been modified with highly purified single wall carbon nanotubes (SWCNTs) dispersed in polyethyleneimine (PEI), polyethylene glycol (PEG) and polypyrrole (PPy). The single wall carbon nanotubes were purified by both thermal and chemical oxidation to achieve maximum purity of ~98% with no damage to the tubes. The SWCNTs were then dispersed by sonication in three different organic polymers (1.0mg/ml SWCNT in 1.0mg/ml of organic polymer). The stable suspension was coated onto the GCE and electrochemical characterization was performed by Cyclic Voltammetry (CV) and Amperometry. The electroactive enzyme glucose oxidase (GOx) was immobilized on the surface of the GCE/(organic polymer-SWCNT) electrode. The amperometric detection of glucose was carried out at 0.7 V versus Ag/AgCl. The GCE/(SWCNT-PEI, PEG, PPY) gave a detection limit of 0.2,633 Î¼M, 0.434 Î¼M, and 0.9,617 Î¼M, and sensitivities of 0.2411 Â± 0.0033 Î¼A mM(-1), r(2)=0.9984, 0.08164 Â± 0.001129 Î¼A mM(-1), r(2)=0.9975, 0.04189 Â± 0.00087 Î¼A mM(-1), and r(2)=0.9944 respectively and a response time of less than 5s. The use of purified SWCNTs has several advantages, including fast

electron transfer rate and stability in the immobilized enzyme. The significant enhancement of the SWCNT modified electrode as a glucose sensor can be attributed to the superior conductivity and large surface area of the well dispersed purified SWCNTs.

Effects of crosslinking ratio, model drugs, and electric field strength on electrically controlled release for alginate-based hydrogel.

https://www.ncbi.nlm.nih.gov/pubmed/22354328

The drug release characteristics of calcium alginate hydrogels, (Ca-Alg), under an electric field assisted transdermal drug delivery system were systematically investigated. The Ca-Alg hydrogels were prepared by the solution-casting using CaCl(2) as a crosslinking agent. The diffusion coefficients and the release mechanism of the anionic model drugs, benzoic acid and tannic acid, and a cationic model drug, folic acid on the Ca-Alg hydrogels were determined and investigated using a modified Franz-Diffusion cell in an MES buffer solution of pH 5.5, at a temperature of 37Â°C, for 48 h. The influences of the crosslinking ratio, -the mole of the crosslinking agent to the mole of the alginate monomer-mesh size, model drug size, drug charge, electric field strength, and electrode polarity were systematically studied. The drug diffusion coefficient decreased with an increasing crosslinking ratio and drug size for all of the model drugs. The drug diffusion coefficient is precisely controlled by an applied electric field and the electrode polarity depending on the drug charge, suitable for a tailor-made transdermal drug delivery system.

Conjugated polymer network films of poly(p-phenylene vinylene) with hole-transporting carbazole pendants: dual photoluminescence and electrochromic behavior.

https://www.ncbi.nlm.nih.gov/pubmed/22329863

A series of poly(p-phenylene vinylene) (PPV) copolymers functionalized with hole-transport and electrochemically active carbazole units as pendant moieties is reported. These polymers exhibit photoluminescence properties by virtue of the PPV analogous backbone. They were also designed as precursor polymer bearing the electroactive carbazole group to form conjugated polymer network (CPN) films by electrodeposition. The electrochemical polymerization of the pendant units eventually lead to a dual property electro-optically active thin film - photoluminescence (PL) behavior that can be attenuated with CPN formation, and a reversible doping and dedoping processes at controlled potentials that lead to an electrochromic behavior. This reveals the ability to incorporate complementary optical and electro-optical properties within the same film using the CPN approach.

It should be possible to design and synthesize other PPV Ï€-conjugated polymers with efficient pendant hole-transport groups exhibiting tunable PL and electrochromism with cross-linking.

Rodlike macromolecules through spatial overlapping of thiophene dendrons.

https://www.ncbi.nlm.nih.gov/pubmed/21547963

Two novel dendritic macromonomers 7 and 8 functionalized with electroactive conjugated thiophene oligomers were synthesized by stepwise cross-coupling reactions and the introduction of a vinyl group at the focal point. Both macromonomers were polymerized into dendronized polymers 9 and 10 by using a radical polymerization method. The photophysical and redox behaviors of dendronized polymers 9 and 10 are significantly different from those of the corresponding macromonomers. This difference may result from the spatial overlapping of thiophene dendrons through Ï€-Ï€ interactions when the dendrons are connected to a polymer backbone. The dendronized polymers can organize into large-area two-dimensional sheets with a thickness of 4.8â€…nm. Polymer 9, which has all-dendritic thiophene side chains, exhibited enhanced conductivity by partial doping with iodine or nitrosonium tetrafluoroborate (NOBF(4)). The novel amphiphilic dendronized polymer 15 was synthesized by the atom-transfer radical polymerization of macromonomer 7 from a poly(ethylene glycol) (PEG) macroinitiator and was found to have a self-organized structure in water.

Antimicrobial applications of electroactive PVK-SWNT nanocomposites.

https://www.ncbi.nlm.nih.gov/pubmed/22091864

The antibacterial properties of a nanocomposite containing an electroactive polymer, polyvinyl-N-carbazole (PVK) (97 wt %), and single-walled carbon nanotubes (SWNT) (3 wt %) was investigated as suspensions in water and as thin film coatings. The toxic effects of four different PVK-SWNT (97:3 wt %) nanocomposite concentrations (1, 0.5, 0.05, and 0.01 mg/mL) containing 0.03, 0.015, 0.0015, and 0.0003 mg/mL of SWNT, respectively, were determined for planktonic cells and biofilms of Escherichia coli (E. coli) and Bacillus subtilis (B. subtilis). The results showed that the nanocomposite PVK-SWNT had antibacterial activity on planktonic cells and biofilms at all concentration levels. Higher bacterial inactivation (94% for E. coli and 90% for B. subtilis) were achieved in planktonic cells at a PVK-SWNT concentration of 1 mg/mL. Atomic force microscopy (AFM) imaging showed significant reduction of biofilm growth on PVK-SWNT coated surfaces. This study established for the first time that the improved dispersion of SWNTs in aqueous solutions in

the presence of PVK enhances the antimicrobial effects of SWNTs at very low concentrations. Furthermore, PVK-SWNT can be used as an effective thin film coating material to resist biofilm formation.

The intrinsic redox reactions of polyamic acid derivatives and their application in hydrogen peroxide sensor.

https://www.ncbi.nlm.nih.gov/pubmed/21496921

Polyamic acids (PAAs) containing benzothiazole (BT) and benzoxazole (BO) pendent groups (PAA-BT and PAA-BO, respectively) which possessed electroactivity were synthesized successfully. The addition of H(2)O(2) chemically oxidized the intrinsic carboxylic acid groups of PAA to form peroxy acid groups, and the peroxy acid further oxidized the electroactive sites of BT and BO to form N-oxides. The N-oxides could be reverted to their original form by electrochemical reduction, thus increasing the electrochemical reductive current. Based on this mechanism, enzyme-free hydrogen peroxide (H(2)O(2)) biosensors were prepared by modifying gold electrodes with the PAA derivatives (PAA-BT/Au and PAA-BO/Au, respectively). These biosensors had rapid response times (3.9-5.2 s) and high selectivity and sensitivity (280.6-311.2 Î¼A/mM-cm(2)). A comparison of the PAA-BT/Au and PAA-BO/Au electrodes with electrodes prepared using polyamide-BT or polyamide-BO (i.e., lacking the carboxylic acid groups) confirmed the mechanism by which PAA derivatives detect H(2)O(2). Modifying the surface morphology of the electrode from a planar to a three-dimensional (3D) configuration enhanced the performance of the PAA-BO/Au electrode. The sensitivity of the 3D-PAA-BO/Au electrode was 1394.9 Î¼A/mM-cm(2), âˆ¼ 4.5 times higher than that of the planar electrode. The detection limit was also enhanced from 5.0 to 1.43 Î¼M. The biosensor was used analytically to detect and measure H(2)O(2) in urine samples collected from healthy individuals and patients suffering from noninvasive bladder cancer. The results were promising and comparable to that measured by a classical HPLC method, which verified the developed biosensor had a potential to provide a usefully analytical approach for bladder cancer.

Microsized graphite sensors for potentiometric determination of cyclobenzaprine hydrochloride in pure powder, tablets, and plasma.

https://www.ncbi.nlm.nih.gov/pubmed/22320088

Two cyclobenzaprine hydrochloride (CZ) microsized graphite selective sensors were investigated with dibutylsebacate as a plasticizer in a polymeric matrix of carboxylated polyvinyl chloride

(PVC-COOH) in the case of sensor 1, based on the interaction between the drug and the dissociated COOH groups in the PVC-COOH. Sensor 2 was based on the interaction between the drug and ammonium reineckate, which acted as anionic electroactive material in the presence of polyvinyl chloride matrix. The two sensors were constructed by using 2-hydroxy propyl beta-cyclodextrin as an ionophore, which has a significant influence on increasing the membrane sensitivity and selectivity of both sensors. Fast and stable Nernstian responses of 1 x 10(-5) - 1 x 10(-2) and 1 x 10(-4) - 1 x 10(-2) M for the two sensors, respectively, with slopes of 58.6 and 55.5 mV/decade, respectively, over the pH range 2-4 were obtained. The proposed method displayed useful analytical characteristics for determination of CZ in its pure powder form with average recoveries 99.95 +/- 0.23 and 99.61 +/- 0.34% for sensors 1 and 2, respectively, and in plasma with good recoveries. The sensors were also used to determine the intact drug in the presence of its degradate and, thus, could be used as stability-indicating methods. The obtained results by the proposed methods were statistically analyzed and compared with those obtained by the U.S. Pharmacopeia method; no significant difference for either accuracy or precision was observed. Results obtained with the two electrodes revealed their performance characteristics, which were evaluated according to International Union of Pure and Applied Chemistry recommendations.

Graphene-based electroresponsive scaffolds as polymeric implants for on-demand drug delivery.

https://www.ncbi.nlm.nih.gov/pubmed/24799416

Stimuli-responsive biomaterials have attracted significant attention in the field of polymeric implants designed as active scaffolds for on-demand drug delivery. Conventional porous scaffolds suffer from drawbacks such as molecular diffusion and material degradation, allowing in most cases only a zero-order drug release profile. The possibility of using external stimulation to trigger drug release is particularly enticing. In this paper, the fabrication of previously unreported graphene hydrogel hybrid electro-active scaffolds capable of controlled small molecule release is presented. Pristine ball-milled graphene sheets are incorporated into a three dimensional macroporous hydrogel matrix to obtain hybrid gels with enhanced mechanical, electrical, and thermal properties. These electroactive scaffolds demonstrate controlled drug release in a pulsatile fashion upon the ON/OFF application of low electrical voltages, at low graphene concentrations (0.2 mg mL(-1)) and by maintaining their structural integrity. Moreover, the in vivo performance of these electroactive scaffolds to release drug molecules without any "resistive heating" is demonstrated. In this study, an

illustration of how the heat dissipating properties of graphene can provide significant and previously unreported advantages in the design of electroresponsive hydrogels, able to maintain optimal functionality by overcoming adverse effects due to unwanted heating, is offered.

Electroactive polyurethane/siloxane derived from castor oil as a versatile cardiac patch, part I: Synthesis, characterization, and myoblast proliferation and differentiation.

https://www.ncbi.nlm.nih.gov/pubmed/26540140

Tissue-engineered cardiac patch aims at regenerating an infarcted heart by improving cardiac function and providing mechanical support to the diseased myocardium. In order to take advantages of electroactivity, a new synthetic method was developed for the introduction of an electroactive oligoaniline into the backbone of prepared patches. For this purpose, a series of electroactive polyurethane/siloxane films containing aniline tetramer (AT) was prepared through sol-gel reaction of trimethoxysilane functional intermediate polyurethane prepolymers made from castor oil and poly(ethylene glycol). Physicochemical, mechanical, and electrical conductivity of samples were evaluated and the recorded results were correlated to their structural characteristics. The optimized films were proved to be biodegradable and have tensile properties suitable for cardiac patch application. The embedded AT moieties in the backbone of the prepared samples preserved their electroactivity with the electrical conductivity in the range of 10-4 S/cm. The prepared films were compatible with proliferation of C2C12 and had potential for enhancing myotube formation even without external electrical stimulation.

Fibronectin adsorption and cell response on electroactive poly(vinylidene fluoride) films.

https://www.ncbi.nlm.nih.gov/pubmed/22356773

Due to the large potential of electroactive materials in novel tissue engineering strategies, the aim of this work is to determine if the crystalline phase and/or the surface electrical charge of electroactive poly(vinylidene fluoride), PVDF, have influence on the biological response in monolayer cell culture. Non-polar Î±-PVDF and electroactive Î²-PVDF were prepared. The Î²-PVDF films were poled by corona discharge to show negative or positive electrical surface charge density. It has been concluded that hydrophilicity of the PVDF substrates depends significantly on crystalline phase and polarity. Furthermore, by means of atomic force microscopy and an enzyme-linked immunosorbent assay test, it has been shown that positive or negative poling strongly influences the behavior of Î²-PVDF supports with respect to fibronectin (FN) adsorption, varying the exhibition of adhesion

ligands of adsorbed FN. Culture of MC3T3-E1 pre-osteoeblasts proved that cell proliferation depends on surface polarity as well. These results open the viability of cell culture stimulation by mechanical deformation of a piezoelectric substrate that results in varying electrical charge densities on the substrate surface.

Electrocatalytic reaction of hydrogen peroxide and NADH based on poly(neutral red) and FAD hybrid film.

https://www.ncbi.nlm.nih.gov/pubmed/22046584

A simple method to immobilize poly(neutral red) (PNR) and flavin adenine dinucleotide (FAD) hybrid film (PNR/FAD) by cyclic voltammetry is proposed. The PNR/FAD hybrid film can be easily prepared on an electrode surface involving electropolymerization of neutral red (NR) monomers and the electrostatic interaction between the positively charged PNR and the negatively charged FAD. It exhibits electroactive, stable, surface-confined, pH-dependent, nano-sized, and compatible properties. It provides good electrocatalytic properties to various species. It shows a sensitivity of 5.4 Î¼A mM(-1) cm(-2) and 21.5 Î¼A mM(-1) cm(-2) for hydrogen peroxide (H(2)O(2)) and nicotinamide adenine dinucleotide (NADH) with the linear range of 0.1 Î¼M-39 mM and 5 Ã— 10(-5) to 2.5 Ã— 10(-4) M, respectively. It shows another linear range of 48.8-355.5 mM with the sensitivity of 12.3 Î¼A mM(-1) cm(-2) for H(2)O(2). In particular, the PNR/FAD hybrid film has potential to replace some hemoproteins to be a cathode of biofuel cells and provide the biosensing system for glucose and ethanol.

A PDDA/poly(2,6-pyridinedicarboxylic acid)-CNTs composite film DNA electrochemical sensor and its application for the detection of specific sequences related to PAT gene and NOS gene.

https://www.ncbi.nlm.nih.gov/pubmed/18585173

2,6-Pyridinedicarboxylic acid (PDC) was electropolymerized on the glassy carbon electrode (GCE) surface combined with carboxylic group-functionalized single-walled carbon nanotubes (SWNTs) by cyclic voltammetry (CV) to form PDC-SWNTs composite film, which was rich in negatively charged carboxylic group. Then, poly(diallyldimethyl ammonium chloride) (PDDA), a linear cationic polyelectrolyte, was electrostatically adsorbed on the PDC-SWNTs/GCE surface. DNA probes with negatively charged phosphate group at the 5' end were immobilized on the PDDA/PDC-SWNTs/GCE due to the strong electrostatic attraction between PDDA and phosphate

group of DNA. It has been found that modification of the electrode with PDC-SWNTs film has enhanced the effective electrode surface area and electron-transfer ability, in addition to providing negatively charged groups for the electrostatic assembly of cationic polyelectrolyte. PDDA plays a key role in the attachment of DNA probes to the PDC-SWNTs composite film and acts as a bridge to connect DNA with PDC-SWNTs film. The cathodic peak current of methylene blue (MB), an electroactive label, decreased obviously after the hybridization of DNA probe (ssDNA) with the complementary DNA (cDNA). This peak current change was used to monitor the recognition of the specific sequences related to PAT gene in the transgenic corn and the polymerase chain reaction (PCR) amplification of NOS gene from the sample of transgenic soybean with satisfactory results. Under optimal conditions, the dynamic detection range of the sensor to PAT gene target sequence was from 1.0x10(-11) to 1.0x10(-6) mol/L with the detection limit of 2.6x10(-12) mol/L.

Control of neural stem cell survival by electroactive polymer substrates.

https://www.ncbi.nlm.nih.gov/pubmed/21494605

Stem cell function is regulated by intrinsic as well as microenvironmental factors, including chemical and mechanical signals. Conducting polymer-based cell culture substrates provide a powerful tool to control both chemical and physical stimuli sensed by stem cells. Here we show that polypyrrole (PPy), a commonly used conducting polymer, can be tailored to modulate survival and maintenance of rat fetal neural stem cells (NSCs). NSCs cultured on PPy substrates containing different counter ions, dodecylbenzenesulfonate (DBS), tosylate (TsO), perchlorate (ClO(4)) and chloride (Cl), showed a distinct correlation between PPy counter ion and cell viability. Specifically, NSC viability was high on PPy(DBS) but low on PPy containing TsO, ClO(4) and Cl. On PPy(DBS), NSC proliferation and differentiation was comparable to standard NSC culture on tissue culture polystyrene. Electrical reduction of PPy(DBS) created a switch for neural stem cell viability, with widespread cell death upon polymer reduction. Coating the PPy(DBS) films with a gel layer composed of a basement membrane matrix efficiently prevented loss of cell viability upon polymer reduction. Here we have defined conditions for the biocompatibility of PPy substrates with NSC culture, critical for the development of devices based on conducting polymers interfacing with NSCs.

Synthesis and characterization of novel biodegradable and electroactive hydrogel based on aniline oligomer and gelatin.

https://www.ncbi.nlm.nih.gov/pubmed/22028067

A biodegradable electroactive hydrogel (AP-g-GA), aniline pentamer (AP) grafting gelatin (GA), is synthesized by a coupling reaction between the carboxyl group of AP and the amino side group of GA in aqueous solution. The electroactivity of the physical hydrogel is confirmed by UV-vis and CV. The hydrophobic AP changes the hydrogel's porous structure of the natural GA and the gel-time, which is confirmed by the rheological behavior of the AP-g-GA and GA. With an increase in the content of AP, the hydrogel gradually forms a porous structure, from "honeycomb" to "bamboo raft". The porous scaffolds can be crosslinked with 3.5% EDC in 90% ethanol. MTT assays show that the AP-g-GA exhibits reduced cytotoxicity compared to EM AP due to the introduction of the biocompatible GA moiety. The in vitro cell cultures suggest that the AP-g-GA#1 (with 1.9% AP) shows the best biocompatibility and cell adhesion ability.

In vitro studies on regulation of osteogenic activities by electrical stimulus on biodegradable electroactive polyelectrolyte multilayers.

https://www.ncbi.nlm.nih.gov/pubmed/24995801

In this study, a novel electroactive tetreaniline-containing degradable polyelectrolyte multilayer film (PEM) coating [(poly(l-glutamic acid)-graft-tetreaniline/poly(l-lysine)-graft-tetreaniline)n, (PGA-g-TA/PLL-g-TA)n] was designed and fabricated by layer-by-layer (LbL) assembly method. Compared with the nongrafted PEMs, the tetreaniline-grafted PEMs showed higher roughness and stiffness in micro/nanoscale structures. The special surface characteristics and the typical electroconductive properties were more beneficial for adhesion, proliferation, and differentiation of preosteoblast MC3T3-E1 cells. Moreover, the enhanced effects were observed on the modulation of MC3T3-E1 cells that differentiated into maturing osteoblasts, when the electroactive PEMs were coupled with electrical stimulus (ES), especially in the early phase of the osteoblast differentiation. The alkaline phosphatase (ALP) activity, calcium deposition, immunofluorescence staining, and RT-qPCR were evaluated on the differentiation of preosteoblast. These data indicate that the comprehensive effects through coupling electroactive scaffolds with electrical stimulus are better to develop bioelectric strategies to control cell functions for bone regeneration.

Design and fabrication of piezoelectric microactuators based on Î²-poly (vinylidene fluoride) films for microfluidic applications.

https://www.ncbi.nlm.nih.gov/pubmed/21096978

This paper reports a fabrication method for producing piezoelectric poly (vinylidene fluoride) films in

their electroactive Î²-phase that features controlled thickness, smooth and flat surface, and high transparency. These piezoelectric films are suitable for being used as integrated microactuators, such as piezoelectric pumps and/or mixers, in microfluidic applications. Their actuation circuit design is also reported. ATR-FTIR, UV-VIS transmittance spectroscopy and SEM techniques were used for calculating the Î²-phase content, for determining the transparency and for evaluating the morphology of the produced Î²-PVDF films, respectively. Î²-PVDF films with a thickness of about 25 Âµm were deposited by spin-coating. It was concluded that the processing parameter that mostly affect the films quality was their drying temperature. Indeed, the drying temperature of 30 Â°C proved to be the most suitable for obtaining non-porous and transparent films, with a Î²-phase content of approximately 75%.

Biodegradable and electroactive TEMPO-substituted acrylamide/lactide copolymers.

https://www.ncbi.nlm.nih.gov/pubmed/20572271

Copolymers composed of PLA and PTAm were prepared by a macromonomer approach. The PLA bearing vinyl group at chain end was copolymerized with 2,2,6,6-tetrametylpiperidine-4-ylacrylamide. The resulted copolymers were oxidized by a peroxide to give PTAm-g-PLA. The structures of the copolymers were confirmed by NMR and FTIR spectroscopy. The comparison of (1)H NMR results and SQUID measurements demonstrated that the oxidation of the PTAm fragment proceeded almost to completion. An MTT assay, cell adhesion and spreading evaluation showed that the copolymers exhibited improved cytocompatibility as compared to the PTAm homopolymer due to the introduction of the biocompatible PLA moiety.

Mechanical stimulation of epithelial cells using polypyrrole microactuators.

https://www.ncbi.nlm.nih.gov/pubmed/21842071

The importance of mechanotransduction for physiological systems is becoming increasingly recognized. The effect of mechanical stimulation is well studied in organs and tissues, for instance by using flexible tissue culture substrates that can be stretched by external means. However, on the cellular and subcellular level, dedicated technology to apply appropriate mechanical stimuli is limited. Here we report an organic electronic microactuator chip for mechanical stimulation of single cells. These chips are manufactured on silicon wafers using traditional microfabrication and photolithography techniques. The active unit of the chip consists of the electroactive polymer polypyrrole that expands upon the application of a low potential. The fact that polypyrrole can be

activated in physiological electrolytes makes it well suited as the active material in a microactuator chip for biomedical applications. Renal epithelial cells, which are responsive to mechanical stimuli and relevant from a physiological perspective, are cultured on top of the microactuator chip. The cells exhibit good adhesion and spread along the surface of the chip. After culturing, individual cells are mechanically stimulated by electrical addressing of the microactuator chip and the response to this stimulation is monitored as an increase in intracellular Ca(2+). This Ca(2+) response is caused by an autocrine ATP signalling pathway associated with mechanical stimulation of the cells. In conclusion, the present work demonstrates a microactuator chip based on an organic conjugated polymer, for mechanical stimulation of biological systems at the cellular and sub-cellular level.

Dendronized polyaniline nanotubes for cardiac tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/21595714

Today, nanobiomaterials represent a very important class of biomaterials because they differ dramatically in their bulk precursors. The properties of these materials are determined by the size and morphology, thus creating a fascinating line in their physicochemical properties. Polyaniline nanotubes (PANINTs) are one of the most promising nanobiomaterials for cardiac tissue engineering applications due to their electroactive properties. The biocompatibility and low hydrophilic properties of PANINTs can be improved by their functionalization with the highly hydrophilic polyglycerol dendrimers (PGLDs). Hydrophilicity plays a fundamental role in tissue regeneration and fundamental forces that govern the process of cell adhesion and proliferation. In this work, the biocompatible properties and cardiomyocyte proliferation onto PANINTs modified by PGLD are described. PGLDs were immobilized onto PANINTs via surface-initiated anionic ring-opening polymerization of glycidol. The microstructure and morphology of PGLD-PANINTs was determined by X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM), respectively. The cardiac cell growth on the PGLD-PANINTs was investigated. The PGLD-coated PANINTs showed noncytotoxic effects to Chinese hamster ovary cells. It was observed that the application of microcurrent stimulates the differentiation of cardiac cells cultured on PGLD-PANINTs scaffolds. The electroactive and biocompatible results of PGLD-PANINTs observed in this work demonstrate the potential of this nanobiomaterial for the culture of cardiac cells and open the possibility of using this material as a biocompatible electroactive three-dimensional matrix in cardiac tissue engineering.

Material strategies for black-to-transmissive window-type polymer electrochromic devices.

https://www.ncbi.nlm.nih.gov/pubmed/21395243

Black-to-transmissive switching polymer electrochromic devices (ECDs) were designed using a set of spray-processable cathodically coloring polymers, a non-color-changing electroactive polymer poly(2,2,6,6-tetramethylpiperidinyloxy-4-yl methacrylate) (PTMA) as the charge-compensating counter electrode, and a highly conducting gel electrolyte (6.5 mS cm(-1)). The color "black" was obtained by utilizing (1) individual copolymers absorbing across the visible spectrum, and (2) blends and bilayers of several polymer electrochromes with complementary spectral absorption. Neutral-state black and ink-like dark purple-blue (or "ink-black") donor-acceptor (DA) copolymers composed of the electron-donor 3,4-propylenedioxythiophene (ProDOT) and the electron-acceptor 2,1,3-benzothiadiazole (BTD) building units, which possess relatively homogeneous absorption profiles across the visible spectrum, were chosen for their propensity to switch to transmissive states upon electrochemical oxidation. A blend of magenta and cyan polymers (PProDOT-(CH(2)OEtHx)(2) and P(ProDOT-BTD-ProDOT), respectively) was produced with the goal of generating the same dark purple-blue color as that obtained with the "ink-black" DA copolymer. While the multi-polymer ECDs demonstrate high contrasts (up to 50%T), and switch from a saturated purple-blue color (L*=32, a*=13, b*=-46) to a light green-blue transmissive state (L*=83, a*=-3, b*=-6), devices made with the DA electrochromic copolymers switch more than two times faster (0.7 s to attain 95% of the full optical change) than those involving the polymer blends (1.6 s), and exhibit more neutral achromatic colors (L*=38, a*=5, b*=-25 for the colored state and L*=87, a*=-3, b*=-2 for the bleached state, correspondingly). The results obtained suggest that these materials should prove to be applicable in both transmissive- (window-type) and reflective-type ECDs.

Synthesis and characterization of 5-octylthieno[3,4-c]pyrrole-4,6-dione derivatives as new monomers for conjugated copolymers.

https://www.ncbi.nlm.nih.gov/pubmed/21114275

An efficient route for the synthesis of 1-iodo-5-octyl-4H-thieno[3,4-c]pyrrole-4,6(5H)-dione as a key intermediate to build new electron-deficient monomers and related conjugated polymers is reported. Along these lines, two new low bandgap copolymers were synthesized from Stille or Suzuki coupling. These polymers were characterized and their properties compared to those of analogous conjugated polymers.

Biosynthesis and characterization of organosoluble conjugated poly(2-aminofluorene) with the pyrazine bridged.

https://www.ncbi.nlm.nih.gov/pubmed/20815396

In this paper, the results on horseradish peroxidase (HRP)-catalyzed oxidative polymerization of amine-functionalized fluorene monomer, 2-amino fluorene (AF), are reported. The resulting polymer exhibits an exciting molecular structure and spectral properties. FT-IR and NMR studies show that the two fluorene units come together by forming an intermediate six-membered pyrazine ring and these formed dimeric units are linked to the each other through C-C couplings to produce fully conjugated polymer structure (AFP). Further characterizations were performed by means of GPC, TGA, DSC, SEM, CV (cyclic voltammetry), fluorescence analyses, and solubility tests. Optical band gaps of this electroactive polymer was found to be 2.60 eV. AFP emits red light and its emission maxima is drastically affected by the kind of the solvents used. In addition, obtained polymer is soluble in common polar and apolar organic solvents.

Evaluation of hydrolysis and fermentation rates in microbial fuel cells.

https://www.ncbi.nlm.nih.gov/pubmed/21347728

This study determined the influence of substrate degradation on power generation in microbial fuel cells (MFCs) and microbial community selection on the anode. Air cathode MFCs were fed synthetic medium containing different substrates (acetate, glucose and starch) using primary clarifier sewage as source of electroactive bacteria. The complexity of the substrate affected the MFC performance both for power generation and COD removal. Power output decreased with an increase in substrate complexity from 99Â±2 mWm(-2) for acetate to 4Â±2 mWm(-2) for starch. The organic matter removal and coulombic efficiency (CE) of MFCs with acetate and glucose (82% of COD removal and 26% CE) were greater than MFCs using starch (60% of COD removal and 19% of CE). The combined hydrolysis-fermentation rate obtained (0.0024 h(-1)) was considerably lower than the fermentation rate (0.018 h(-1)), indicating that hydrolysis of complex compounds limits current output over fermentation. Statistical analysis of microbial community fingerprints, developed on the anode, showed that microbial communities were enriched according to the type of substrate used. Microbial communities producing high power outputs (fed acetate) clustered separately from bacterial communities producing low power outputs (fed complex compounds).

Overoxidized polypyrrole/graphene nanocomposite with good electrochemical performance

as novel electrode material for the detection of adenine and guanine.

https://www.ncbi.nlm.nih.gov/pubmed/25022509

Most conducting polymer/graphene composites have excellent electrical conductivity. However, the background currents of these composites modified electrodes are much larger. In order to improve the sensitivities of these methods, it is necessary to decrease the background signal. In this paper, porous structure films of overoxidized polypyrrole/graphene (PPyox/GR) have been electrochemically coated onto glassy carbon electrode (GCE) and successfully utilized as an efficient electrode material for the quantitive detection of adenine and guanine, two of the most important components of DNA and RNA. The permselective polymer coatings with low background current could improve the selectivity and sensitivity of microelectrodes for the electropositive purine bases. The GRs into these polymers would further improve sensitivity by increasing the electroactive surface area. The electrochemical sensor can be applied to the quantification of adenine and guanine with a linear range covering 0.06-100 ÂµM and 0.04-100 ÂµM, and a low detection limit of 0.02 Î¼M and 0.01 Î¼M, respectively. More importantly, the proposed method was applied to quantify adenine and guanine in calf thymus DNA with satisfactory results.

Bioelectrochemical control of neural cell development on conducting polymers.

https://www.ncbi.nlm.nih.gov/pubmed/20864170

Electrically conducting polymers hold promise for developing advanced neuroprostheses, bionic systems and neural repair devices. Among them, poly(3, 4-ethylenedioxythiophene) doped with polystyrene sulfonate (PEDOT:PSS) exhibits superior physicochemical properties but biocompatibility issues have limited its use. We describe combinations of electrochemical and molecule self-assembling methods to consistently control neural cell development on PEDOT:PSS while maintaining very low interfacial impedance. Electro-adsorbed polylysine enabled long-term neuronal survival and growth on the nanostructured polymer. Neurite extension was strongly inhibited by an additional layer of PSS or heparin, which in turn could be either removed electrically or further coated with spermine to activate cell growth. Binding basic fibroblast growth factor (bFGF) to the heparin layer inhibited neurons but promoted proliferation and migration of precursor cells. This methodology may orchestrate neural cell behavior on electroactive polymers, thus improving cell/electrode communication in prosthetic devices and providing a platform for tissue repair strategies.

Mediator-free amperometric glucose biosensor based on glucose oxidase entrapped in poly(vinyl alcohol) matrix.

https://www.ncbi.nlm.nih.gov/pubmed/20877902

A simple and novel amperometric biosensor for glucose detection is proposed. It is based on the immobilization of glucose oxidase (GOx) in a poly(vinyl alcohol) (PVA) matrix directly drop casted on a platinum electrode surface (Pt/GOx-PVA). Glucose was determined in the absence of a mediator used to transfer electrons between the electrode and the enzyme. The correlation between peak current (i(p)) and scan rate has been verified and the effect of pH solution has been checked. Glucose detection has been performed amperometrically at -400 mV by using pulsed amperometric detection (PAD). Under the selected optimal conditions, the biosensor showed low detection limit (10 Î¼M), wide dynamic range (0.1-37 mM) and high sensitivity. The biosensor amperometric response revealed it to be specific to glucose without significant interference from other sugars and electroactive species coexisting with glucose in biological fluids. Response stability was another interesting feature of the developed system as it was almost completely recovered when the biosensor was left in opportune storage conditions (i.e., a response decrease of only 13% after 35 days in air at room temperature). Finally, X-Ray Photoelectron Spectroscopy (XPS) characterization revealed a homogeneous film deposited on the Pt substrate whose structure is also preserved under operative conditions.

RAFT "grafting-through" approach to surface-anchored polymers: Electrodeposition of an electroactive methacrylate monomer.

https://www.ncbi.nlm.nih.gov/pubmed/21337014

The synthesis of homopolymer and diblock copolymers on surfaces was demonstrated using electrodeposition of a methacrylate-functionalized carbazole dendron and subsequent reversible addition-fragmentation chain transfer (RAFT) "grafting-through" polymerization. First, the anodically electroactive carbazole dendron with methacrylate moiety (G1CzMA) was electrodeposited over a conducting surface (i.e. gold or indium tin oxide (ITO)) using cyclic voltammetry (CV). The electrodeposition process formed a crosslinked layer of carbazole units bearing exposed methacrylate moieties. This film was then used as the surface for RAFT polymerization process of methyl methacrylate (MMA), styrene (S), and tert-butyl acrylate (TBA) in the presence of a free RAFT agent and a free radical initiator, resulting in grafted polymer chains. The molecular weights and the polydispersity indices (PDI) of the sacrificial polymers were determined by gel permeation

chromatography (GPC). The stages of surface modification were investigated using X-ray photoelectron spectroscopy (XPS), ellipsometry, and atomic force microscopy (AFM) to confirm the surface composition, thickness, and film morphology, respectively. UV-Vis spectroscopy also confirmed the formation of an electro-optically active crosslinked carbazole film with a [Formula: see text] - [Formula: see text] absorption band from 450-650nm. Static water contact angle measurements confirmed the changes in surface energy of the ultrathin films with each modification step. The controlled polymer growth from the conducting polymer-modified surface suggests the viability of combining electrodeposition and grafting-through approach to form functional polymer ultrathin films.

Fabrication of an implantable fine needle-type glucose sensor using gamma-polyglutamic acid.

https://www.ncbi.nlm.nih.gov/pubmed/20467129

Implantable fine needle-type glucose sensors with an outer diameter of less that 0.2 mm were fabricated using a low-cost and non-animal origin polyamide, gamma-polyglutamic acid (PGA) as a glucose oxidase (GOx) immobilizing material. Two types of PGA, gamma-polyglutamic acid (PGAH) and gamma-polyglutamic acid sodium salt (PGANa), were employed to prepare GOx immobilized film by the covalent attachment of GOx using water-soluble carbodiimide (EDC). Nafion/cellulose acetate composite film and polyurethane/polydimethylsiloxane composite film were employed as a permselective inner film and a biocompatible outer film, respectively. The procedure of enzyme-immobilized film fabrication affected the stability of the sensor; that is, GOx immobilized film prepared by pouring a mixture solution of GOx and EDC on a PGA precoated surface showed higher sensor stability than that prepared by pouring a mixture solution of GOx, PGA and EDC. Although, obvious differences in the sensor properties were not observed between the use of PGANa and PGAH, the electrode prepared with PGAH had a lower swelling degree. The glucose sensors prepared with both PGANa and PGAH were practically not affected by the existence of electroactive compounds, such as uric acid, and provided long-term stability for approximately 5 weeks. These sensors also showed good performance in horse serum.

Synthesis of covalently attached hexadecaanilines on carbon nanotubes: toward electronic nanocarbon preparation.

https://www.ncbi.nlm.nih.gov/pubmed/20644756

We describe the direct covalent-grafting synthesis of well-defined aniline oligomers, such as tetraaniline (A(4)) and hexadecaaniline (A(16), major)/eicosaaniline (A(20), minor), on the sidewalls of carbon nanotubes (CNTs), via dediazonization reaction, for achieving highly soluble nanomaterials suitable for printing purposes, with long-term physical stability. Chemically grafting a layer of electroactive hexadecaanilines on CNTs resembles semiconductive encapsulation of functionalized CNTs. The resulting covalent nanoconjugates SWNT-(A(4))(x), MWNT-(A(4))(x), SWNT-(A(16/20))(x), and MWNT-(A(16/20))(x) were characterized by various spectroscopic and microscopic mapping methods. The combination of transmission electron microscopy (TEM) and electron energy loss spectroscopy (EELS) analyses provided direct evidence for A(16/20) attachment to the CNTs, giving confirmation of the presence of heteroatoms surrounding the CNTs that was absent in the parent CNTs. Subsequent atom mapping in the vicinity of the tube structure allowed us to illustrate the 3D distribution of heteroatoms along the CNT surface.

Analytical applications of microbial fuel cells. Part II: Toxicity, microbial activity and quantification, single analyte detection and other uses.

https://www.ncbi.nlm.nih.gov/pubmed/24906984

Microbial fuel cells were rediscovered twenty years ago and now are a very active research area. The reasons behind this new activity are the relatively recent discovery of electrogenic or electroactive bacteria and the vision of two important practical applications, as wastewater treatment coupled with clean energy production and power supply systems for isolated low-power sensor devices. Although some analytical applications of MFCs were proposed earlier (as biochemical oxygen demand sensing) only lately a myriad of new uses of this technology are being presented by research groups around the world, which combine both biological-microbiological and electroanalytical expertises. This is the second part of a review of MFC applications in the area of analytical sciences. In Part I a general introduction to biological-based analytical methods including bioassays, biosensors, MFCs design, operating principles, as well as, perhaps the main and earlier presented application, the use as a BOD sensor was reviewed. In Part II, other proposed uses are presented and discussed. As other microbially based analytical systems, MFCs are satisfactory systems to measure and integrate complex parameters that are difficult or impossible to measure otherwise, such as water toxicity (where the toxic effect to aquatic organisms needed to be integrated). We explore here the methods proposed to measure toxicity, microbial metabolism, and, being of special interest to space exploration, life sensors. Also, some methods with higher

specificity, proposed to detect a single analyte, are presented. Different possibilities to increase selectivity and sensitivity, by using molecular biology or other modern techniques are also discussed here.

Polyazetidine-coated microelectrodes: electrochemical and diffusion characterization of different redox substrates.

https://www.ncbi.nlm.nih.gov/pubmed/21192663

The present paper reports on the diffusion characteristics and electron transfer properties of a membrane obtained from polyazetidine prepolymer (PAP) consisting of repeating units of 1-(aminomethyl)-1-{2-[(6-oxyhexane)amino]ethyl}-3-hydroxyazetidinium chloride studied in the presence of seven simple redox electroactive molecules: ABTS, catechol, dopamine, ferrocenecarboxylic acid, ferricyanide, ferrocyanide, and the osmium complex bis(2,2-bipyridyl)-4-aminomethylpyridine chloride hexafluorophosphate (Os[(bpy)(2) 4-AMP Cl](+)). Using water as medium, the apparent diffusion coefficients (D(app)), the concentrations of the compounds in the membrane, and the heterogeneous rate constants (k(s)) were calculated as a function of temperature, and the influence thereof on these parameters was evaluated. Even if D(app) and k(s) values in the presence of PAP are smaller than in solution, this decrease is small enough to indicate that the PAP membrane shows excellent diffusion and electron-exchange properties with respect to other commonly used membranes reported in the literature.

Electrochromic thin films from a redox active diarylethene by electrochemical polymerization.

https://www.ncbi.nlm.nih.gov/pubmed/21137810

A diarylethene substituted with 3,4-(propane-1,3-diyldioxy)thiophene (ProDOT) was synthesized to induce electrochemical deposition of diarylethenes. The ProDOT substituted diarylethene (BTFPP) showed reversible photochromism from colorless to purple upon exposure to a UV light and bleached to colorless by a visibly light. The oxidation potential of the new ProDOT substituted diarylethene was lower than that of the unsubstituted diarylethenes due to the electroactive ProDOT unit. Under an electrochemical condition, the solution of BTFPP gave soluble polymers but deposited insoluble film on a working electrode coated with a PEDOT layer. This result indicates that the PEDOT nano layer (68 nm thick) function as a seeding layer to induce polymerization and electrodeposition of BTFPP. Furthermore electro-copolymerization using a mixture of BTFPP and

EDOT afforded electrodeposition of the copolymers on the PEDOT seeding layer. An electrochromic electrode was successfully fabricated by depositing the photochromic BTFPP on an ITO glass, which shows a reversible electrochromic change from violet to sky blue.

Insights into the formation and operation of polyaniline sulfonate/cytochrome c multilayer electrodes: contributions of polyelectrolytes' properties.

https://www.ncbi.nlm.nih.gov/pubmed/20882225

The multilayer formation of two different sulfonated polyanilines with cytochrome c is presented and mechanistic aspects of the contributions of the polyelectrolytes' properties to the characteristics of the assemblies are discussed. These two modified polymers, PASA1 and PASA2 are chemically synthesized and differ in the grade of sulfonation, substitution, and the chain length of the polymer. The influence of these properties on the multilayer assembly with cytochrome c is studied in detail by Quartz Crystal Microbalance (QCM) technique and Cyclic Voltammetry (CV). It is shown that the multilayer formation is successful, however, the redox activity of polyanilines itself has to be taken into account. In the case of a strong redox activity (PASA2) voltammetric analysis allows the separation of redox processes addressed to the polyelectrolyte and cyt c. For multilayers with PASA1 as building block electroactivity can be predominantly attributed to cyt c ensuring a high amount of electroactive protein and a low probability for interfering redox reaction, making this system suitable for biosensor applications.

Mycotoxin detection on antibody-immobilized conducting polymer-supported electrochemically polymerized acacia gum.

https://www.ncbi.nlm.nih.gov/pubmed/21078291

Electrochemical polymerization of acacia gum (AG) was initiated by electroactive polyaniline (PANI) monomers by radical cation formation and their coupling reactions with AG molecules. R(CT) values obtained from electrochemical impedance spectroscopy analysis at various AG concentrations with PANI were drastically decreased, confirming formation of conducting AG complexes with PANI. Quantitative analysis of ochratoxin-A (OTA) detection in electrolyte was carried out on rabbit antibody-immobilized PANI and PANI-AG matrices. The observed sensitivities of 50, 150, and 250 mg AG-added PANI matrix-based platforms were 3.3 Â± 0.5, 10.0 Â± 0.5, and 12.7 Â± 0.5 Î¼A/ng/ml, respectively. The sensitivity of only PANI electrodes was 2.6 Â± 0.3 Î¼A/ng/ml, which was relatively lower than AG-added PANI. This increase was due to the presence of glycan

functional groups in AG molecules that supported the retention of activity of antibodies. In addition, enhanced electron transportation at AG-PANI film surface was observed due to formation of an electroactive polymer film of two different electroactive functions to contribute toward enhancement in the detection sensitivity.

Prussian blue mediated amplification combined with signal enhancement of ordered mesoporous carbon for ultrasensitive and specific quantification of metolcarb by a three-dimensional molecularly imprinted electrochemical sensor.

https://www.ncbi.nlm.nih.gov/pubmed/25240126

In this work, we presented a three-dimensional (3D) molecularly imprinted electrochemical sensor (MIECS) with novel strategy for ultrasensitive and specific quantification of metolcarb based on prussian blue (PB) mediated amplification combined with signal enhancement of ordered mesoporous carbon. The molecularly imprinted polymers were synthesized by electrochemically induced redox polymerization of para aminobenzoic acid (p-ABA) in the presence of template metolcarb. Ordered mesoporous carbon material (CMK-3) was introduced to enhance the electrochemical response by improving the structure of the modified electrodes and facilitating charge transfer processes of PB which was used as an inherent electrochemical active probe. The modification process for the working electrodes of the MIECS was characterized by scanning electron microscope (SEM) and cyclic voltammetry (CV), and several important parameters controlling the performance of the MIECS were investigated and optimized in detail. The MIECS with 3D structure had the advantages of ease of preparation, high porous surface structure, speedy response, ultrasensitivity, selectivity, reliable stability, good reproducibility and repeatability. Under the optimal conditions, the MIECS offered an excellent current response for metolcarb in the linear response range of 5.0 Ã— 10(-10)-1.0 Ã— 10(-4) mol L(-1) and the limit of detection (LOD) was calculated to be 9.3 Ã— 10 (-11)mol L(-1) (S/N = 3). The proposed MIECS has been successfully applied for the determination of metolcarb in real samples with satisfactory recoveries. Furthermore, the construction route of this ultrasensitive 3D MIECS may provide a guideline for the determination of non-electroactive analytes in environmental control and food safety.

Guidance of neurite outgrowth on aligned electrospun polypyrrole/poly(styrene-beta-isobutylene-beta-styrene) fiber platforms.

https://www.ncbi.nlm.nih.gov/pubmed/20694967

The purpose of this work was to investigate the potential biomedical application of novel aligned electrospun polypyrrole (PPy)/poly(styrene-beta-isobutylene-beta-styrene) (SIBS) fibers. After successfully aligning the electroactive PPy/SIBS fibers based on our modified electrospinning method, we demonstrated that neurite outgrowth from PC12 cells could be highly orientated parallel to the aligned PPy/SIBS fibers. Physical interactions between the nerve cells and PPy/SIBS fibers through filopodia "sensing" were observed using atomic force microscopy. These observations indicate a role of contact guidance as a mechanism for the observed alignment. This work highlights the capacity for electroactive PPy/SIBS fibers to support and guide nerve cell differentiation through topographic cues, which is a highly desirable characteristic in medical implants for neurological applications.

Electrochemistry of carbon nanotubes: reactive processes, dual sensing-actuating properties and devices.

https://www.ncbi.nlm.nih.gov/pubmed/22447630

Single-walled carbon nanotubes (SWCNT) embedded in a non-electroactive polymer are electrochemically characterized. The increasing voltammetric maximums obtained with rising temperature or electrolyte concentration point to a chemical nature of the processes. The chemical kinetic control of the processes is corroborated by its empirical chemical kinetics: the initial reaction rates are obtained from the chronoamperometric responses to potential steps. The activation energy of the reaction includes information about the structural state of the SWCNT before the potential step. Under constant current the potential evolution (chronopotentiometric response) and consumed electrical energy at any time change as a function of (are sensors of) the experimental temperature or the electrolyte concentration. The reactive material, or any device based on this material, senses these working variables, and shows dual and simultaneous actuating-sensing properties.

Electropolymerization molecularly imprinted polymer (E-MIP) SPR sensing of drug molecules: pre-polymerization complexed terthiophene and carbazole electroactive monomers.

https://www.ncbi.nlm.nih.gov/pubmed/21081269

A novel chemosensitive ultrathin film with high selectivity was developed for the detection of naproxen, paracetamol, and theophylline using non-covalent electropolymerized molecular imprinted polymers (E-MIP). A series of monofunctional and bifunctional H-bonding terthiophene and

carbazole monomers were compared for imprinting these drugs without the use of a separate cross-linker. A key step is the fast and efficient potentiostatic method of washing the template, which facilitated enhanced real-time sensing by surface plasmon resonance (SPR) spectroscopy. Various surface characterizations (contact angle, ellipsometry, XPS, AFM) of the E-MIP film verified the templating and release of the drug from the cross-linked conducting polymer film.

Nanoparticle formation and ultrathin film electrodeposition of carbazole dendronized polynorbornenes prepared by ring-opening metathesis polymerization.

https://www.ncbi.nlm.nih.gov/pubmed/20942447

We report on the synthesis, electropolymerization, and nanoparticle formation of a series of electroactive carbazole-terminated dendronized linear polynorbornenes prepared by living ring-opening metathesis polymerization (ROMP). The molecular weight (MW) of the dendronized polymers was controlled by varying the feed ratio between the dendronized monomer and first-generation Grubbs' catalyst. Ultrathin films were prepared by electrodeposition. The electrochemical behavior and viscoelastic properties of such films were found to be highly dependent on the dendron generation and linear polymer MW as studied by electrochemical quartz crystal microbalance (E-QCM). Moreover, nanoparticle formation and size/shape control were observed by tuning the surface wetting properties of the substrate during adsorption and by intramolecular cross-linking via chemical oxidation in solution.

Electrochemistry of cytochrome P450 enzyme on nanoparticle-containing membrane-coated electrode and its applications for drug sensing.

https://www.ncbi.nlm.nih.gov/pubmed/18164676

In the current study, we describe an improved system to study the two-electron delivery reaction pathway of cytochrome P450, family 2, subfamily B, polypeptide 6 (CYP2B6) in vitro. In particular, a biocompatible film containing colloidal gold nanoparticles and chitosan was used to encapsulate CYP2B6 on an electrode. The electrocatalytic behaviors of CYP2B6 toward common drugs in the absence of NADHP-cytochrome P450 reductase as electron donor were studied. In an anaerobic solution, direct and reversible electron transfer between the electroactive heme center of CYP2B6 and the electrode was observed with a formal potential of -0.454 +/- 0.006 V at pH 7.4. In an air-saturated solution, an increase in the bioelectrocatalytic reduction current was observed after drug addition. The bioelectrocatalytic products were analyzed using high-performance liquid

chromatography (HPLC) and electrospray ionization-mass spectrometry (ESI-MS). Both results confirmed that C-hydroxylation and heteroatom release were the main pathways for CYP2B6-mediated drug oxidation, similar to what occurred in vivo. The use of immobilized proteins in nanoparticle-containing films in drug biosensing was also demonstrated.

pH-, sugar-, and temperature-sensitive electrochemical switch amplified by enzymatic reaction and controlled by logic gates based on semi-interpenetrating polymer networks.

https://www.ncbi.nlm.nih.gov/pubmed/22239642

Phenylboronic acid (PBA) moieties are grafted onto the backbone of poly(acrylic acid) (PAA), forming the PAA-PBA polyelectrolyte. The semi-interpenetrating polymer network (semi-IPN) films composed of PAA-PBA and poly(N,N-diethylacrylamide) (PDEA) were then synthesized on electrode surface with entrapped horseradish peroxidase (HRP), designated as PDEA-(PAA-PBA)-HRP. The films demonstrated reversible pH-, fructose-, and thermo-responsive on-off behavior toward electroactive probe K(3)Fe(CN)(6) in its cyclic voltammetric (CV) response. This multiswitchable CV behavior of the system could be further employed to control and modulate the electrochemical reduction of H(2)O(2) catalyzed by HRP immobilized in the films with K(3)Fe(CN)(6) as the mediator in solution. The responsive mechanism of the system was also explored and discussed. The pH-sensitive property was attributed to the electrostatic interaction between the PAA component of the films and the probe at different pH; the thermo-responsive behavior originated from the structure change of PDEA hydrogel component of the films with temperature; the fructose-sensitive property was ascribed to the structure change of the films induced by the complexation between the PBA constituent and the sugar. This smart system could be used as a 3-input logic network composed of enabled OR (EnOR) gates in chemical or biomolecular computing by combining the multiresponsive property of the films and the amplification effect of bioelectrocatalysis and demonstrated the potential perspective for fabricating novel multiswitchable electrochemical biosensors and bioelectronic devices.

Electrochemical characterization of a single-walled carbon nanotube electrode for detection of glucose.

https://www.ncbi.nlm.nih.gov/pubmed/20541640

We developed glucose biosensing electrodes using single-walled carbon nanotube (SWCNT) films on flexible, transparent poly(ethylene terephthalate). The homogeneous SWCNT films were

fabricated by a vacuum filtration method, and the averaged resistivity and transparency of the fabricated flexible SWCNT films were 400 Omega sq(-1) and 80%, respectively. The glucose sensing electrodes were constructed by encapsulating glucose oxidase (GOx) by Nafion binder into the SWCNT film, and the variation in current response as a function of enzyme loading amount, Nafion thickness were investigated. 30 mg mL(-1) GOx and 2% Nafion was optimal for the detection of glucose. When ferrocene monocarboxylic acid (FMCA) was introduced as diffusional electron mediator, the current responses toward glucose of the Nafion/GOx/SWCNT electrodes in glucose solution containing FMCA were dramatically improved, and the developed sensor was independent of oxygen. In the application of GOx immobilized SWCNT films for glucose detection, a linear electrical response was observed for concentrations ranging from 0.25 to 3.0 mM, and the detection limit and the sensitivity were assessed to be 97 microM and 9.32 microA mM(-1) cm(-2), respectively. Moreover, according to the Lineweaver-Burk plot, the apparent Michaelis-Menten constant was calculated to be 23.8 mM, and the current responses did not interfere with coexisting electroactive species, indicating that Nafion is an effective permselective polymer barrier.

Combined voltammetric and spectroscopic analysis of small molecule-biopolymer interactions: the levodopa and serum albumin system.

https://www.ncbi.nlm.nih.gov/pubmed/22265536

An analytical method was researched for the simultaneous determination of reactants and products during the binding of important small molecules such as levodopa (LD) with biopolymers such as bovine serum albumin (BSA). Voltammetry and fluorescence spectroscopy were used to obtain the analytical profiles from different reactant mixtures as a function of concentration. This enabled the extraction of the equilibrium constants (K(SV)) which are reported for the first time. Voltammetric results supported the formation of the LD-BSA complex but not that with dopamine. Further information of the LD-BSA system was unattainable because the measured composite profiles could not be extracted. New information was obtained when the extended data matrix was resolved by the MCR-ALS method. The previously unavailable extracted voltammogram profile of LD-BSA complex indicated that the complex was electroactive; this was unexpected if the LD-BSA system was in its folded state, and hence, it was suggested that the protein must be unfolded. The observation that the drug:BSA stoichiometry was 3:1, i.e. (levodopa)(3)-BSA, supported this suggestion; these results were obtained from the MCR-ALS extracted concentration profiles for the three reaction components.

Optimizing PANi doped electroactive substrates as patches for the regeneration of cardiac muscle.

https://www.ncbi.nlm.nih.gov/pubmed/21373812

In scaffold aided regeneration of muscular tissue, composite materials are currently utilized as a temporary substrate to stimulate tissue formation by controlled electrochemical signals as well as continuous mechanical stimulation until the regeneration processes are completed. Among them, composites from the blending of conductive (CPs) and biocompatible polymers are powerfully emerging as a successful strategy for the regeneration of myocardium due to their unique conductive and biological recognition properties able to assure a more efficient electroactive stimulation of cells. Here, different composite substrates made of synthesized polyaniline (sPANi) and polycaprolactone (PCL) were investigated as platforms for cardiac tissue regeneration. Preliminary, a comparative analysis of substrates conductivity performed on casted films endowed with synthesized polyaniline (sPANi) short fibres or blended with emeraldine base polyaniline (EBPANi) allows to study the attitude of charge transport, depending on the conducting filler amount, shape and spatial distribution. In particular, conducibility tests indicated that sPANi short fibres provide a more efficient transfer of electric signal due to the spatial organization of electroactive needle-like phases up to form a percolative network. On the basis of this characterization, sPANi/PCL electrospun membranes have been also optimized to mimic either the morphological and functional features of the cardiac muscle ECM. The presence of sPANi does not relevantly affect the fibre architecture as confirmed by SEM/image analysis investigation which shows a broader distribution of fibres with only a slight reduction of the average fibre diameter from 7.1 to 6.4 Î¼m. Meanwhile, biological assays--evaluation of cell survival rate by MTT assay and immunostaining of sarcomeric Î±-actinin of cardiomyocites-like cells--clearly indicate that conductive signals offered by PANi needles, promote the cardiogenic differentiation of hMSC into cardiomyocite-like cells. These preliminary results concur to promise the development of electroactive biodegradable substrates able to efficiently stimulate the basic cell mechanisms, paving the way towards a new generation of synthetic patches for the support of the regeneration of damaged myocardium.

Periodic macroporous nanocrystalline antimony-doped tin oxide electrode.

https://www.ncbi.nlm.nih.gov/pubmed/21391718

Optically transparent and electrically conductive electrodes are ubiquitous in the myriad world of

devices. They are an indispensable component of solar and photoelectrochemical cells, organic and polymer light emitting diodes, lasers, displays, electrochromic windows, photodetectors, and chemical sensors. The majority of the electrodes in such devices are made of large electronic band-gap doped metal oxides fashioned as a dense low-surface-area film deposited on a glass substrate. Typical transparent conducting oxide materials include indium-, fluorine-, or antimony-doped tin oxides. Herein we introduce for the first time a transparent conductive periodic macroporous electrode that has been self-assembled from 6 nm nanocrystalline antimony-doped tin oxide with high thermal stability, optimized electrical conductivity, and high quality photonic crystal properties, and present an electrochemically actuated optical light switch built from this electrode, whose operation is predicated on its unique combination of electrical, optical, and photonic properties. The ability of this macroporous electrode to host active functional materials like dyes, polymers, nanocrystals, and nanowires provides new opportunities to create devices with improved performance enabled by the large area, spatially accessible and electroactive internal surface.

Cytochrome c/polyelectrolyte multilayers investigated by E-QCM-D: effect of temperature on the assembly structure.

https://www.ncbi.nlm.nih.gov/pubmed/21634413

Protein multilayers, consisting of cytochrome c (cyt c) and poly(aniline sulfonic acid) (PASA), are investigated by electrochemical quartz crystal microbalance with dissipation monitoring (E-QCM-D). This technique reveals that a four-bilayer assembly has rather rigid properties. A thickness of 16.3 Â± 0.8 nm is calculated with the Sauerbrey equation and is found to be in good agreement with a viscoelastic model. The electroactive amount of cyt c is estimated by the deposited mass under the assumption of 50% coupled water. Temperature-induced stabilization of the multilayer assembly has been investigated in the temperature range between 30 and 45 Â°C. The treatment results in a loss of material and a contraction of the film. The electroactive amount of cyt c also decreases during heating and remains constant after the cooling period. The contraction of the film is accompanied by the enhanced stability of the assembly. In addition, it is found that cyt c and PASA can be assembled at higher temperatures, resulting in the formation of multilayer systems with less dissipation.

Myoglobin-biomimetic electroactive materials made by surface molecular imprinting on silica beads and their use as ionophores in polymeric membranes for potentiometric transduction.

https://www.ncbi.nlm.nih.gov/pubmed/21683568

Myoglobin (Mb) is among the cardiac biomarkers playing a major role in urgent diagnosis of cardiovascular diseases. Its monitoring in point-of-care is therefore fundamental. Pursuing this goal, a novel biomimetic ionophore for the potentiometric transduction of Mb is presented. It was synthesized by surface molecular imprinting (SMI) with the purpose of developing highly efficient sensor layers for near-stereochemical recognition of Mb. The template (Mb) was imprinted on a silane surface that was covalently attached to silica beads by means of self-assembled monolayers. First the silica was modified with an external layer of aldehyde groups. Then, Mb was attached by reaction with its amine groups (on the external surface) and subsequent formation of imine bonds. The vacant places surrounding Mb were filled by polymerization of the silane monomers 3-aminopropyltrimethoxysilane (APTMS) and propyltrimethoxysilane (PTMS). Finally, the template was removed by imine cleavage after treatment with oxalic acid. The results materials were finely dispersed in plasticized PVC selective membranes and used as ionophores in potentiometric transduction. The best analytical features were found in HEPES buffer of pH 4. Under this condition, the limits of detection were of 1.3 Ã— 10(-6)mol/L for a linear response after 8.0 Ã— 10(-7) mol/L with an anionic slope of -65.9 mV/decade. The imprinting effect was tested by preparing non-imprinted (NI) particles and employing these materials as ionophores. The resulting membranes showed no ability to detect Mb. Good selectivity was observed towards creatinine, sacarose, fructose, galactose, sodium glutamate, and alanine. The analytical application was conducted successfully and showed accurate and precise results.

Special section on biomimetics of movement.

https://www.ncbi.nlm.nih.gov/pubmed/22128305

Movement in biology is an essential aspect of survival for many organisms, animals and plants. Implementing movement efficiently to meet specific needs is a key attribute of natural living systems, and can provide ideas for man-made developments. If we had to find a subtitle able to essentially convey the aim of this special section, it could read as follows: 'taking inspiration from nature for new materials, actuators, structures and controls for systems that move'. Our world is characterized by a huge variety of technical, engineering systems that move. They surround us in countless products that integrate actuators for different kinds of purposes. Basically, any kind of mechatronic system, such as those used for consumer products, machines, vehicles, industrial systems, robots, etc, is based on one or more devices that move, according to different implementations and motion

ranges, often in response to external and internal stimuli. Despite this, technical solutions to develop systems that move do not evolve very quickly as they rely on traditional and well consolidated actuation technologies, which are implemented according to known architectures and with established materials. This fact limits our capability to overcome challenges related to the needs continuously raised by new fields of application, either at small or at large scales. Biomimetics-based approaches may provide innovative thinking and technologies in the field, taking inspiration from nature for smart and effective solutions. In an effort to disseminate current advances in this field, this special section collects some papers that cover different topics. A brief synopsis of the content of each contribution is presented below. The first paper, by Lienhard et al [1], deals with bioinspiration for the realization of structural parts in systems that passively move. It presents a bioinspired hingeless flapping mechanism, considered as a solution to the kinematics of deployable systems for architectural structures. The approach relies on structural elasticity to replace the need for local hinges. To this end, the authors have used fibre-reinforced polymers combining high tensile strength with low bending stiffness. The solution favours lower structural complexity as well as higher design versatility. Bioinspiration from the elastic kinetics of plants is a central pillar of the paper, which highlights the interrelation of form, actuation and kinematics in those natural systems. The second paper, by Nakata et al [2], deals with bioinspired systems that actively move, and, more specifically, fly. The paper is about the aerodynamics of a bio-inspired flexible flapping-wing micro air vehicle conceived to fly in a Reynolds number regime used by most natural flyers, including insects, bats and birds. The paper presents a study of the flexible wing aerodynamics of the flapping vehicle by combining an in-house computational fluid dynamic model with wind tunnel experiments. In particular, the developed model is shown to be able to predict unsteady aerodynamics in terms of vortex and wake structures and their relationship with aerodynamic force generation. Simulations are validated by wind tunnel experiments, confirming the effectiveness of the adopted design solutions, as well as the importance of wing flexibility in designing small flapping-wing vehicles. The third paper, by Annunziata et al [3], deals with bioinspired control strategies for systems that move. In particular, the paper describes approaches to increase the stiffness variability in multi-muscle driven joints. Different strategies for simultaneous control of torque and stiffness in a hinge joint actuated by two antagonistic muscle pairs are presented. The proposed strategies combine torque and stiffness control by co-activation with approaches based on activation overflow and inverse modelling. Extensive simulations are performed and described to assess the control efficacy. In the fourth paper, Merker et al [4] present a study on stable walking with asymmetric legs. The authors are concerned with the need to clarify to what extent differences in the leg function of contralateral

limbs can be tolerated during walking or running. A bipedal spring-mass model simulating walking with compliant legs is used to show that even remarkable differences between contralateral legs can not only be tolerated, but may also introduce advantages to the robustness of the system dynamics. This study might contribute to shedding light on the stability of asymmetric leg walking, including the potential benefits of asymmetry, with possible implications for design of prosthetic or orthotic systems. The last two papers of this special section deal with active bioinspired systems driven by new actuators made of smart materials. In particular, the paper authored by Rossi et al [5] presents an underwater fish-like robot based on bending structures driven by shape memory alloys. These kinds of actuators are used to bend the backbone of the fish, which in turn causes a change in the curvature of the fish body. The paper describes the mechanisms by which standard swimming patterns can be reproduced with the proposed design, and show characterizations in terms of the actuation speed and position accuracy of prototype systems. The last paper, by Carpi et al [6], presents an overview on ionic- and electronic-type electromechanically active polymer actuators as artificial muscles for bioinspired applications. The electrical responsiveness and numerous functional and structural properties that these materials and actuators have in common with natural muscles are shown to be the key motivation by which they are studied as artificial muscles for a huge variety of possible uses. The authors describe the fundamental aspects of relevant technologies and emphasize how after several years of basic research, electromechanically active polymer actuators are today facing their important initial transition from academia into commercialization. In conclusion, we hope that the selection of papers in this special section might help to provide readers with a balanced overview, through examples on the relevant fundamental aspects, materials, actuators, structures, controls and on their effective integration, in order to develop approaches which will be successful in 'taking inspiration from nature for systems that move'. References [1] Lienhard J, Schleicher S, Poppinga S, Masselter T, Milwich M, Speck T and Knippers J 2011 Flectofin: a hingeless flapping mechanism inspired by nature Bioinsp. Biomim. 6 045001 [2] Nakata T, Liu H, Tanaka Y, Nishihashi N, Wang X and Sato A 2011 Aerodynamics of a bio-inspired flexible flapping-wing micro air vehicle Bioinsp. Biomim. 6 045002 [3] Annunziata S, Paskarbeit J and Schneider A 2011 Novel bioinspired control approaches to increase the stiffness variability in multi-muscle driven joints Bioinsp. Biomim. 6 045003 [4] Merker A, Rummel J and Seyfarth A 2011 Stable walking with asymmetric legs Bioinsp. Biomim. 6 045004 [5] Rossi C, Colorado J, Coral W and Barrientos A 2011 Bending continuous structures with SMAs: a novel robotic fish design Bioinsp. Biomim. 6 045005 [6] Carpi F, Kornbluh R, Sommer-Larsen P and Alici G 2011 Electroactive polymer actuators as artificial muscles: are they ready for bioinspired applications?

Bioinsp. Biomim. 6 045006.

Tubular or subsurface morphology of octabutoxyphthalocyanine upon self-assembly in polymer matrices: effect of the casting solvent.

https://www.ncbi.nlm.nih.gov/pubmed/21500292

Spontaneous phase-separated, controlled aggregate structures of photo- and electroactive molecules in polymer matrices are of interest for device fabrication. We show that the self-assembly of octabutoxyphthalocyanine (Pc) in polymer matrices leads to tubular morphology of Pc when the film is prepared with tetrachloroethane (TCE) and subsurface droplet morphology with chloroform. The same morphology is seen with both bisphenol A polycarbonate (BPAPC) and poly(methyl methacrylate) (PMMA) as the matrix. The subsurface morphology results from the rapid association of Pc in the polymer matrix, as the film forms. With the tubular morphology in the films prepared with TCE, percolation threshold is reached with a concentration of Pc as low as 3% (wt) in the polymer. Such phase-separated self-assembly occurs, without any annealing of the films. Even in the absence of the polymer, Pc crystallized from TCE also shows tubular morphology, whereas it exhibits a columnar morphology with chloroform. X-ray diffraction of Pc crystallized from either solvent shows the columnar stacking of the Pc molecules. However, the morphology is tubular when TCE is used. We attribute the difference in the morphology to the higher viscosity of TCE and the diffusion-limited growth, which causes the tubular morphology, whereas the instantaneous self-assembly in less-viscous chloroform leads to droplets. The solvent effect observed here could be used to tailor the morphology of such photoconductive molecules in polymer matrices.

Sensitive and selective electrochemical detection of carbon monoxide in saline at a Pt-Ru/Nafion/MnO2-modified electrode.

https://www.ncbi.nlm.nih.gov/pubmed/22322802

We fabricated a sensitive and selective electrochemical carbon monoxide (CO) sensor for physiological conditions based on the Pt-Ru system. At a bare Pt-Ru electrode, a linear amperometric response to CO concentration was obtained in the range of 0.9-9 ÂµM. However, significant current response to model electroactive interferents for physiological conditions, uric acid (UA), ascorbic acid (AA) and hydrogen peroxide (HP), was also recorded at the Pt-Ru electrode. The response to UA and AA was highly suppressed by coating the Pt-Ru electrode surface with a Nafion layer, and the response to HP was almost completely eliminated by the additional coating

with a MnO(2)/chitosan layer. Finally, at the Pt-Ru/Nafion/MnO(2) electrode, amperometric CO detection with a sensitivity of 173 nA cm(-2) ÂµM(-1) was obtained in the concentration range of 0.9-9 ÂµM with the UA, AA and HP signal being below 1.7% at the same concentration of CO.

Direct electrochemistry and electrocatalysis of anthraquinone-monosulfonate/polyaniline hybrid film synthesized by a novel electrochemical doping-dedoping-redoping method on pre-activated spectroscopically pure graphite surface.

https://www.ncbi.nlm.nih.gov/pubmed/21212886

Polyaniline (PANI) film in the form of emeraldine salt (ES) doped with anthraquinone-2-sulfonate (AQS) was synthesized by a novel electrochemical doping-dedoping-redoping method on pre-activated spectroscopically pure graphite electrode surface. SEM showed the highly porous microstructure with sponge-like morphology of the AQS/PANI hybrid film, which has more available active sites for facilitating electron transfer and energy efficiency of redox reactions. FTIR and UV-vis spectra demonstrated the incorporation of AQS into the conductive PANI matrix. Cyclic voltammetric (CV), electrochemical impedance spectroscope (EIS), rotating ring-disk electrode (RRDE) and chronoamperometry (CA) techniques indicated that the AQS/PANI composite has high electrocatalytic activity and remarkable stability for the two-electron reduction of oxygen via an electrochemical-chemical mechanism at the base of the porous PANI film. The acid centers of PANI (protonated imine group) played an important role not only in two internal redox transform processes, but also in an external charge transfer reaction during the electrocatalytic reduction of oxygen. The incorporation of anionic AQS groups into PANI matrix to prepare electroactive PANI using the electrochemical doping-dedoping-redoping method is conceptually new, and may be extended to the development of new functional materials from many other conducting polymers and quinonoid compounds for wide applications in catalysis, sensors, molecular electronics, and so on.

Influence of ferrite nanoparticle type and content on the crystallization kinetics and electroactive phase nucleation of poly(vinylidene fluoride).

https://www.ncbi.nlm.nih.gov/pubmed/21545124

This work reports on the nucleation of the Î²-phase of poly(vinylidene fluoride) (PVDF) by incorporating CoFe(2)O(4) and NiFe(2)O(4) nanoparticles, leading in this way to the preparation of magnetoelectric composites. The fraction of filler nanoparticles needed to produce the same Î²- to Î±-phase ratio in crystallized PVDF is 1 order of magnitude lower in the cobalt ferrite nanoparticles.

The interaction between nanoparticles and PVDF chains induce the all-trans conformation in PVDF segments, and this structure then propagates in crystal growth. The nucleation kinetics is enhanced by the presence of nanoparticles, as corroborated by the increasing number of spherulites with increasing nanoparticle content and by the variations of the Avrami's exponent. Further, the decrease of the crystalline fraction of PVDF with increasing nanoparticle content indicates that an important fraction of polymer chains are confined in interphases with the filler particle.

Catalytic oxidation and determination of Î²-NADH using self-assembly hybrid of gold nanoparticles and graphene.

https://www.ncbi.nlm.nih.gov/pubmed/21594262

A self-assembly hybrid of gold nanoparticles on graphene modified electrodes for low-potential NADH detection has been achieved. We used the natural polymer chitosan (Chit) to assist the stabilization of graphene in aqueous solution, and immobilize the electronegative Au nanoparticles (NPs) through electrostatic attraction. The synergy of Au NPs with graphene for catalytic oxidation of NADH made the overpotential ca. 220 mV less positive than that on the bare electrode, and remarkably increased the oxidation current. The amperometric sensors based on such modified electrodes for detection of NADH exhibited a good linearity from 1.5 to 320 Î¼M, and showed high sensitivity with a low detection limit of 1.2 Î¼M (S/N = 3). It could also exclude common interfering electroactive compounds like ascorbic acid and possessed good reproducibility and operational stability. Such eminent performance of the Au-RGO/Chit film together with the ability of graphene to significantly enhance the electron transfer between enzymes and the electrode suggested its promise for constructing novel graphene based dehydrogenase biosensors.

Molecularly imprinted polymer-based potentiometric sensor for 2-aminopyridine as a potential impurity in piroxicam.

https://www.ncbi.nlm.nih.gov/pubmed/21322122

A molecularly imprinted polymer-based potentiometric sensor was fabricated for determination of 2-aminopyridine (2-AP). The electroactive component is the 2-APH(+) . To form this specie the determination is carried out in a bufferic solution at pH 4.5 in which 2-AP is prevalently monoprotonated. Under these conditions, the membrane potential, increases with 2-AP concentration over a wide range of concentration (5 ÂµM to 100 mM) with a near Nernstian response of 54.1 mV/decade and detection limit of 2.0 ÂµM. The response time is less than 5 s and

the sensor can be used for more than 3 months without any significant divergence in response. The selectivity coefficients of the proposed sensor were evaluated and exhibited good selectivity to 2-AP with respect to the electrode based on a non-imprinted polymer. The utility of the sensor was successfully tested by examining of 2-AP in piroxicam (PX) as a potential impurity.

Electroactive polymer patches for wearable haptic interfaces.

https://www.ncbi.nlm.nih.gov/pubmed/22256288

Fully wearable and unobtrusive sensing will enable the possibility of monitoring people anywhere and anytime, for healthcare, well-being, protection and safety. Many research groups have exploited textiles as the ideal platform for pervasive monitoring. This paper reports advances in electroactive polymer technology oriented to mechanical sensing and actuation within textile interfaces. The preliminary development of a textile-based glove in which electroactive polymers act as force/position sensors and haptic feedback actuators is presented.

Flame oxidation of stainless steel felt enhances anodic biofilm formation and current output in bioelectrochemical systems.

https://www.ncbi.nlm.nih.gov/pubmed/24911921

Stainless steel (SS) can be an attractive material to create large electrodes for microbial bioelectrochemical systems (BESs), due to its low cost and high conductivity. However, poor biocompatibility limits its successful application today. Here we report a simple and effective method to make SS electrodes biocompatible by means of flame oxidation. Physicochemical characterization of electrode surface indicated that iron oxide nanoparticles (IONPs) were generated in situ on an SS felt surface by flame oxidation. IONPs-coating dramatically enhanced the biocompatibility of SS felt and consequently resulted in a robust electroactive biofilm formation at its surface in BESs. The maximum current densities reached at IONPs-coated SS felt electrodes were 16.5 times and 4.8 times higher than the untreated SS felts and carbon felts, respectively. Furthermore, the maximum current density achieved with the IONPs-coated SS felt (1.92 mA/cm(2), 27.42 mA/cm(3)) is one of the highest current densities reported thus far. These results demonstrate for the first time that flame oxidized SS felts could be a good alternative to carbon-based electrodes for achieving high current densities in BESs. Most importantly, high conductivity, excellent mechanical strength, strong chemical stability, large specific surface area, and comparatively low cost of flame oxidized SS felts offer exciting opportunities for scaling-up of the anodes for BESs.

Polyelectrolyte and carbon nanotube multilayers made from ionic liquid solutions.

https://www.ncbi.nlm.nih.gov/pubmed/20931147

The inevitable contact of substrates with water during the traditional practice of layer-by-layer assembly (LBL) creates problems for multiple potential applications of LBL films in electronics. To resolve this issue, we demonstrate here the possibility of a LBL process using ionic liquids (ILs), which potentially eliminates corrosion and hydration processes related to aqueous media and opens additional possibilities in structural control of LBL films. ILs are also considered to be one of the best "green" processing solvents, and hence, are advantageous in respect to traditional organic solvents. Poly(ethyleneimine) (PEI) and poly(sodium styrenesulfonate) (PSS) were dispersed in a hydrophilic IL and successfully deposited in the LBL fashion. To produce electroactive thin films with significance to electronics, a similar process was realized for PSS-modified single-walled carbon nanotubes (SWNT-PSS) and poly(vinyl alcohol) (PVA). Characterization of the coating using standard spectroscopy and microscopy techniques typical of the multilayer field indicated that there are both similarities and differences in the structure and properties of LBL films build from ILs and aqueous solutions. The films exhibited electrical conductivity of 10(2) S m(-1) with transparency as high as 98% for visible light, which is comparable to similar parameters for many carbon nanotube and graphene films prepared by both aqueous LBL and other methods.

High-power lithium-ion capacitor using LiMnBO3 -nanobead anode and polyaniline-nanofiber cathode with excellent cycle life.

https://www.ncbi.nlm.nih.gov/pubmed/24920598

LiMnBO3 nanobeads (LMB-NB) with uniform size and distribution were synthesized using a urea-assisted microwave/solvothermal method. The potential application of LMB-NBs as an anode for a lithium-ion hybrid capacitor (Li-AHC) was tested with a polyaniline-nanofiber (PANI-NF) cathode in a nonaqueous LiPF6 (1â€‰M)-ethylene carbonate/dimethyl carbonate electrolyte. Cyclic voltammetry (CV) and charge-discharge (C/DC) studies revealed that the PANI-NF/LMB-NB cell showed an exceptional capacitance behavior between 0-3 V along with a prolonged cycle life. A discharge capacitance of about 125 F g(-1) , and energy and power densities of about 42 Wh kg(-1) and 1500 W kg(-1) , respectively, could be obtained at a current density of 1 A g(-1) ; those Li-AHC values are higher relative to cells containing various lithium intercalation materials in nonaqueous electrolytes. In addition, the PANI-NF/LMB-NB cell also had an outstanding rate performance with a capacitance of 54 F g(-1) and a power density of 3250 W kg(-1) at a current density of 2.25 A g(-1)

and maintained 94% of its initial value after 30000 cycles. This improved capacitive performance with an excellent electrochemical stability could be the result of the morphological features and inherent conductive nature of the electroactive species.

A polyvinylchloride-based cadmium ion-selective electrode using [Moâ,,(OAc)â,,(Hâ,,-calix[4]arene)] as an electroactive material.

https://www.ncbi.nlm.nih.gov/pubmed/21099036

A highly electroactive material [Moâ,,(OAc)â,,(Hâ,,-calix[4]arene)] is used as a neutral carrier for CdÂ²+ ions in this paper. The membrane is fabricated by using ionophore [Moâ,,(OAc)â,,(Hâ,,-calix[4]arene)]:poly(vinyl chloride) (PVC): dibutylphthalate(DBP):sodium tetraphenyl borate (NaTPB) in the ratio of 40:300:470:5 respectively and tetrahydrofuran (THF) used as a solvent. The membrane electrode performed in the concentration range of 9.9 x 10â•»â•¸-1.0 x 10â•»Â¹ M (2.34 x 10â•»â•µ-23.64 mg/mL) having the Nernstian slope of 30.0Â±1.0 mV and the best detection limit was observed at 9.8 x 10â•»â•¸ M (2.31 x 10â•»â•µ mg/mL). The proposed membrane electrode has the response time of 12 s and a useful working pH range of 1.0-7.0, and used over a period of 10 months and work satisfactorily in the test solution having 30% (v/v) non-aqueous content. Electrode sensor has distinguishable ability for CdÂ²+ ion with regard to several alkali, alkaline earth, transition and heavy metal ions. It was used in direct potentiometry as an indicator electrode, in the potentiometric titration of 10â•»Â³ M CdÂ²+ solution against 10â•»Â² M of ethylenediaminetetraacetic acid (EDTA).

Polypeptide-guided assembly of conducting polymer nanocomposites.

https://www.ncbi.nlm.nih.gov/pubmed/20689898

A strategy for fabrication of electroactive nanocomposites with nanoscale organization, based on self-assembly, is reported. Gold nanoparticles are assembled by a polypeptide folding-dependent bridging. The polypeptides are further utilized to recruit and associate with a water soluble conducting polymer. The polymer is homogenously incorporated into the nanocomposite, forming conducting pathways which make the composite material highly conducting.

Interpenetrating Conducting Hydrogel Materials for Neural Interfacing Electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/28198591

Conducting hydrogels (CHs) are an emerging technology in the field of medical electrodes and brain-machine interfaces. The greatest challenge to the fabrication of CH electrodes is the hybridization of dissimilar polymers (conductive polymer and hydrogel) to ensure the formation of interpenetrating polymer networks (IPN) required to achieve both soft and electroactive materials. A new hydrogel system is developed that enables tailored placement of covalently immobilized dopant groups within the hydrogel matrix. The role of immobilized dopant in the formation of CH is investigated through covalent linking of sulfonate doping groups to poly(vinyl alcohol) (PVA) macromers. These groups control the electrochemical growth of the conducting polymer poly(3,4-ethylenedioxythiophene) (PEDOT) and subsequent material properties. The effect of dopant density and interdopant spacing on the physical, electrochemical, and mechanical properties of the resultant CHs is examined. Cytocompatible PVA hydrogels with PEDOT penetration throughout the depth of the electrode are produced. Interdopant spacing is found to be the key factor in the formation of IPNs, with smaller interdopant spacing producing CH electrodes with greater charge storage capacity and lower impedance due to increased PEDOT growth throughout the network. This approach facilitates tailorable, high-performance CH electrodes for next generation, low impedance neuroprosthetic devices.

High, Anisotropic, and Substrate-Independent Mobility in Polymer Field-Effect Transistors Based on Preassembled Semiconducting Nanofibrils.

https://www.ncbi.nlm.nih.gov/pubmed/28117966

Achieving nanoscale control over the crystalline structure and morphology of electroactive polymer films and the possibility to transfer them onto any solid substrate are important tasks for the fabrication of high-performance organic/polymeric field-effect transistors (FETs). In this work, we demonstrate that ultrathin active layers preassembled at the water/air interface can possess high, anisotropic, and substrate-independent mobility in polymer FETs. By exploiting a modified approach to the Langmuir-Schaeffer technique, we self-assemble conjugated polymers in fibrillar structures possessing controlled thickness, nanoscale structure, and morphology; these highly ordered nanofibrils can be transferred unaltered onto any arbitrary substrate. We show that FETs based on these films possess high and anisotropic hole mobility approaching 1 cm2 V-1 s-1 along the nanofibrils, being over 1 order of magnitude beyond the state-of-the-art for Langmuir-Schaefer polymer FETs. Significantly, we demonstrate that the FET performances are independent of the chemical nature and dielectric permittivity of the substrate, overcoming a critical limit in the field of

polymer FETs. Our method allows the fabrication of ultrathin films for low-cost, high-performance, transparent, and flexible devices supported on any dielectric substrate.

Bacterial cellulose-based sheet-like carbon aerogels for the in situ growth of nickel sulfide as high performance electrode materials for asymmetric supercapacitors.

https://www.ncbi.nlm.nih.gov/pubmed/28304051

Electroactive materials, such as nickel sulfide (NiS), with high theoretical capacities have attracted broad interest to fabricate highly efficient supercapacitors. Preventing aggregation and increasing the conductivity of NiS particles are key challenging tasks to fully achieve excellent electrochemical properties of NiS. One effective approach to solve these problems is to combine NiS with highly porous and conductive carbon materials such as carbon aerogels. In this study, a green and facile method for the in situ growth of NiS particles on bacterial cellulose (BC)-derived sheet-like carbon aerogels (CAs) has been reported. CA prepared by the dissolution-gelation-carbonization process was used as a framework to construct NiS/CA composite aerogels with NiS uniformly decorated on the pore walls of CA. It was found that the NiS/CA composite aerogel electrodes exhibit excellent capacitive performance with high specific capacitance (1606 F g-1), good rate capacitance retention (69% at 10 A g-1), and enhanced cycling stability (91.2% retention after 10â€‰000 continuous cyclic voltammetry cycles at 100 mV s-1). Furthermore, asymmetric supercapacitors (ASCs) were constructed utilizing NiS/CA composite and CA as the positive and negative electrode materials, respectively. Through the synergistic effect of three-dimensional porous structures and conductive networks derived from CA and the high capacitive performance offered by NiS, the ASC device exhibited an energy density of âˆ¼21.5 Wh kg-1 and a power density of 700 W kg-1 at the working voltage of 1.4 V in 2 M KOH aqueous solution. The ASC device also showed excellent long-term cycle stability with âˆ¼87.1% specific capacitance retention after 10â€‰000 cycles of cyclic voltammetry scans. Therefore, the NiS/CA composite shows great potential as a promising alternative to high-performance electrode materials for supercapacitors.

Fibrin Association at Hybrid Biointerfaces Made of Clot-Binding Peptides and Polythiophene.

https://www.ncbi.nlm.nih.gov/pubmed/27364985

The properties as biointerfaces of electroactive conducting polymer-peptide biocomposites formed by poly(3,4-ethylenedioxythiophene) (PEDOT) and CREKA or CR(NMe)EKA peptide sequences (where Glu has been replaced by N-methyl-Glu in the latter) have been compared. CREKA is a

linear pentapeptide that recognizes clotted plasma proteins and selectively homes to tumors, while CR(NMe)EKA is an engineer to improve such properties by altering peptide-fibrin interactions. Differences between PEDOT-CREKA and PEDOT-CR(NMe)EKA reflect dissemblance in the organization of the peptides into the polymeric matrix. Both peptides affect fibrinogen thrombin-catalyzed polymerization causing the immediate formation of fibrin, whereas in the absence of thrombin this phenomenon is only observed for CR(NMe)EKA. Consistently, the fibrin-adsorption capacity is higher for PEDOT-CR(NMe)EKA than for PEDOT-CREKA, even though in both cases adsorbed fibrin exhibits round-like morphologies rather than the characteristic fibrous structure. PEDOT-peptide films coated with fibrin are selective in terms of cell adhesion, promoting the attachment of metastatic cells with respect to normal cells.

Enhanced bioelectricity generation and azo dye treatment in a reversible photo-bioelectrochemical cell by using novel anthraquinone-2,6-disulfonate (AQDS)/MnOx-doped polypyrrole film electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/27875767

A novel anthraquinone-2,6-disulfonate/MnOx-doped polypyrrole film (AQDS/Mn/PPy) electrode was prepared by one-step electropolymerization method and was used to improve performance of a reversible photo-bioelectrochemical cell (RPBEC). The RPBEC was operated in polarity reversion depended on dark/light reaction of alga Chlorella vulgaris by which sequential decolorization of azo dye and mineralization of decolorization products coupled with bioelectricity generation can be achieved. The results showed that formation of uniform AQDS/Mn/PPy film significantly enhanced electroactive surface area and electrocatalytic activity of carbon electrode. The RPBEC with AQDS/Mn/PPy electrodes demonstrated 77% increases in maximum power and 73% increases in Congo red decolorization rate before polarity reversion, and 198% increases in maximum power and 138% increases in decolorization products mineralization rate after polarity reversion, respectively, compared to the RPBEC with bare electrode. This was resulted from simultaneous dynamics improvement in half-reaction rate of anode and photo-biocathode due to enhanced electron transfer and algal-bacterial biofilm formation.

Electrospun silk fibroin scaffolds coated with reduced graphene promote neurite outgrowth of PC-12 cells under electrical stimulation.

https://www.ncbi.nlm.nih.gov/pubmed/28629024

Novel approaches to neural research require biocompatible materials capable to act as electrode structures or scaffolds for tissue engineering in order to stimulate or restore the functionality of damaged tissues. This work offers promising results that indicate the potential use of electrospun silk fibroin (SF) scaffolds coated with reduced graphene oxide (rGO) in this sense. The coated material becomes conductor and electroactive. A complete characterisation of SF/rGO scaffolds is provided in terms of electrochemistry, mechanical behaviour and chemical conformation of fibroin. The excellent biocompatibility of this novel material is proved with cultures of PC-12 cells. The coating with rGO improved the adhesion of cells in comparison with cells growing onto the surface of pure SF scaffolds. Also, the use of SF/rGO scaffolds combined with electrical stimulation promoted the differentiation into neural phenotypes reaching comparable or even superior levels to those obtained by means of the traditional treatment with neural growth factor (NGF).

Advanced Materials for Use in Soft Self-Healing Devices.

https://www.ncbi.nlm.nih.gov/pubmed/28229499

Devices integrated with self-healing ability can benefit from long-term use as well as enhanced reliability, maintenance and durability. This progress report reviews the developments in the field of self-healing polymers/composites and wearable devices thereof. One part of the progress report presents and discusses several aspects of the self-healing materials chemistry (from non-covalent to reversible covalent-based mechanisms), as well as the required main approaches used for functionalizing the composites to enhance their electrical conductivity, magnetic, dielectric, electroactive and/or photoactive properties. The second and complementary part of the progress report links the self-healing materials with partially or fully self-healing device technologies, including wearable sensors, supercapacitors, solar cells and fabrics. Some of the strong and weak points in the development of each self-healing device are clearly highlighted and criticized, respectively. Several ideas regarding further improvement of soft self-healing devices are proposed.

Lithium n-Doped Polyaniline as a High-Performance Electroactive Material for Rechargeable Batteries.

https://www.ncbi.nlm.nih.gov/pubmed/28044392

The discovery of conducting lithium-doped polyaniline with reversible redox chemistry allows simultaneous unprecedented capacity and stability in a non-aqueous Li battery. This compound (lithium emeraldinate) was synthesized by lithium-proton exchange on the emeraldine base in an

anhydrous lithium-based electrolyte. A combination of UV/Vis-NIR spectroelectrochemistry, XPS, FTIR, and EQCM characterization allowed a unified description of the chemical and electrochemical behavior, showing facile charge delocalization of the doped states and the reversibility of the redox processes in this form of polyaniline. From a practical point of view, lithium emeraldinate behaves as a high-capacity organic active material (230â€…mAhâ€‰g-1) that enables preparation of relatively thick composite electrodes with a low amount of carbon additives and high energy density (460â€…Whâ€‰kg-1). Concomitantly, at 1C rate, 400 cycles were achieved without significant capacity loss, while the coulombic efficiency is greater than 99â€‰%.

Redox mechanism of neurotoxicity by a serotonin-acrolein polymeric melanoid.

https://www.ncbi.nlm.nih.gov/pubmed/20309663

Postoperative cognitive dysfunction may be associated with the toxic products of lipid peroxidation, such as the Î±,Î²-unsaturated aldehyde acrolein, which accumulates in aging. We previously identified an acrolein-mediated, serotonin-derived melanoid product, or SDM. This study further characterizes this putative novel neuromelanin, which is not made from catecholamines. In addition to its strong protein-binding properties, we observed that SDM binds Fe(2+) readily and exhibits complex redox characteristics. SDM may exist as a two-dimensional network of polymers that coalesce into larger entities exhibiting electroactive properties. These observations suggest that SDM may contribute to the decline in cognition due to focal degeneration from SDM-mediated free-radical production. We know that inhalational anesthetics sequester acrolein, which is toxic to neurons, and we propose that the local increase in acrolein depletes serotonin levels and enhances neuronal vulnerability through the production of neuromelanin-like structures, such as SDM.

Dipole correlation effects on the local field and the effective dielectric constant in composite dielectrics containing high-k inclusions.

https://www.ncbi.nlm.nih.gov/pubmed/27357433

Mixing dielectric polymers with high permittivity (high-k) inclusions can affect their electrical properties. In actuation applications of dielectric elastomers, the polarized inclusions generate additional volume polarization-related electrostriction. In energy storage applications, it is possible to store more energy in dielectric composites because of additional polarization of the inclusions and interfaces. However, mixing an electroactive polymer with high-k inclusions also brings several disadvantages. The expulsion of the field from the interior of high-k fillers and the presence of two

poles on the filler surface along the applied field direction result in higher local fields EL near the inclusion poles. The resulting field enhancement lowers the breakdown field (Eb) threshold for the material and therefore compromises the actuation and energy storage capabilities of dielectric composites. To mitigate this issue, the dependence of EL on the morphology of inclusion distribution, the field localization effect in chained configurations, and the role of the dipole-dipole correlation effects in the enhancement of the dipolar field of inclusions are analyzed. We show that the dipolar correlation effects are strong in large inclusion composites and their contribution to the inclusion dipole moment Î¼ and to the local fields EL can reach 30-50%. A new method for deriving the composite permittivity from the field EL distribution, based on a caged probe technique, is also presented.

Nanometric thin polymeric films based on molecularly imprinted technology: towards electrochemical sensing applications.

https://www.ncbi.nlm.nih.gov/pubmed/20668737

A new approach for assembling selective electrodes based on molecularly imprinted polymers (MIPs) is presented. The approach is based on the radical polymerization of a mixture of methacrylic acid (MAA) and ethyleneglycol dimethacrylate (EGDMA) in the presence of an initiator, benzoyl peroxide (BPO) and an activator, N,N'-dimethyl-p-toluidine (DMpT) at room temperature and atmospheric pressure. To form nanometric thin polymeric films the polymerization solution was spin-coated in the course of polymerization. The different physical and chemical parameters that affected the properties of the films, such as the spinning rate and the EGDMA:MAA ratio, were studied and optimized. A variety of techniques, e.g., rheoscopy, SEM, AFM, profilometry and electrochemistry, were used to characterize the films and the polymerization process. By optimizing the conditions very thin and reproducible films could be prepared and imprinted. The electrochemical behavior of the films showed that they were permeable to water-soluble electroactive species providing that either polyethylene glycol or template species were added to the polymerization mixture. Finally, we demonstrated that films imprinted with ferrocenylmethyl alcohol (Fc-MeOH) successfully extracted the imprinted species after their removal from MIPs.

Development of electroactive nanofibers based on thermoplastic polyurethane and poly(o-ethoxyaniline) for biological applications.

https://www.ncbi.nlm.nih.gov/pubmed/27727504

Electroactive nanofibers based on thermoplastic polyurethane (TPU) and poly(alkoxy anilines) produced by electrospinning has been explored for biomaterials applications. The thermoplastic polyurethane is a biocompatible polymer with good mechanical properties. The production of TPU nanofibers requires the application of high voltage during electrospinning in order to prepare uniform mats due to its weak ability to elongate during the process. To overcome this limitation, a conductive polymer can be incorporated to the process, allowing generates mats without defects. In this study, poly(o-ethoxyaniline) POEA doped with dodecylbenzene sulfonic acid (DBSA) was blended with thermoplastic polyurethane (TPU) by solution method. Films were produced by casting and nanofibers were prepared by electrospinning. The effect of the POEA on morphology, distribution of diameter and cell viability of the nanofibers was evaluated. The results demonstrated that the incorporation of POEA in TPU provided to the mats a suitable morphology for cellular growth.

Softened and flexible biodegradable poly(lactic acid) and its electromechanical properties for actuator application.

https://www.ncbi.nlm.nih.gov/pubmed/27479892

Poly (lactic acid) (PLA) is a biodegradable polymer with high stiffness presenting a limitation for using in actuator applications. Adding a plasticizer is one way to solve this problem to enhance flexibility and improve electromechanical properties of pristine PLA. In this work, the PLA films were prepared via a simple solvent casting method. The influences of plasticizer type and electric field strength on electromechanical behavior of PLA films were investigated by the melt rheometer and bending measurement. For the PLA films filled with dibutyl phthalate (DBP), the storage modulus, G', immediately increased towards its steady state and rapidly recovered to its original value with and without electric field, respectively, which can be referred to a reversible system. On the other hand, the PLA film with Tween 20 processed the highest âˆ†G×³/G×³0 of 1.34 due to the available amount of polarized groups. In the bending measurement, the dielectrophoresis forces of plasticized PLA films were found to increase with increasing electric field where the deflections occurred towards anode side as the polarized groups generated negative charges. The DBP_PLA1.5D film exhibited the greatest bending and dielectrophoresis force. Thus, the biodegradable PLA along with DBP combine to have a great potential towards actuator application.

Incorporating conjugated carbonyl compounds into carbon nanomaterials as electrode materials for electrochemical energy storage.

https://www.ncbi.nlm.nih.gov/pubmed/27845454

The increasing demand for energy and growing concerns for environmental issues are promoting the development of organic electrode materials. Among these, conjugated carbonyl compounds (CCCs) represent one of the most attractive and promising candidates for sustainable and eco-benign energy storage devices in the coming future. However, most of the current compounds suffer from dissolution in organic electrolytes and low electronic conductivity, which result in severe capacity decay and poor rate performance. Recently, researchers have achieved considerable progress by introducing electroactive carbonyl compounds into carbon nanomaterials. This perspective provides an overview of the up-to-date development of these nanocomposites in metal ion batteries (lithium-ion batteries or sodium-ion batteries) and supercapacitors (SCs), including the synthesis, performance improvement and applications. We mainly focus on carbon nanotubes (CNTs), graphene and mesoporous carbon (MC) as carbon nanomaterials because of their high specific surface area, good conductivity, electrochemical stability and favourable interaction with conjugated carbonyl compounds. This strategy opens up new possibilities to realize cost-effective, sustainable and versatile energy storage devices.

Polymer-based protein engineering grown ferrocene-containing redox polymers improve current generation in an enzymatic biofuel cell.

https://www.ncbi.nlm.nih.gov/pubmed/27424262

Enzymatic biofuel cells (EBFCs) are capable of generating electricity from physiologically present fuels making them promising power sources for the future of implantable devices. The potential application of such systems is limited, however, by inefficient current generation. Polymer-based protein engineering (PBPE) offers a unique method to tailor enzyme function through tunable modification of the enzyme surface with functional polymers. In this study, we report on the modification of glucose oxidase (GOX) with ferrocene-containing redox polymers to increase current generation efficiency in an enzyme-modified anode. Poly(N-(3-dimethyl(ferrocenyl)methylammonium bromide)propyl acrylamide) (pFcAc) was grown from covalently attached, water-soluble initiator molecules on the surface of GOX in a "grafting-from" approach using atom transfer radical polymerization (ATRP). The covalently-coupled ferrocene-containing polymers on the enzyme surface promoted the effective "wiring" of the GOX active site to an external electrode. The resulting GOX-pFcAc conjugates generated over an order of magnitude increase in current generation efficiency and a 4-fold increase in maximum EBFC power density (â‰ˆ1.7ÂµWcm(-2)) with similar

open circuit voltage (0.27V) compared to native GOX when physically adsorbed onto paddle-shaped electrodes made up of electrospun polyacrylonitrile fibers coated with gold nanoparticles and multi-wall carbon nanotubes. The formation of electroactive enzyme-redox polymer conjugates using PBPE represents a powerful new tool for the improvement of mediated enzyme-based bioelectronics without the need for free redox mediators or anode/cathode compartmentalization.

Atomistic Engineering of Chemiluminogens: Synthesis, Properties and Polymerization of 2,3-Dihydro-Pyrrolo[3,4-d]Pyridazine-1,4-Dione Scaffolds.

https://www.ncbi.nlm.nih.gov/pubmed/27864701

Two chemiluminescent compounds containing 2,5-di(thien-2-yl)pyrrole and pyridazine units, namely 5,7-di(thiophen-2-yl)-2,3-dihydro-1H-pyrrolo[3,4-d]pyridazine-1,4(6H)-dione (5) and 6-phenyl-5,7-di(thiophen-2-yl)-2,3-dihydro-1H-pyrrolo[3,4-d]pyridazine-1,4(6H)-dione (6), were successfully synthesized and electrochemically polymerized. The compounds have chemiluminescent properties and glow in the presence of hydrogen peroxide in basic medium. The intensity of the glow can be increased dramatically by using Fe3+ ions, hemin (1.0Â ppm) or blood samples (1.0Â ppm) as catalyst. The compounds 5 and 6 have one well-defined irreversible oxidation peak at 1.08Â V and 1.33Â V vs Ag/AgCl, respectively. Electrochemical polymerization of both 5 and 6 were carried out successfully by repeating potential scanning in the presence of BF3. Et2O in an electrolyte solution of 0.1Â M LiClO4 dissolved in acetonitrile. The electronic band gaps (Eg) of the polymers P5 and P6 were found to be 2.02Â eV and 2.16Â eV, respectively. On the other hand, the corresponding polymers are electroactive and exhibited electrochromic features. Graphical Abstract á…Ÿ.

Shape-memory polymer nanocomposites with a 3D conductive network for bidirectional actuation and locomotion application.

https://www.ncbi.nlm.nih.gov/pubmed/27740656

Electrical stimulation of shape-memory polymers (SMPs) has many advantages over thermal methods; creating an efficient conductive path through the bulk polymers is essential for developing high performance electroactive systems. Here, we show that a three-dimensional (3D) porous carbon nanotube sponge can serve as a built-in integral conductive network to provide internal, homogeneous, in situ Joule heating for shape-memory polymers, thus significantly improving the mechanical and thermal behavior of SMPs. As a result, the 3D nanocomposites show a fast

response and produce large exerting forces (with a maximum flexural stress of 14.6 MPa) during shape recovery. We further studied the construction of a double-layer composite structure for bidirectional actuation, in which the shape change is dominated by the temperature-dependent exerting force from the top and bottom layer, alternately. An inchworm-type robot is demonstrated whose locomotion is realized by such bidirectional shape memory. Our large stroke shape-memory nanocomposites have promising applications in many areas including artificial muscles and bionic robots.

Knitting and weaving artificial muscles.

https://www.ncbi.nlm.nih.gov/pubmed/28138542

A need exists for artificial muscles that are silent, soft, and compliant, with performance characteristics similar to those of skeletal muscle, enabling natural interaction of assistive devices with humans. By combining one of humankind's oldest technologies, textile processing, with electroactive polymers, we demonstrate here the feasibility of wearable, soft artificial muscles made by weaving and knitting, with tunable force and strain. These textile actuators were produced from cellulose yarns assembled into fabrics and coated with conducting polymers using a metal-free deposition. To increase the output force, we assembled yarns in parallel by weaving. The force scaled linearly with the number of yarns in the woven fabric. To amplify the strain, we knitted a stretchable fabric, exhibiting a 53-fold increase in strain. In addition, the textile construction added mechanical stability to the actuators. Textile processing permits scalable and rational production of wearable artificial muscles, and enables novel ways to design assistive devices.

Conducting Block Copolymer Binders for Carbon-Free Hybrid Vanadium Pentoxide Cathodes with Enhanced Performance.

https://www.ncbi.nlm.nih.gov/pubmed/27676130

Polymeric binders are essential to battery electrodes, mechanically stabilizing the active materials. Most often, these binders are insulating, and conductive carbons must be added to the electrode structure. Conductive polymer binders, those that transport both ions and electrons, are of primary interest because they potentially eliminate the need for carbon additives. However, it is challenging to incorporate both ion- and electron-conductive polymeric binders into electrode systems because of differences in physical affinities among the two polymer types and the electroactive material. Here, we investigate amphiphilic polymeric binders comprised of electron- and ion-conducting

poly(3-hexylthiophene)-block-poly(ethylene oxide) (P3HT-b-PEO) as compared to P3HT, PEO, and a blend of P3HT/PEO homopolymers in carbon-free V2O5 cathodes. The electrode with P3HT-b-PEO binder has the highest capacity of 190 mAh/g, whereas V2O5 is only 77 mAh/g at a C rate of 0.1 after over 200 cycles: a 2.5-fold improvement. Similarly P3HT, PEO, and the blend have capacities of 139, 130, and 70 mAh/g, which are not nearly as impressive as the block copolymer binder. The unique architecture of P3HT-b-PEO, wherein P3HT and PEO blocks are covalently bonded, promotes the uniform distribution of conductive binders within the V2O5 structure, whereas the analogous P3HT/PEO blend suffers from phase separation. This work demonstrates that conductive block copolymer binders enable carbon-free electrodes for lithium-ion battery systems.

Newton Output Blocking Force under Low-Voltage Stimulation for Carbon Nanotube-Electroactive Polymer Composite Artificial Muscles.

https://www.ncbi.nlm.nih.gov/pubmed/28107622

This is a study on the development of carbon nanotube-based composite actuators using a new ionic liquid-doped electroactive ionic polymer. For scalable production purposes, a simple hot-pressing method was used. Carbon nanotube/ionic liquid-Nafion/carbon nanotube composite films were fabricated that exhibited a large output blocking force and a stable cycling life with low alternating voltage stimuli in air. Of particular interest and importance, a blocking force of 1.5 N was achieved at an applied voltage of 6 V. Operational durability was confirmed by testing in air for over 30â€¯000 cycles (or 43 h). The superior actuation performance of the carbon nanotube/ionic liquid-Nafion/carbon nanotube composite, coupled with easy manufacturability, low driving voltage, and reliable operation, promises great potential for artificial muscle and biomimetic applications.

Electrochemical Behavior of PEDOT/Lignin in Ionic Liquid Electrolytes: Suitable Cathode/Electrolyte System for Sodium Batteries.

https://www.ncbi.nlm.nih.gov/pubmed/28198593

Biomass-derived polymers, such as lignin, contain quinone/ hydroquinone redox moieties that can be used to store charge. Composites based on the biopolymer lignin and several conjugated polymers have shown good charge-storage properties. However, their performance has been only studied in acidic aqueous media limiting their applications mainly to supercapacitors. Here, we show that PEDOT/lignin (PEDOT: poly(3,4-ethylenedioxythiophene)) biopolymers are electroactive in aprotic ionic liquids (ILs) and we move a step further by assembling sodium full cell batteries using

PEDOT/lignin as electrode material and IL electrolytes. Thus, the electrochemical activity and cycling of PEDOT/lignin electrodes was investigated in 1-butyl-1-methylpyrrolidinium bis(trifluoromethylsulfonyl)imide (BMPyrTFSI), 1-butyl-1-methylpyrrolidinium bis(fluorosulfonyl)imide (BMPyrFSI), 1-ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide (EMImTFSI) and 1-ethyl-3-methylimidazolium bis(fluorosulfonyl)imide (EMImFSI) IL electrolytes. The effects of water and sodium salt addition to the ILs were investigated to obtain optimum electrolyte systems for sodium batteries. Finally, sodium batteries based on PEDOT/lignin cathode with imidazolium-based IL electrolyte showed higher capacity values than pyrrolidinium ones, reaching 70 mAhg-1 . Our results demonstrate that PEDOT/lignin composites can serve as low cost and sustainable cathode materials for sodium batteries.

Fundamental aspects of electrochemically controlled wetting of nanoscale composite materials.

https://www.ncbi.nlm.nih.gov/pubmed/28540379

Electroactive films based on conducting polymers have numerous potential applications, but practical devices frequently require a combination of properties not met by a single component. This has prompted an extension to composite materials, notably those in which particulates are immobilised within a polymer film. Irrespective of the polymer and the intended application, film wetting is important: by various means, it facilitates transport processes - of electronic charge, charge-balancing counter ions ("dopant") and analyte/reactant molecules - and motion of polymer segments. While film solvent content and transfer have been widely studied for pristine polymer films exposed to molecular solvents, extension to non-conventional solvents (such as ionic liquids) or to composite films has been given much less attention. Here we consider such cases based on polyaniline films. We explore two factors, the nature of the electrolyte (solvent and film-permeating ions) and the effect of introducing particulate species into the film. In the first instance, we compare film behaviours when exposed to a conventional protic solvent (water) with an aprotic ionic liquid (Ethaline) and the intermediate case of a protic ionic liquid (Oxaline). Secondly, we explore the effect of inclusion of physically diverse particulates: multi-walled carbon nanotubes, graphite or molybdenum dioxide. We use electrochemistry to control and monitor the film redox state and change therein, and acoustic wave measurements to diagnose rheologically vs. gravimetrically determined response. The outcomes provide insights of relevance to future practical applications, including charge/discharge rates and cycle life for energy storage devices, "salt" transfer in water

purification technologies, and the extent of film "memory" of previous environments when sequentially exposed to different media.

A strategy for photothermal conversion of polymeric nanoparticles by polyaniline for smart control of targeted drug delivery.

https://www.ncbi.nlm.nih.gov/pubmed/28257002

The near-infrared (NIR)-mediated novel strategy to control the drug release from nanocarriers has developed rapidly in recent decades. Polyaniline as a non-cytotoxic and electroactive material for studying cellular proliferation has attracted great attention in recent years. In the present work, polyaniline-mediated polymeric nanoparticles were developed to target the delivery of cisplatin and release it in a controllable way. The prepared polyaniline nanoparticles displayed a size of 90Â Â±Â 1.0 nm, a favorable morphology in water, and could be targeted to tumors through the high affinity between trastuzumab and the overexpressed Her2 in tumor cells. In addition, the developed nanoparticles demonstrated exciting photothermal conversion efficiency induced by NIR light and achieved significant cell inhibition efficiency (93.97%) in vitro when exposed to an 808 nm NIR laser with the power of 1.54 W for 5 min. Therefore, the developed external control release delivery system with excellent specificity and high cytotoxicity exhibited great potential in cell research and our research demonstrated that the polyaniline also has potential in the application of photothermal conversion in biomedicine.

Stretchable degradable and electroactive shape memory copolymers with tunable recovery temperature enhance myogenic differentiation.

https://www.ncbi.nlm.nih.gov/pubmed/27640917

Development of flexible degradable electroactive shape memory polymers (ESMPs) with tunable switching temperature (around body temperature) for tissue engineering is still a challenge. Here we designed and synthesized a series of shape memory copolymers with electroactivity, super stretchability and tunable recovery temperature based on poly(Îµ-caprolactone) (PCL) with different molecular weight and conductive amino capped aniline trimer, and demonstrated their potential to enhance myogenic differentiation from C2C12 myoblast cells. We characterized the copolymers by Fourier transform infrared spectroscopy (FT-IR), proton nuclear magnetic resonance (1H NMR), cyclic voltammetry (CV), ultraviolet-visible spectroscopy (UV-vis), differential scanning calorimetry (DSC), shape memory test, tensile test and in vitro enzymatic degradation study. The electroactive

biodegradable shape memory copolymers showed great elasticity, tunable recovery temperature around 37Â°C, and good shape memory properties. Furthermore, proliferation and differentiation of C2C12 myoblasts were investigated on electroactive copolymers films, and they greatly enhanced the proliferation, myotube formation and related myogenic differentiation genes expression of C2C12 myoblasts compared to the pure PCL with molecular weight of 80,000. Our study suggests that these electroactive, highly stretchable, biodegradable shape memory polymers with tunable recovery temperature near the body temperature have great potential in skeletal muscle tissue engineering application.

The Regulation of Osteogenesis Using Electroactive Polypyrrole Films.

https://www.ncbi.nlm.nih.gov/pubmed/30974534

To evaluate the effect of electrical conductivity of biomaterials on osteogenesis, polypyrrole (PPy) was fabricated by oxidative chemical polymerization as substrates for cell culture. Through adjusting the concentrations of monomer and initiator, polypyrrole films with different electrical conductivities were fabricated. These fabricated polypyrrole films are transparent enough for easy optical microscopy. Fourier transform infrared spectroscopy, X-ray spectroscopy and four-point probe were used to assess the microstructures, surface chemical compositions and electrical sheet resistance of films, respectively. Results indicate that higher monomer and initiator concentration leads to highly-branched PPy chains and thus promotes the electron mobility and electrical conductivity. Selected polypyrrole films then were applied for culturing rat bone marrow stromal cells. Cell viability and mineralization assays reveal that not only these films are biocompatible, but also capable of enhancing the calcium deposition into the extra cellular matrix by the differentiated cells.

Superior Charge Storage and Power Density of a Conducting Polymer-Modified Covalent Organic Framework.

https://www.ncbi.nlm.nih.gov/pubmed/27725966

The low conductivity of two-dimensional covalent organic frameworks (2D COFs), and most related coordination polymers, limits their applicability in optoelectronic and electrical energy storage (EES) devices. Although some networks exhibit promising conductivity, these examples generally lack structural versatility, one of the most attractive features of framework materials design. Here we enhance the electrical conductivity of a redox-active 2D COF film by electropolymerizing 3,4-ethylenedioxythiophene (EDOT) within its pores. The resulting poly(3,4-ethylenedioxythiophene)

(PEDOT)-infiltrated COF films exhibit dramatically improved electrochemical responses, including quantitative access to their redox-active groups, even for 1 Î¼m-thick COF films that otherwise provide poor electrochemical performance. PEDOT-modified COF films can accommodate high charging rates (10-1600 C) without compromising performance and exhibit both a 10-fold higher current response relative to unmodified films and stable capacitances for at least 10â€¯000 cycles. This work represents the first time that electroactive COFs or crystalline framework materials have shown volumetric energy and power densities comparable with other porous carbon-based electrodes, thereby demonstrating the promise of redox-active COFs for EES devices.

Full Polymer Dielectric Elastomeric Actuators (DEA) Functionalised with Carbon Nanotubes and High-K Ceramics.

https://www.ncbi.nlm.nih.gov/pubmed/30404345

Dielectric elastomer actuators (DEA) are special devices which have a simple working and construction principle and outstanding actuation properties. The DEAs consist of a combination of different materials for the dielectric and electrode layers. The combination of these layers causes incompatibilities in their interconnections. Dramatic differences in the mechanical properties and bad adhesion of the layers are the principal causes for the reduction of the actuation displacement and strong reduction of lifetime. Common DEAs achieve actuation displacements of 2% and a durability of some million cycles. The following investigations represent a new approach to solving the problems of common systems. The investigated DEA consists of only one basic raw polymer, which was modified according to the required demands of each layer. The basic raw polymer was modified with single-walled carbon nanotubes or high-k ceramics, for example, lead magnesium niobate-lead titanate. The development of the full polymer DEA comprised the development of materials and technologies to realise a reproducible layer composition. It was proven that the full polymer actuator worked according to the theoretical rules. The investigated system achieved actuation displacements above 20% regarding thickness, outstanding interconnections at each layer without any failures, and durability above 3 million cycles without any indication of an impending malfunction.

Electroactive 3D Scaffolds Based on Silk Fibroin and Water-Borne Polyaniline for Skeletal Muscle Tissue Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/28671759

Silk fibroin (SF) with good biocompatibility and degradability has great potential for tissue engineering. However, the SF based scaffolds lack the electroactivity to regulate the myogenic differentiation for the regeneration of muscle tissue, which is sensitive to electrical signal. Herein, a series of electroactive biodegradable scaffolds based on SF and water-soluble conductive poly(aniline-co-N-(4-sulfophenyl) aniline) (PASA) via a green method for skeletal muscle tissue engineering are designed. SF/PASA scaffolds are prepared by vortex of aqueous solution of SF and PASA under physiological condition. Murine-derived L929 fibroblast and C2C12 myoblast cells are used to evaluate cytotoxicity of SF/PASA scaffolds. Moreover, myogenic differentiation of C2C12 cells is investigated by analyzing the morphology of myotubes and related gene expression. These results suggest that electroactive SF/PASA scaffolds with a suitable microenvironment, which can enhance the myogenic differentiation of C2C12 cells, have a great potential for skeletal muscle regeneration.

A Simple and Scalable Fabrication Method for Organic Electronic Devices on Textiles.

https://www.ncbi.nlm.nih.gov/pubmed/28362384

Today, wearable electronics devices combine a large variety of functional, stretchable, and flexible technologies. However, in many cases, these devices cannot be worn under everyday conditions. Therefore, textiles are commonly considered the best substrate to accommodate electronic devices in wearable use. In this paper, we describe how to selectively pattern organic electroactive materials on textiles from a solution in an easy and scalable manner. This versatile deposition technique enables the fabrication of wearable organic electronic devices on clothes.

Ferrocene-coated CdSe/ZnS quantum dots as electroactive nanoparticles hybrids.

https://www.ncbi.nlm.nih.gov/pubmed/20585158

Electrochemical properties of core-shell CdSe/ZnS quantum dots (QDs) in a non-aqueous solution are presented. Cathodic reduction and anodic oxidation processes involving the QD HOMO and LUMO levels as well as defect states were identified by cyclic voltammetry. The electrochemical bandgap was estimated from the anodic and cathodic redox peaks and found to match well with the optical bandgap estimated from the absorption spectrum. The trioctylphosphine oxide ligands on the surface of the QDs were exchanged to electroactive ferrocenyl thiols and the resulting material was characterized by NMR and optical spectroscopy. Cyclic voltammetry showed that the redox potentials of the QDs are modified due to the presence of ferrocene on the surface of the QD. The

QD oxidation peak decreased and the reduction peak shifted to more negative potentials. The concurrent shift of the ferrocene redox peaks indicates that the system displays features of a 'molecular hybrid', where both the QD and the ligand influence each other.

A polyamidoamine dendrimer-streptavidin supramolecular architecture for biosensor development.

https://www.ncbi.nlm.nih.gov/pubmed/28686995

A novel polyamidoamine dendrimer-streptavidin supramolecular architecture suitable as a versatile platform for biosensor development is reported. The dendrimer was electrodeposited on a glassy carbon electrode via cyclic voltammetry. The dendrimer electrode was further modified with streptavidin by electrostatic attraction upon drop coating. The platform i.e. the dendrimer-streptavidin modified electrode was electrochemically interrogated in phosphate buffer, ferrocyanide and H2O2. The dendrimer-streptavidin platform was used in the preparation of a simple DNA biosensor as a proof of concept. The supramolecular architecture of dendrimer-streptavidin was stable, electroactive and thus lends itself as a versatile immobilisation layer for any biotinylated bioreceptors in biosensor development.

New immobilisation method for oligonucleotides on electrodes enables highly-sensitive, electrochemical label-free gene sensing.

https://www.ncbi.nlm.nih.gov/pubmed/28582708

We present a versatile and facile procedure for the immobilisation of bioprobe molecules to an electrochemical sensing element. We eliminate lengthy preparation procedures for direct functionalisation of electrode surfaces by pre-attaching probe molecules to carboxylic acid bearing termonomers of pyrrole phenylenes or thiophene phenylenes. We demonstrate that these conjugates can be electrodeposited at low potentials to form nano-scale porous, electroactive conducting polymer films, exposing the bioprobe and retaining activity and specificity for binding, exemplified here with DNA sensors. The electrochemical reaction impedance for Fe(CN)63-/4- on oligonucleotide-modified electrodes showed remarkable (down to aM) detection sensitivity for target DNA sequences present in solution. Cross-sensitivity to non-complementary target sequences is small and multi-target arrays are easily made. There is no need for labelling of either probe or target oligonucleotide.

Yolk-Shell Nanocomposites of a Gold Nanocore Encapsulated in an Electroactive Polyaniline Shell for Catalytic Aerobic Oxidation.

https://www.ncbi.nlm.nih.gov/pubmed/31457122

Noble metal nanoparticles (NPs) have been widely applied in nanocatalysis owing to the benefits associated with their miniature size. However, improving their stability and reusability during catalytic applications still remains a great challenge. To this end, monodispersed gold@void@polyaniline yolk-shell nanocomposites (Au@void@PANI YSNs) were synthesized using bottom-up template-assisted methods. Au@SiO2 NPs, prepared from a modified sol-gel process, were used as templates for the thiol-ene click reaction with 4-vinylaniline (VAn) to immobilize the aniline moieties, which later performed as the initiation sites for the oxidative copolymerization of aniline from the outer surface of the Au@SiO2-VAn NPs with an electroactive PANI shell (Au@SiO2@PANI NPs). The silica layer sandwiched between the Au core and PANI shell was selectively removed by aqueous hydrofluoric acid to produce Au@void@PANI YSNs with a movable Au core. The electroactive PANI shell not only serves as a physical barrier that prevents the self-association of Au cores and provides a vacant cavity where chemical transformations take place on the Au cores in a controlled manner but also improves the activity and stability of Au cores due to the electrons delocalization and transfer from the Au d orbitals of the nanocores to the Ï€-conjugated ligands of the PANI shell, as proved by the X-ray photoelectron spectroscopy results. The as-synthesized YSNs were found to perform as flexible and reusable heterogeneous catalysts with high catalytic efficiency for the aerobic oxidation of alcohol in aqueous solution. One may find the present study to be a general and effective way to fabricate monodispersed hollow nanomaterials in a controlled and green manner.

Chitin degradation and electricity generation by Aeromonas hydrophila in microbial fuel cells.

https://www.ncbi.nlm.nih.gov/pubmed/27810527

Chitin is one of the most abundant biopolymers in nature and the main composition of shrimp and crab shells (usually as food wastes). Thus it is essential to investigate the potential of degrading chitin for energy recovery. This study investigated the anaerobic degradation of chitin by Aeromonas hydrophila, a chitinolytic and popular electroactive bacterium, in both fermentation and microbial fuel cell (MFC) systems. The primary chitin metabolites produced in MFC were succinate, lactate, acetate, formate, and ethanol. The total metabolite concentration from chitin degradation increased

seven-fold in MFC compared to the fermentation system, as well as additional electricity generation. Moreover, A.Â hydrophila degraded GlcNAc (the intermediate of chitin hydrolysis) significantly faster (0.97 and 0.94Â mMÂ C/d/mM-GlcNAc) than chitin (0.13 and 0.03Â mMÂ C/d/mM-GlcNAc) in MFC and fermentation systems, indicating that extracellular hydrolysis of chitin was the rate-limiting step and this step could be accelerated in MFC. Furthermore, more chemicals produced by the addition of exogenous mediators in MFC. This study proves that the chitin could be degraded effectively by an electroactive bacterium in MFC, and our results suggest that this bioelectrochemical system might be useful for the degradation of recalcitrant biomass to recover energy.

Synthesis of Water-Dispersible Molecularly Imprinted Electroactive Nanoparticles for the Sensitive and Selective Paracetamol Detection.

https://www.ncbi.nlm.nih.gov/pubmed/27463123

A novel kind of water-dispersible molecularly imprinted electroactive nanoparticles was prepared combining macromolecular self-assembly with molecularly imprinting technique employing paracetamol (PCM) as template molecule. An amphiphilic electroactive copolymer (P(NVC-EHA-AA), PNEA) containing carbazole group was first synthesized through a one-pot free radical copolymerization. The coassembly of the electroactive copolymers with the template molecules (PCM) in aqueous solution generated nanoparticles embedded with PCM, leading to the formation of molecularly imprinted electroactive nanoparticles (MIENPs). A robust MIP film was formed on the surface of electrode by electrodeposition of MIENPs and subsequent electropolymerization of the carbazole units in MIENPs. After the extraction of PCM molecules, a MIP sensor was successfully constructed. It should be noted that electropolymerization of the electroactive units in MIENPs creates cross-conjugated polymer network, which not only locks the recognition sites but also significantly accelerates the electron transfer and thus enhances the response signal of the MIP sensor. These advantages endowed the MIP sensor with good selectivity and high sensitivity for PCM detection. The MIP sensor could recognize PCM from its possible interfering substances with good selectivity. Under the optimal conditions, two linear ranges from 1 Î¼M to 0.1 mM and 0.1 to 10 mM with a detection limit of 0.3 Î¼M were obtained for PCM detection. The MIP sensor also showed good stability and repeatability, which has been successfully used to analyze PCM in tablets and human urine samples with satisfactory results.

Layer-by-layer assembly of collagen and electroactive myoglobin.

https://www.ncbi.nlm.nih.gov/pubmed/20457010

In this work, an electrochemically inert protein collagen was successfully assembled with electroactive myoglobin (Mb) into {collagen/Mb}(n) layer-by-layer (LbL) films on solid surfaces. UV-vis spectroscopy and cyclic voltammetry (CV) were used to confirm the film growth and characterize the films. The collagen films provided a biocompatible microenvironment for Mb, and Mb in the stable {collagen/Mb}(n) films showed a nearly reversible CV response for its heme Fe(III)/Fe(II) redox couple. The direct electrochemistry of Mb in the films was used to electrocatalyze the reduction of oxygen and hydrogen peroxide. The interaction between collagen and Mb under different pH conditions was also explored. Not only the positively charged Mb at pH 5.0 but also the negatively charged Mb at pH 9.0 could be assembled with collagen into {collagen/Mb}(n) films. This work provides a novel example to assemble LbL films with two different proteins, and may establish a foundation for fabricating the new type of biosensors based on the direct electron transfer of redox proteins with underlying electrodes.

Pt NPs and DNAzyme functionalized polymer nanospheres as triple signal amplification strategy for highly sensitive electrochemical immunosensor of tumour marker.

https://www.ncbi.nlm.nih.gov/pubmed/27362254

Highly sensitive determination of tumour markers is the key for early diagnosis of cancer. Herein, triple signal amplification strategy resulting from polymer nanospheres, Pt NPs, and DNAzyme was proposed in the developed electrochemical immunosensor. First, electroactive polymer nanospheres were synthesized by infinite coordination polymerization of ferrocenedicarboxylic acid, which could generate strong electrochemical signals due to plentiful ferrocene molecules. Further, the polymer nanospheres were functionalized by Pt NPs and DNAzyme (hemin/G-quadruplex) with the ability of catalyzing H2O2, which contributes to enhance the electrochemical signals. The prepared conjugations were characterized by transmission electron microscope (TEM) and energy dispersive X-ray spectroscopy (EDX). And the process of preparation was monitored by zeta potential. Based on the sandwich-type immunoassay, the electrochemical immunosensor was constructed employing the conjugations as signal tags. Under optimal conditions, the DPV peak increased with the increasing of alpha fetal protein (AFP) concentration, and the linear range was from 0.1pgmL(-1) to 100ngmL(-1) with low detection limit of 0.086pgmL(-1). Meanwhile, the designed immunosensor exhibited excellent selectivity and anti-interference property, good reproducibility and stability. More importantly, there were no significant differences in analyzing real clinical samples between

designed immunosensor and commercial ELISA.

Electroconductive natural polymer-based hydrogels.

https://www.ncbi.nlm.nih.gov/pubmed/27721086

Hydrogels prepared from natural polymers have received immense considerations over the past decade due to their safe nature, biocompatibility, hydrophilic properties, and biodegradable nature. More recently, when treated with electroactive materials, these hydrogels were endowed with high electrical conductivity, electrochemical redox properties, and electromechanical properties; consequently, forming a smart hydrogel. The biological properties of these smart hydrogels, classified as electroconductive hydrogels, can be combined with electronics. Thus, they are considered as good candidates for some potential uses, which include bioconductors, biosensors, electro-stimulated drug delivery systems, as well as neuron-, muscle-, and skin-tissue engineering. However, there is lacking comprehensive information on the current state of these electroconductive hydrogels which complicates our understanding of this new type of biomaterials as well as their potential applications. Hence, this review provides a summary on the current development of electroconductive natural polymer-based hydrogels (ENPHs). We have introduced various types of ENPHs, with a brief description of their advantages and shortcomings. In addition, emerging technologies regarding their synthesis developed during the past decade are discussed. Finally, two attractive potential applications of ENPHs, cell culture and biomedical devices, are reviewed, along with their current challenges.

Electric Field Actuation of Tough Electroactive Hydrogels Cross-Linked by Functional Triblock Copolymer Micelles.

https://www.ncbi.nlm.nih.gov/pubmed/27617830

Multiresponsive polyelectrolyte hydrogels with extraordinary toughness have great potential in soft device applications. Previously we have demonstrated a series of tough and multiresponsive hydrogels by using multifunctional triblock copolymer (Pluronic F127 diacrylate, F127DA) micelles to cross-link cationic polyelectrolyte chains into 3D network. Herein, we further synthesize negatively charged hydrogels comprising 2-acrylamido-2-methyl propylsulfonic acid (AMPS) monomers by using F127DA micelles as cross-linkers. Similar to the positive nanomicelle (NM) hydrogels, the negative NM hydrogels exhibited a compressive strength up to 59 MPa with a fracture strain up to 98%, and tensile fracture strain higher than 2000%. These charged hydrogels were actuated by

electric field when immersed in salt solutions. The effects of electrolyte concentration, electric field strength, and ionic monomer content on the electric actuation behavior of these electroactive hydrogels (EAHs) have been systematically investigated. It is concluded that the electroactive hydrogels show a fast actuation rate with a bending angle up to 87Â° at 120 s and the bending angle was cyclically reversed upon changing bias direction without a large decrease. This study demonstrates that such tough and multiresponsive electroactive hydrogels may have great potential in sensors, actuators, switches, and artificial muscles.

Controlled carbon nanotube layers for impedimetric immunosensors: High performance label free detection and quantification of anti-cholera toxin antibody.

https://www.ncbi.nlm.nih.gov/pubmed/28599177

An original impedimetric immunosensor was developed based on carbon nanotube (CNT) deposits with controlled thicknesses for enhanced electroactive surface areas leading to improved sensor performances. Cholera monitoring was chosen as the model immune system for this setup. These CNT deposits were characterized using confocal laser microscopy and electrochemical methods. To form the sensor device, the CNT deposits were functionalized via electrocoating of polypyrrole-nitrilotriacetic acid (poly(pyrrole-NTA)) followed by the formation of a Cu (II) complex with the NTA functions. The bioreceptor unit, cholera toxin B Subunit, modified with biotin, was then immobilized via coordination of the biotin groups with the NTA-Cu(II) complex. Each step of the formation of the immunosensor and the subsequent binding of the analyte antibody anti-cholera toxin were investigated with cyclic voltammetry and Electrochemical Impedance Spectroscopy. After optimization, the resulting impedimetric cholera sensor shows excellent reproducibility, increased sensitivities, a very satisfying detection limit of 10-13gmL-1 and an exceptional linear range for anti-cholera detection of 8 orders of magnitude (10-13-10-5gmL-1) and a sensitivity of 24.7 Â± 0.4Î© per order of magnitude.

Electroactive Ionic Soft Actuators with Monolithically Integrated Gold Nanocomposite Electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/28417488

Electroactive ionic gel/metal nanocomposites are produced by implanting supersonically accelerated neutral gold nanoparticles into a novel chemically crosslinked ion conductive soft polymer. The ionic gel consists of chemically crosslinked poly(acrylic acid) and polyacrylonitrile networks, blended with

halloysite nanoclays and imidazolium-based ionic liquid. The material exhibits mechanical properties similar to that of elastomers (Young's modulus â‰ˆ 0.35 MPa) together with high ionic conductivity. The fabrication of thin (â‰ˆ100 nm thick) nanostructured compliant electrodes by means of supersonic cluster beam implantation (SCBI) does not significantly alter the mechanical properties of the soft polymer and provides controlled electrical properties and large surface area for ions storage. SCBI is cost effective and suitable for the scaleup manufacturing of electroactive soft actuators. This study reports the high-strain electromechanical actuation performance of the novel ionic gel/metal nanocomposites in a low-voltage regime (from 0.1 to 5 V), with long-term stability up to 76 000 cycles with no electrode delamination or deterioration. The observed behavior is due to both the intrinsic features of the ionic gel (elasticity and ionic transport capability) and the electrical and morphological features of the electrodes, providing low specific resistance (<100 Î© cm-2), high electrochemical capacitance (â‰ˆmF g-1), and minimal mechanical stress at the polymer/metal composite interface upon deformation.

Biocompatible electrically conductive nanofibers from inorganic-organic shape memory polymers.

https://www.ncbi.nlm.nih.gov/pubmed/27690245

A porous shape memory scaffold with both biomimetic structures and electrical conductivity properties is highly promising for nerve tissue engineering applications. In this study, a new shape memory polyurethane polymer which consists of inorganic polydimethylsiloxane (PDMS) segments with organic poly(Îµ-caprolactone) (PCL) segments was synthesized. Based on this poly(PCL/PDMS urethane), a series of electrically conductive nanofibers were electrospun by incorporating different amounts of carbon-black. Our results showed that after adding carbon black into nanofibers, the fiber diameters increased from 399Â±76 to 619Â±138nm, the crystallinity decreased from 33 to 25% and the resistivity reduced from 3.6 GÎ©/mm to 1.8 kÎ©/mm. Carbon black did not significantly influence the shape memory properties of the resulting nanofibers, and all the composite nanofibers exhibited decent shape recovery ratios of >90% and shape fixity ratios of >82% even after 5 thermo-mechanical cycles. PC12 cells were cultured on the shape memory nanofibers and the composite scaffolds showed good biocompatibility by promoting cell-cell interactions. Our study demonstrated that the poly(PCL/PDMS urethane)/carbon-black nanofibers with shape memory properties could be potentially used as smart 4-dimensional (4D) scaffolds for nerve tissue regeneration.

Carrier generation and electronic properties of a single-component pure organic metal.

https://www.ncbi.nlm.nih.gov/pubmed/27723739

Metallic conduction generally requires high carrier concentration and wide bandwidth derived from strong orbital interaction between atoms or molecules. These requisites are especially important in organic compounds because a molecule is fundamentally an insulator; only multi-component salts with strong intermolecular interaction-namely, only charge transfer complexes and conducting polymers-have demonstrated intrinsic metallic behaviour. Herein we report a single-component electroactive molecule, zwitterionic tetrathiafulvalene(TTF)-extended dicarboxylate radical (TED), exhibiting metallic conduction even at low temperatures. TED exhibits d.c. conductivities of 530â€‰Sâ€‰cm-1 at 300â€‰K and 1,000â€‰Sâ€‰cm-1 at 50â€‰K with copper-like electronic properties. Spectroscopic and theoretical investigations of the carrier-generation mechanism and the electronic states of this single molecular species reveal a unique electronic structure with a spin-density gradient in the extended TTF moieties that becomes, in itself, a metallic state.

Synthesis and characterization of a material derived from 4-mercaptobenzoic acid: A novel platform for oligonucleotide immobilization.

https://www.ncbi.nlm.nih.gov/pubmed/28153318

This paper reports the electrochemical modification of pencil carbon graphite electrodes with a polymeric material derived from 4-mercaptobenzoic acid. Acidic solutions (pH 0 and 5.02) yielded an insulating polymeric film with anionic permselective properties. Scanning Electron Microscopy (SEM) analysis showed a complete coverage of the carbon graphite electrodes with a laminar-like polymeric structure. Different characterization studies indicate that the carboxyl group remained unchanged since the absorbance peak and oxidation potential did not change with the increase in pH at the pKa accounting for the carboxyl/carboxylate redox transition. The functionalized matrix was activated using carbodiimide, succinimide and an amine-modified oligonucleotide. The immobilization and hybridization processes were successfully verified using the redox electroactive indicator methylene blue, where better electrochemical signals were obtained when compared with the traditional self-assembled monolayer system. The selectivity of the system was verified using a noncomplementary target where no significant difference in electric current was observed when compared to the system containing only the probe. The method showed a good linear correlation coefficient (r2=0.9915), low limit of detection (1.17nmolL-1), and an acceptable precision (RSD=2.75%). The proposed method is suitable for further studies using different sequences of

oligonucleotides.

Pulse electrosynthesis of novel wormlike gadolinium oxide nanostructure and its nanocomposite with conjugated electroactive polymer as a hybrid and high efficient electrode material for energy storage device.

https://www.ncbi.nlm.nih.gov/pubmed/27592187

An effective approach for increasing the life cycle of pure p-type conductive polymers is combining conventional conductive polymers and nanomaterials to fabricate hybrid electrodes. In this paper, Gadolinium oxide (Gd2O3) has first been synthesized using pulse electrochemical approach. Hybrid POAP/Gd2O3 films have then been fabricated by POAP electropolymerization in the presence of Gd2O3 nanoparticles as active electrodes for electrochemical supercapacitors. Surface and electrochemical analyses have been used for characterization of Gd2O3 and POAP/Gd2O3 composite films. Different electrochemical methods including galvanostatic charge discharge experiments, cyclic voltammetry and electrochemical impedance spectroscopy have been applied to study the system performance. Specific capacitance, specific energy and specific power of the composite film are calculated 300FÂ·g-1, 41.66WhÂ·kg-1 and 833.22WÂ·kg-1 respectively. This work introduces new nanocomposite materials for electrochemical redox capacitors with such advantages as the ease of synthesis, high active surface area and stability in an aqueous electrolyte.

Poly (3,4-ethylenedioxythiophene) graphene oxide composite coatings for controlling magnesium implant corrosion.

https://www.ncbi.nlm.nih.gov/pubmed/27867108

Magnesium (Mg) is a promising biodegradable implant material because of its appropriate mechanical properties and safe degradation products. However, in vivo corrosion speed and hydrogen gas production need to be controlled for uses in biomedical applications. Here we report the development of a conducting polymer 3,4-ethylenedioxythiphene (PEDOT) and graphene oxide (GO) composite coating as a corrosion control layer. PEDOT/GO was electropolymerized on Mg samples in ethanol media. The coated Mg samples were subjected to various corrosion tests. The PEDOT/GO coating significantly reduced the rate of corrosion as evidenced by lower Mg ion concentration and pH of the corrosion media. In addition, the coating decreased the evolved hydrogen. Electrochemical analysis of the corroding samples showed more positive corrosion

potential, a decreased corrosion current, and an increase in the polarization resistance. PEDOT/GO corrosion protection is attributed to three factors; an initial passive layer preventing solution ingress, buildup of negative charges in the film, and formation of corrosion protective Mg phosphate layer through redox coupling with Mg corrosion. To explore the biocompatibility of the coated implants in vitro, corrosion media from PEDOT/GO coated or uncoated Mg samples were exposed to cultured neurons where PEDOT/GO coated samples showed decreased toxicity. These results suggest that PEDOT/GO coating will be an effective treatment for controlling corrosion of Mg based medical implants.

Incorporation of glass-reinforced hydroxyapatite microparticles into poly(lactic acid) electrospun fibre mats for biomedical applications.

https://www.ncbi.nlm.nih.gov/pubmed/28415405

Tissue engineering is constantly evolving towards novel materials that mimic the properties of the replaced injured tissue or organ. A hybrid electrospun membrane of electroactive poly(l-acid lactic) (PLLA) polymer with glass reinforced hydroxyapatite (BonelikeÂ®) microparticles placed among the polymer fibres in a morphology like "islands in the sea" was processed. The incorporation of 60 to 80wt% BonelikeÂ® bone grafts granules with â‰¤150Î¼m into the polymer solution lead to an amorphous polymeric fibre membranes, and a decrease of the average polymer fibre diameter from 550Â±150nm for neat PLA down to 440Â±170nm for the hybrid composite. The presence of BonelikeÂ® in the polymer mats reduced the activation energy for thermal degradation from 134kJÂ·mol-1, obtained for the neat PLLA membranes down to 71kJÂ·mol-1, calculated for the hybrid composite membranes. In vitro cell culture results suggest that the developed processing method does not induce cytotoxic effects in MG 63 osteoblastic cells, and creates an environment that enhances cell proliferation, when compared to the neat PLLA membrane. The simplicity and scalability of the processing method suggests a large application potential of this novel hybrid polymer-microparticles fibre membranes for bone regenerative medicine.

Hydrogel-reinforced polypyrrole electroactuator.

https://www.ncbi.nlm.nih.gov/pubmed/28268297

Robust electroactuators that are lightweight, power-efficient and capable of generating high forces at a low actuation voltage are of great demand in the design of micro-electromechanical systems (MEMS) for biomedical applications. In this work, electroactive composite films of alginate hydrogel

and polypyrrole/polyethylene glycol (PPy/PEG) are synthesized and characterized as actuators for driving an implantable insulin micropump. A porous and flexible alginate hydrogel back layer is used to mechanically reinforce the PPy/PEG film by enhancing the actuator's resistance to its generated tension but without increase of its overall rigidness. Scanning electron microscopy (SEM) reveals that the PPy/PEG grows through the alginate hydrogel layer, thus forming a well-integrated composite and eliminating the possibility of delamination in long term applications. Mechanical test proves this alginate-PPy/PEG composite film to be more stretchable than the PPy/PEG film, and electroactuation test in phosphate buffered saline (PBS) demonstrated a large deformation at +2 V in 60 s. Taken together, our work here indicates great promise for this new type of composite actuator to be used in biomedical MEMS.

Design of a mechanism for converting the energy of knee motions by using electroactive polymers.

https://www.ncbi.nlm.nih.gov/pubmed/28258972

Harvesting energy from human body motions has become a promising option to prolong battery life for powering medical devices for autonomy. Up to now, different generating principles including dielectric electroactive polymers (DEAPs) have been suggested for energy conversion. However, there is a lack of mechanisms that are specifically designed to convert energy with DEAPs. In a proof of concept study, a mechanical system was designed for stretching DEAPs in those phases of the gait cycle, in which the muscles mainly perform negative work. Rotational movements of the knee joint are transformed into linear movements by using a cable pull. The DEAP can be charged during the stretching phase and discharged during releasing and allows for the conversion of kinetic energy into electric energy. To evaluate the concept, tests were conducted. It was found that the developed body energy harvesting (BEH) system has a performance in the range of 24-40 Î¼W at normal walking speed. The converted energy is sufficient for powering sensors in medical devices such as active orthoses or prostheses.

Solution-Assembled Blends of Regioregularity-Controlled Polythiophenes for Coexistence of Mechanical Resilience and Electronic Performance.

https://www.ncbi.nlm.nih.gov/pubmed/28363015

Considering all the potential applications of organic electronics in portable, wearable, and implantable devices, it is of great importance to develop electroactive materials that possess

mechanical reliability along with excellent electronic performance. The coexistence of these two attributes, however, is very difficult to achieve because there is an inverse relationship between the electrical properties and the mechanical flexibility, both of which are associated with the conjugation length and intermolecular ordering of the polymers. Herein, we demonstrate a simple and robust approach based on solution assembly of two different poly(3-hexylthiophene)s (P3HTs) with regioregularity (RR) contents of 97% and 66% to impart both electrical and mechanical properties to films for organic electronic applications. The 97% RR P3HT exhibits high electronic performance but poor mechanical resilience, and vice versa for the 66% RR P3HT. Selective crystallization of high RR P3HT induced by solution assembly allows the use of a one-step process to construct percolated networks of high RR P3HT nanowires (NWs) in a low RR P3HT matrix. Only 5 wt % of high RR P3HT NWs in a 95 wt % low RR P3HT matrix was required to produce hole mobilities comparable to that of pure high RR P3HT, and this blend film exhibited improvements by factors of 20 and 60 in elongation at break and toughness, respectively. Selective self-assembly of RR-controlled polymers allowed us to overcome the fragile nature of highly crystalline conjugated polymer films without sacrificing their electronic properties.

Novel thin layer flow-cell screen-printed graphene electrode for enzymatic sensors.

https://www.ncbi.nlm.nih.gov/pubmed/27771135

A new Screen-printed electrodes (SPE) integrated in one channel flow-cell was developed. The one channel flow-cell is attached and directly changeable with electrode. In the new flow-cell the injection is done through an "in-line luer injection port" which can be less aggressive than wall-jet flow cell for a biological recognition element immobilized on the surface of the electrode. The sample volume can be easily controlled by the operator through a syringe. In this novel thin layer flow-cell screen-printed electrodes, the working electrode was modified with graphene materials, and an enhancement of electroactive area to 388% over a standard electrode was found. This new configuration was applied to study the entrapped cellobiose dehydrogenase from the ascomycete Corynascus thermophilus (CtCDH) in a photocrosslinkable PVA-based polymer. The calibration curve of lactose using optimized parameters shows a wide linear measurement ranges between 0.25 and 5mM. A good operational stability of the CtCDH-PVA-modified graphene electrode is obtained, which keeps the same initial activity during 8h and exhibits a good storage stability with a decrease of only 9% in analytical response after 3 months storage at 4â—¦C.

Electrical Stimulation Using Conductive Polymer Polypyrrole Counters Reduced Neurite Outgrowth of Primary Prefrontal Cortical Neurons from NRG1-KO and DISC1-LI Mice.

https://www.ncbi.nlm.nih.gov/pubmed/28198409

Deficits in neurite outgrowth, possibly involving dysregulation of risk genes neuregulin-1 (NRG1) and disrupted in schizophrenia 1 (DISC1) have been implicated in psychiatric disorders including schizophrenia. Electrical stimulation using conductive polymers has been shown to stimulate neurite outgrowth of differentiating human neural stem cells. This study investigated the use of the electroactive conductive polymer polypyrrole (Ppy) to counter impaired neurite outgrowth of primary pre-frontal cortical (PFC) neurons from NRG1-knock out (NRG1-KO) and DISC1-locus impairment (DISC1-LI) mice. Whereas NRG1-KO and DISC1-LI exhibited reduced neurite length and number of neurite branches compared to wild-type controls, this was not apparent for cultures on electroactive Ppy. Additionally, the use of the Ppy substrate normalised the synaptophysin and PSD95 protein and mRNA expression whereas both are usually reduced by NRG1-KO or DISC1-LI. Our findings support the utility of Ppy mediated electrical stimulation to prevent the reduction of neurite outgrowth and related synaptic protein expression in the primary PFC neurons from NRG1-KO and DISC1-LI mice, providing proof-of-concept for treating neurodevelopmental diseases including schizophrenia.

Materials Design and System Construction for Conventional and New-Concept Supercapacitors.

https://www.ncbi.nlm.nih.gov/pubmed/28638780

With the development of renewable energy and electrified transportation, electrochemical energy storage will be more urgent in the future. Supercapacitors have received extensive attention due to their high power density, fast charge and discharge rates, and long-term cycling stability. During past five years, supercapacitors have been boomed benefited from the development of nanostructured materials synthesis and the promoted innovation of devices construction. In this review, we have summarized the current state-of-the-art development on the fabrication of high-performance supercapacitors. From the electrode material perspective, a variety of materials have been explored for advanced electrode materials with smart material-design strategies such as carbonaceous materials, metal compounds and conducting polymers. Proper nanostructures are engineered to provide sufficient electroactive sites and enhance the kinetics of ion and electron transport. Besides, new-concept supercapacitors have been developed for practical application. Microsupercapacitors and fiber supercapacitors have been explored for portable and compact

electronic devices. Subsequently, we have introduced Li-/Na-ion supercapacitors composed of battery-type electrodes and capacitor-type electrode. Integrated energy devices are also explored by incorporating supercapacitors with energy conversion systems for sustainable energy storage. In brief, this review provides a comprehensive summary of recent progress on electrode materials design and burgeoning devices constructions for high-performance supercapacitors.

A conducting polymer with enhanced electronic stability applied in cardiac models.

https://www.ncbi.nlm.nih.gov/pubmed/28138526

Electrically active constructs can have a beneficial effect on electroresponsive tissues, such as the brain, heart, and nervous system. Conducting polymers (CPs) are being considered as components of these constructs because of their intrinsic electroactive and flexible nature. However, their clinical application has been largely hampered by their short operational time due to a decrease in their electronic properties. We show that, by immobilizing the dopant in the conductive scaffold, we can prevent its electric deterioration. We grew polyaniline (PANI) doped with phytic acid on the surface of a chitosan film. The strong chelation between phytic acid and chitosan led to a conductive patch with retained electroactivity, low surface resistivity (35.85 Â± 9.40 kilohms per square), and oxidized form after 2 weeks of incubation in physiological medium. Ex vivo experiments revealed that the conductive nature of the patch has an immediate effect on the electrophysiology of the heart. Preliminary in vivo experiments showed that the conductive patch does not induce proarrhythmogenic activities in the heart. Our findings set the foundation for the design of electronically stable CP-based scaffolds. This provides a robust conductive system that could be used at the interface with electroresponsive tissue to better understand the interaction and effect of these materials on the electrophysiology of these tissues.

Simultaneous Voltammetric Measurements of Glucose and Dopamine Demonstrate the Coupling of Glucose Availability with Increased Metabolic Demand in the Rat Striatum.

https://www.ncbi.nlm.nih.gov/pubmed/27984698

Cerebral blood flow ensures delivery of nutrients, such as glucose, to brain sites with increased metabolic demand. However, little is known about rapid glucose dynamics at discrete locations during neuronal activation in vivo. Acute exposure to many substances of abuse elicits dopamine release and neuronal activation in the striatum; however, the concomitant changes in striatal glucose remain largely unknown. Recent developments have combined fast-scan cyclic voltammetry

with glucose oxidase enzyme modified carbon-fiber microelectrodes to enable the measurement of glucose dynamics with subsecond temporal resolution in the mammalian brain. This work evaluates several waveforms to enable the first simultaneous detection of endogenous glucose and dopamine at single recording sites. These molecules, one electroactive and one nonelectroactive, were found to fluctuate in the dorsal striatum in response to electrical stimulation of the midbrain and systemic infusion of cocaine/raclopride. The data reveal the second-by-second dynamics of these species in a striatal microenvironment, and directly demonstrate the coupling of glucose availability with increased metabolic demand. This work provides a foundation that will enable detailed investigation of local mechanisms that regulate the coupling of cerebral blood flow with metabolic demand under normal conditions, and in animal studies of drug abuse and addiction.

A novel molecularly imprinted electrochemical sensor modified with carbon dots, chitosan, gold nanoparticles for the determination of patulin.

https://www.ncbi.nlm.nih.gov/pubmed/28697441

In this paper, molecular imprinting technique was applied to the electrochemical sensor. We used 2-oxindole as dummy template, Ï•-Aminothiophenol (Ï•-ATP) as functional monomers, combined with the high sensitivity of electrochemical detection, to achieve a specific and efficient detection of patulin in fruit juice. In addition, carbon dots and chitosan were used as the modifying material to improve electron-transfer rate, expand the electroactive surface of glassy carbon electrode and enhance strength of the signal. The Au-S bond and hydrogen bond were employed to complete the assembly of the Ï•-ATP and 2-oxindole on the surface of the electrode. Then, polymer membranes were formed by electropolymerization in a polymer solution containing Ï•-ATP, HAuCl4, tetrabutylammonium perchlorate (TBAP) and the template molecule 2- oxindole. After elution, the specific cavity can adsorb the target patulin. Cyclic voltammetry (CV) and differential pulse voltammetry (DPV) measurements were performed to monitor the electropolymerization process and its optimization. Transmission electron microscopy (TEM), Scanning electron microscopy (SEM) and Atomic force microscopy (AFM) analyses were used for characterization. This was the first time that the molecularly imprinted polymer (MIP) technology combined with carbon dots, chitosan and Au nanoparticles modification and was applied in the electrochemical detection of patulin. The linear response range of the MIP sensor was from 1 Ã— 10-12 to 1 Ã— 10-9molL-1 and the limit of detection (LOD) was 7.57 Ã— 10-13molL-1. The sensor had a high-speed real-time detection capability, low sample consumption, high sensitivity, low interference, good stability and could

become a new promising method for the detection of patulin.

Efficient Capture and Isolation of Tumor-Related Circulating Cell-Free DNA from Cancer Patients Using Electroactive Conducting Polymer Nanowire Platforms.

https://www.ncbi.nlm.nih.gov/pubmed/27162553

Circulating cell-free DNA (cfDNA) is currently recognized as a key non-invasive biomarker for cancer diagnosis and progression and therapeutic efficacy monitoring. Because cfDNA has been detected in patients with diverse types of cancers, the use of efficient strategies to isolate cfDNA not only provides valuable insights into tumour biology, but also offers the potential for developing new cancer-specific targets. However, the challenges associated with conventional cfDNA extraction methods prevent their further clinical applications. Here, we developed a nanostructured conductive polymer platform for the efficient capture and release of circulating cfDNA and demonstrated its potential clinical utility using unprocessed plasma samples from patients with breast and lung cancers. Our results confirmed that the platform's enhanced efficiency allows tumor-specific circulating cfDNA to be recovered at high yield and purity.

Electrically-responsive core-shell hybrid microfibers for controlled drug release and cell culture.

https://www.ncbi.nlm.nih.gov/pubmed/28392307

It is an active research field to develop fiber-shaped smart materials for biomedical applications. Here we report the development of the multifunctional core-shell hybrid microfibers with excellent mechanical and electrical performance as a new smart biomaterial. The microfibers were synthesized using a combination of co-axial spinning with a microfluidic device and subsequent dip-coating, containing a hydrogel core of bacterial cellulose (BC) and a conductive polymer shell layer of poly(3,4-ethylenedioxythiophene) (PEDOT). The hybrid microfibers were featured with a well-controlled microscopic morphology, exhibiting enhanced mechanic properties. A model drug, diclofenac sodium, can be loaded in the core layer of the microfibers in situ during the process of synthesis. Our experiments suggested that the releasing behaviors of the drug molecules from the microfibers were enhanced by external electrical stimulation. Interestingly, we demonstrated an excellent biocompatibility and electroactivity of the hybrid microfibers for PC12 cell culture, thus promising a flexible template for the reconstruction of electrically-responsive tissues mimicking muscle fibers or nerve networks.

Chiral conducting surfaces via electrochemical oxidation of L-leucine-oligothiophenes.

https://www.ncbi.nlm.nih.gov/pubmed/20718451

Polythiophenes bearing a specific chiral center such as L-leucine have been prepared via the electrochemical oxidation of a series of L-leucine functionalized oligothiophenes (monothiophenes and terthiophenes). These oligothiophenes have been prepared through the condensation of L-leucine methyl ester and the corresponding thiophene monomers in the presence of hydroxybenzotriazole (HOBt) and N,N'-dicyclohexylcarbodiimide (DCC) followed by hydrolysis of the esters. The electroactive polymers are electrochemically stable and exhibit excellent adhesive properties on electrode surfaces (platinum, gold, and glassy carbon) as well as interesting optical properties in both doped and undoped states. Hydrogen bonds between a free amino acid (L-leucine, D-leucine, L-alanine, D-alanine, and D/L-alanine) and the L-leucine based polythiophenes (chiral conducting surface) were probed using cyclic voltammetry. Preliminary results show that the capacitive current of a modified L-leucine-polythiophene electrode decreases as a result of the formation of a hydrogen bond barrier on the surface of the chiral conducting surface accompanied with a shift of the oxidation potential. Cyclic voltammetry responses resulting from the interaction of the chiral conducting surface with L and Dfree amino acid isomers are similar. The formation of hydrogen bonds between the chiral conducting surfaces and the free amino acids was characterized by (1)H NMR. A chemical shift was observed for the N-H group in monomer 6 as a result of the hydrogen bond formation between the L-leucine methyl ester (D-leucine methyl ester, D/L-leucine methyl ester) and monomer 6.

Electroactive BaTiO3 nanoparticle-functionalized fibrous scaffolds enhance osteogenic differentiation of mesenchymal stem cells.

https://www.ncbi.nlm.nih.gov/pubmed/28603415

It has been proven that the surface topographic cues of fiber arrangement can induce osteogenic differentiation of mesenchymal stem cells. However, this effect alone is weak and insufficient to meet the needs of regenerative medicine. In this work, electroactivity concept was introduced to enhance the osteoinductivity of fibrous scaffolds. The randomly oriented and aligned electroactive fibrous scaffolds of poly-(l-lactic acid) (PLLA) with incorporation of ferroelectric ceramic BaTiO3 (BTO) nanoparticles (NPs) were fabricated by electrospinning. Physicochemical properties, including fiber morphology, microstructure, composition, thermal stability, surface roughness, and surface wettability, of these fibrous scaffolds were studied. The dielectric properties of the scaffolds

were evaluated. The results showed that the randomly oriented BTO/PLLA composite fibrous scaffolds had the highest dielectric permittivity of 1.19, which is of the same order of magnitude as the natural bone. The combined effects of fiber orientation and electrical activity on the osteogenic responses of bone marrow mesenchymal stem cells (BM-MSCs) were specifically investigated. Randomly oriented composite fibrous scaffolds significantly promoted polygonal spreading and encouraged early osteogenic differentiation in BM-MSCs, whereas aligned composite fibrous scaffolds promoted cell elongation and discouraged osteogenic differentiation. These results evidenced that randomly fiber orientation and biomimetic electric activity have combining effects on osteogenic differentiation of BM-MSCs. Our findings indicate that coupling effects of multi-physical properties should be paid more attention to mimic the microenvironment for enhancing osteogenic differentiation of BM-MSCs.

Functionalized nanocomposites with the optimal graphene oxide/Au ratio for amplified immunoassay of E. coli to estimate quality deterioration in dairy product.

https://www.ncbi.nlm.nih.gov/pubmed/27818044

An amplified electrochemical immunosensor was developed by exploiting poly(diallyldimethylammonium chloride)-functionalized graphene oxide and gold nanoparticles (GO-PDDA@AuNP) as sensing platform. Highlight of this work was to investigate and optimize the ratio of GO-PDDA to AuNP for sensitivity enhancement. The suitable GO-PDDA@AuNP nanocomposites were proven to not only provide an excellent biocompatible microenvironment for the immobilized antibody, but also accelerate electron transfer to enhance electrochemical signal. Moreover, the {dAb-Au-THi} nanoprobes as biorecognition elements were designed by utilizing the amplification effect of AuNPs to load detection antibody (dAb) and enormous thionine (THi), in which dAb was used for specific recognition of E. coli and THi served as electroactive species. Under optimal conditions, experimental results demonstrated that the variations (Î”I) in the peak current linearly depended on the logarithmic value of E. coli concentration from 50 to 5.0Ã—106cfumL-1 with the detection limit of 35cfumL-1. Recovery experiments were also performed for E. coli assay in dairy product (pure fresh milk, yogurt in shelf-life and expired yogurt), and the recoveries of standard additions were in the range of 89.7-112.6%. The excellent performance of the proposed strategy indicated its promising prospect as a valuable tool to estimate the quality deterioration in dairy product.

Integration of a zero dead-volume PDMS rotary switch valve in a miniaturised (bio)electroanalytical system.

https://www.ncbi.nlm.nih.gov/pubmed/20449514

This work features the design, fabrication and characterisation of a miniaturised electroanalytical lab on a chip that allows the performance of a complete bioassay, from the capture of magnetic particles through their functionalisation and sample incubation to the detection of electroactive reaction products. The system is built using mainly polymeric materials such as PMMA and PDMS and fast prototyping techniques such as milling and moulding. The system also includes a set of microelectrodes, photo-lithographed on a silicon chip. The novelty lies in the design of the rotary microvalve, which contains a microreactor so that various reaction and incubation steps can be carried out in isolation from the detection event with zero dead volume. This avoids contamination and fouling of the electrodes by proteins or other organic matter, and extends the useful lifetime of the detector. The system operation is demonstrated by a model example, consisting in the functionalisation of streptavidin-coated magnetic particles with biotinylated beta-galactosidase over periods ranging from 5 to 15 min, at which point the particles saturate. Although the system is intended for the development of enzyme-based electrochemical bioassays, the concept of its rotary microreactor can be applied more broadly.

High-performance glucose biosensor based on chitosan-glucose oxidase immobilized polypyrrole/Nafion/functionalized multi-walled carbon nanotubes bio-nanohybrid film.

https://www.ncbi.nlm.nih.gov/pubmed/27485503

A highly electroactive bio-nanohybrid film of polypyrrole (PPy)-Nafion (Nf)-functionalized multi-walled carbon nanotubes (fMWCNTs) nanocomposite was prepared on the glassy carbon electrode (GCE) by a facile one-step electrochemical polymerization technique followed by chitosan-glucose oxidase (CH-GOx) immobilization on its surface to achieve a high-performance glucose biosensor. The as-fabricated nanohybrid composite provides high surface area for GOx immobilization and thus enhances the enzyme-loading efficiency. The structural characterization revealed that the PPy-Nf-fMWCNTs nanocomposite films were uniformly formed on GCE and after GOx immobilization, the surface porosities of the film were decreased due to enzyme encapsulation inside the bio-nanohybrid composite materials. The electrochemical behavior of the fabricated biosensor was investigated by cyclic voltammetry (CV), electrochemical impedance spectroscopy (EIS), and amperometry measurements. The results indicated an excellent catalytic property of

bio-nanohybrid film for glucose detection with improved sensitivity of 2860.3Î¼AmM(-1)cm(-2), the linear range up to 4.7mM (R(2)=0.9992), and a low detection limit of 5Î¼M under a signal/noise (S/N) ratio of 3. Furthermore, the resulting biosensor presented reliable selectivity, better long-term stability, good repeatability, reproducibility, and acceptable measurement of glucose concentration in real serum samples. Thus, this fabricated biosensor provides an efficient and highly sensitive platform for glucose sensing and can open up new avenues for clinical applications.

Electroactivity and stability of polylactide/polypyrrole composites.

https://www.ncbi.nlm.nih.gov/pubmed/20961496

Electrically conductive biodegradable composites are useful in biomedical engineering to mediate electrical interactions between cells and electrical components. Because conductive polymers are often subjected to progressive oxidative deterioration and dedoping, their electrical stability in aqueous environment is, therefore, critical. We used cyclic voltammetry (CV) to investigate the electroactivity and stability of conductive membranes made of only 5% conductive polypyrrole (PPy) particles blended with 95% insulating polylactide (PLLA). During 1000 CV scans, the electroactivity of the composite membranes revealed a period of initial activation, followed by a relatively stable period and subsequent slow deterioration process. PPy membranes doped with heparin, a cell-adhesive polysaccharide and polyanion, displayed electrical stability superior to that of PPy membranes doped with chlorine anions. The latter, however, recorded a higher initial electroactivity during the first ca. 150 scans. XPS analysis showed that the deterioration of the electroactivity was likely due to the oxidation of the PPy. ATR-FT-IR and SEM were also used to characterize the materials. The PLLA/PPy membranes were thus electroactive and maximum electroactivity was achieved through an activation process. The heparin-doped PPy composite was electrically stable and may, thus, be used for multiple long-term electrical stimulations.

Electrocatalytic (Bio)Nanostructures Based on Polymer-Grafted Platinum Nanoparticles for Analytical Purpose.

https://www.ncbi.nlm.nih.gov/pubmed/27192083

Functionalized platinum nanoparticles (PtNPs) possess electrocatalytic properties toward H2O2 oxidation, which are of great interest for the construction of electrochemical oxidoreductase-based sensors. In this context, we have shown that polymer-grafted PtNPs could efficiently be used as building bricks for electroactive structures. In the present work, we prepared different

2D-nanostructures based on these elementary bricks, followed by the subsequent grafting of enzymes. The aim was to provide well-defined architectures to establish a correlation between their electrocatalytic properties and the arrangement of building bricks. Two different nanostructures have been elaborated via the smart combination of surface initiated-atom transfer radical polymerization (SI-ATRP), functionalized PtNPs (Br-PtNPs) and Langmuir-Blodgett (LB) technique. The first nanostructure (A) has been elaborated from LB films of poly(methacrylic acid)-grafted PtNPs (PMAA-PtNPs). The second nanostructure (B) consisted in the elaboration of polymer brushes (PMAA brushes) from Br-PtNPs LB films. In both systems, grafting of the glucose oxidase (GOx) has been performed directly to nanostructures, via peptide bonding. Structural features of nanostructures have been carefully characterized (compression isotherms, neutron reflectivity, and profilometry) and correlated to their electrocatalytic properties toward H2O2 oxidation or glucose sensing.

Novel amperometric glucose biosensor based on MXene nanocomposite.

https://www.ncbi.nlm.nih.gov/pubmed/27830757

A biosensor platform based on Au/MXene nanocomposite for sensitive enzymatic glucose detection is reported. The biosensor leverages the unique electrocatalytic properties and synergistic effects between Au nanoparticles and MXene sheets. An amperometric glucose biosensor is fabricated by the immobilization of glucose oxidase (GOx) enzyme on Nafion solubilized Au/ MXene nanocomposite over glassy carbon electrode (GCE). The biomediated Au nanoparticles play a significant role in facilitating the electron exchange between the electroactive center of GOx and the electrode. The GOx/Au/MXene/Nafion/GCE biosensor electrode displayed a linear amperometric response in the glucose concentration range from 0.1 to 18â€‰mM with a relatively high sensitivity of 4.2â€‰Î¼AmM-1 cm-2 and a detection limit of 5.9â€‰Î¼M (S/Nâ€‰=â€‰3). Furthermore, the biosensor exhibited excellent stability, reproducibility and repeatability. Therefore, the Au/MXene nanocomposite reported in this work is a potential candidate as an electrochemical transducer in electrochemical biosensors.

Dispersion-Assembly Approach to Synthesize Three-Dimensional Graphene/Polymer Composite Aerogel as a Powerful Organic Cathode for Rechargeable Li and Na Batteries.

https://www.ncbi.nlm.nih.gov/pubmed/28425698

Polymer cathode materials are promising alternatives to inorganic counterparts for both lithium-ion

batteries (LIBs) and sodium-ion batteries (SIBs) due to their high theoretical capacity, adjustable molecular structure, and strong adaptability to different counterions in batteries, etc. However, they suffer from poor practical capacity and low rate capability because of their intrinsically poor conductivity. Herein, we report the synthesis of self-assembled graphene/poly(anthraquinonyl sufide) (PAQS) composite aerogel (GPA) with efficient integration of a three-dimensional (3D) graphene framework with electroactive PAQS particles via a novel dispersion-assembly strategy which can be used as a free-standing flexible cathode upon mechanical pressing. The entire GPA cathode can deliver the highest capacity of 156 mAh g-1 at 0.1 C (1 C = 225 mAh g-1) with an ultrahigh utilization (94.9%) of PAQS and exhibits an excellent rate performance with 102 mAh g-1 at 20 C in LIBs. Furthermore, the flexible GPA film was also tested as cathode for SIBs and demonstrated a high-rate capability with 72 mAh g-1 at 5 C and an ultralong cycling stability (71.4% capacity retention after 1000 cycles at 0.5 C) which has rarely been achieved before. Such excellent electrochemical performance of GPA as cathode for both LIBs and SIBs could be ascribed to the fast redox kinetics and electron transportation within GPA, resulting from the interconnected conductive framework of graphene and the intimate interaction between graphene and PAQS through an efficient wrapping structure. This approach opens a universal way to develop cathode materials for powerful batteries with different metal-based counter electrodes.

Scalable Synthesis and Multi-Electron Transfer of Aniline/Fluorene Copolymer for Solution-Processable Battery Cathodes.

https://www.ncbi.nlm.nih.gov/pubmed/28387972

In this study, the authors report the highly efficient, multigram-scale synthesis of an ester-functionalized, poly(aniline-co-fluorene) polymer. The excellent solubility and film-forming ability of this polymer facilitate its application as a reversible battery cathode. Electrochemical quartz crystal microbalance with dissipation monitoring confirms a multi-electron transfer process, resulting in a specific discharge capacity of 51 mAh g-1 and a high reversible doping level of 0.69. Galvanostatic cycling at 1 C demonstrates excellent electrode stability with a capacity retention of 95.2% after 100 cycles. Therefore, this work demonstrates a novel electroactive polymer that exemplifies how chemical functionality may be used to properly balance processability and electroactivity of macromolecular battery cathodes.

A soluble and fluorescent new type thienylpyrrole based conjugated polymer: optical,

electrical and electrochemical properties.

https://www.ncbi.nlm.nih.gov/pubmed/27171850

Recently, increased attention has been focused on the synthesis of soluble and processable conducting polymers due to interest in their potential application. For this purpose a new type electroactive 2,5-di(2-thienyl)pyrrole derivative was synthesized and its novel solution-processable and fluorescent polymer, namely poly(N-(2,5-di(thiophen-2-yl)-1H-pyrrol-1-yl)-3,4,5-tris(dodecyloxy)benzamide) (P(TPDOB)), was electrochemically synthesized. Characterization of the monomer and the polymer was performed by (1)H-NMR, (13)C-NMR, cyclic voltammetry, and UV-vis and fluorescence spectroscopy. This soluble polymer has very well-defined and reversible redox processes in the acetonitrile-lithium perchlorate (ACN/LiClO4) couple. Moreover, P(TPDOB) shows multielectrochromic behavior: blue in the oxidized state, caesious in the intermediate state and greenish in the neutral state. Also the copolymer consists of EDOT and TPDOB was synthesized by cyclic voltammetry. A copolymer film has superior electrochromic and electrical properties when compared with a homopolymer. Furthermore, the fluorescence features of the monomer and the polymer were investigated. Although the monomer is a violet light emitter, its polymer is a yellow light emitter. Synthesis of this new type solution-processable and fluorescent conducting polymer is an alternative to the conventional synthesis of soluble conducting polymers which allows the direct application of the conductive polymer to any desired surface for potential technological applications.

Impact of electrolyte composition on the reactivity of a redox active polymer studied through surface interrogation and ion-sensitive scanning electrochemical microscopy.

https://www.ncbi.nlm.nih.gov/pubmed/27064026

Elucidating the impact of interactions between the electrolyte and electroactive species in redox active polymers is key to designing better-performing electrodes for electrochemical energy storage and conversion. Here, we present on the improvement of the electrochemical activity of poly(para-nitrostyrene) (PNS) in solution and as a film by exploiting the ionic interactions between reduced PNS and K(+), which showed increased reactivity when compared to tetrabutylammonium (TBA(+))- and Li(+)-containing electrolytes. While cyclic voltammetry enabled the study of the effects of cations on the electrochemical reversibility and the reduction potential of PNS, scanning electrochemical microscopy (SECM) provided new tools to probe the ionic and redox reactivity of this system. Using an ion-sensitive Hg SECM tip allowed to probe the ingress of ions into PNS redox

active films, while surface interrogation SECM (SI-SECM) measured the specific kinetics of PNS and a solution phase mediator in the presence of the tested electrolytes. SI-SECM measurements illustrated that the interrogation kinetics of PNS in the presence of K(+) compared to TBA(+) and Li(+) are greatly enhanced under the same surface concentration of adsorbed radical anion, exhibiting up to a 40-fold change in redox kinetics. We foresee using this new application of SECM methods for elucidating optimal interactions that enhance polymer reactivity for applications in redox flow batteries.

Self-Healing Conductive Injectable Hydrogels with Antibacterial Activity as Cell Delivery Carrier for Cardiac Cell Therapy.

https://www.ncbi.nlm.nih.gov/pubmed/27311127

Cell therapy is a promising strategy to regenerate cardiac tissue for myocardial infarction. Injectable hydrogels with conductivity and self-healing ability are highly desirable as cell delivery vehicles for cardiac regeneration. Here, we developed self-healable conductive injectable hydrogels based on chitosan-graft-aniline tetramer (CS-AT) and dibenzaldehyde-terminated poly(ethylene glycol) (PEG-DA) as cell delivery vehicles for myocardial infarction. Self-healed electroactive hydrogels were obtained after mixing CS-AT and PEG-DA solutions at physiological conditions. Rapid self-healing behavior was investigated by rheometer. Swelling behavior, morphology, mechanical strength, electrochemistry, conductivity, adhesiveness to host tissue and antibacterial property of the injectable hydrogels were fully studied. Conductivity of the hydrogels is âˆ¼10(-3) SÂ·cm(-1), which is quite close to native cardiac tissue. Proliferation of C2C12 myoblasts in the hydrogel showed its good biocompatibility. After injection, viability of C2C12 cells in the hydrogels showed no significant difference with that before injection. Two different cell types were successfully encapsulated in the hydrogels by self-healing effect. Cell delivery profile of C2C12 myoblasts and H9c2 cardiac cells showed a tunable release rate, and in vivo cell retention in the conductive hydrogels was also studied. Subcutaneous injection and in vivo degradation of the hydrogels demonstrated their injectability and biodegradability. Together, these self-healing conductive biodegradable injectable hydrogels are excellent candidates as cell delivery vehicle for cardiac repair.

A Resettable Keypad Lock with Visible Readout Based on Closed Bipolar Electrochemistry and Electrochromic Poly(3-methylthiophene) Films.

https://www.ncbi.nlm.nih.gov/pubmed/26914514

A closed bipolar electrode (BPE) system was developed with electrochromic poly(3-methylthiophene) (PMT) films electropolymerized on the ITO/rGO electrode as one pole of BPE in the reporting reservoir and the bare ITO electrode as another pole of BPE in the analyte reservoir, in which rGO represents reduced graphene oxide. Under a suitable driving voltage (Vtot), the electrochemical reduction/oxidation of electroactive probes, such as H2O2/glutathione (Glu), in the analyte reservoir could induce the reversible color change of PMT films in the reporting reservoir between blue and red. Based on this, a keypad lock with H2O2 , Glu, and Vtot =-3.0â€…V as the three inputs and the color change of PMT films as the visible output was established. This system was easily operated and did not need to synthesize the complex compounds or DNA molecules. The security system was easy to reset and could be used repeatedly.

Highly selective "turn-on" fluorescent sensing of fluoride ion based on a conjugated polymer thin film-Fe3+ complex.

https://www.ncbi.nlm.nih.gov/pubmed/28390489

We designed a new fluorescent conjugated polymer thin film sensor via direct electropolymerization of the corresponding electroactive monomer M onto the surface of ITO electrode, and the thin film-Fe3+ complex was used for the highly-selective detection of fluoride ion (F-) in water environmental samples. The as-obtained thin film could effectively detect Fe3+ as a selective turn-off fluorescent sensor, and exhibited outstanding reversibility. This film in the presence of Fe3+ showed a highly selective turn-on response toward F- over other anions with a 5-fold enhancement in the fluorescence intensity. F- with a relatively wide concentration range from 10Â Î¼M to 3Â mM could be determined in a rather simple and sensitive manner with a detection limit of 6.78Â Î¼M (0.128Â ppm). Analytical applicability of the film-Fe3+ complex for determining the levels of F- in environmental water samples has been successfully demonstrated by fluorescent analysis with satisfactory results. This strategy will provide a new approach for the facile design of new molecular sensing devices and practical application in environments.

Redox properties of extracellular polymeric substances (EPS) from electroactive bacteria.

https://www.ncbi.nlm.nih.gov/pubmed/27991531

Although the capacity for electroactive bacteria to convert environmental metallic minerals and organic pollutants is well known, the role of the redox properties of microbial extracellular polymeric substances (EPS) in this process is poorly understood. In this work, the redox properties of EPS

from two widely present electroactive bacterial strains (Shewanella oneidensis and Pseudomonas putida) were explored. Electrochemical analysis demonstrates that the EPS extracted from the two strains exhibited redox properties. Spectroelectrochemical and protein electrophoresis analyses indicate that the extracted EPS from S. oneidensis and P. putida contained heme-binding proteins, which were identified as the possible redox components in the EPS. The results of heme-mediated behavior of EPS may provide an insight into the important roles of EPS in electroactive bacteria to maximize their redox capability for biogeochemical cycling, environmental bioremediation and wastewater treatment.

Thermally and Electrically Triggered Triple-Shape Memory Behavior of Poly(vinyl acetate)/Poly(lactic acid) Due to Graphene-Induced Phase Separation.

https://www.ncbi.nlm.nih.gov/pubmed/28640585

This work aimed to develop a facile and broadly applicable method for fabricating multistimuli responsive triple-shape memory polymers (SMPs). Hence, herein the SMPs were prepared through the simple physical blending of two commercially available biopolymers, poly(lactic acid) (PLA) and poly(vinyl acetate) (PVAc), in the presence of robust and conductive graphene nanoplatelets. Interestingly, atomic force microscopy observations and thermal analyses revealed that the presence of nanofillers led to phase separation and appearance of two well-separated transition temperatures in the blend of these two miscible polymers. Consequently, shape memory results showed that the unfilled blend of PLA/PVAc with a single thermal transition can only show moderate heat triggered dual-shape memory behavior. While, PLA/PVAc/graphene nanocomposite blends demonstrated excellent thermally and electrically actuated triple-shape memory effects besides their remarkable dual-shape memory behavior. In addition, electrical conductivity of the blend was enhanced by âˆ¼14 orders of magnitude in the presence of graphene. More interestingly, electroactive shape recovery experiments exhibited that depending on the applied voltage, temporary shapes in each region of sample can be either individually or simultaneously recovered.

New CNT/poly(brilliant green) and CNT/poly(3,4-ethylenedioxythiophene) based electrochemical enzyme biosensors.

https://www.ncbi.nlm.nih.gov/pubmed/27237835

A combination of the electroactive polymer poly(brilliant green) (PBG) or conducting polymer poly(3,4-ethylenedioxythiophene) (PEDOT) with carbon nanotubes to obtain CNT/PBG and

CNT/PEDOT modified carbon film electrodes (CFE) has been investigated as a new biosensor platform, incorporating the enzymes glucose oxidase (GOx) as test enzyme, alcohol oxidase (AlcOx) or alcohol dehydrogenase (AlcDH). The sensing parameters were optimized for all biosensors based on CNT/PBG/CFE, CNT/PEDOT/CFE platforms. Under optimized conditions, both GOx biosensors exhibited very similar sensitivities, while in the case of AlcOx and AlcDH biosensors, AlcOx/CNT/PBG/CFE was found to give a higher sensitivity and lower detection limit. The influence of dissolved O2 on oxidase-biosensor performance was investigated and was shown to be different for each enzyme. Comparisons were made with similar reported biosensors, showing the advantages of the new biosensors, and excellent selectivity against potential interferents was successfully demonstrated. Finally, alcohol biosensors were successfully used for the determination of ethanol in alcoholic beverages.

Characterization and optimization of actuating poly(ethylene glycol) diacrylate/acrylic acid hydrogels as artificial muscles.

https://www.ncbi.nlm.nih.gov/pubmed/31456596

Large volume deficiencies in skeletal muscle tissue fail to heal with conservative treatments, and improved treatment methods are needed. Tissue engineered scaffolds for skeletal muscle need to mimic the optimal environment for muscle development by providing the proper electric, mechanical, and chemical cues. Electroactive polymers, polymers that change in size or shape in response to an electric field, may be able to provide the optimal environment for muscle growth. In this study, an electroactive polymer made from poly(ethylene glycol) diacrylate (PEGDA) and acrylic acid (AA) is characterized and optimized for movement and biocompatibility. Hydrogel sample thickness, overall polymer concentration, and the ratio of PEGDA to AA were found to significantly impact the actuation response. C2C12 mouse myoblast cells attached and proliferated on hydrogel samples with various ratios of PEGDA to AA. Future experiments will produce hydrogel samples combined with aligned guidance cues in the form of electrospun fibers to provide a favorable environment for muscle development.

Removal of Differential Capacitive Interferences in Fast-Scan Cyclic Voltammetry.

https://www.ncbi.nlm.nih.gov/pubmed/28488873

Due to its high spatiotemporal resolution, fast-scan cyclic voltammetry (FSCV) at carbon-fiber microelectrodes enables the localized in vivo monitoring of subsecond fluctuations in electroactive

neurotransmitter concentrations. In practice, resolution of the analytical signal relies on digital background subtraction for removal of the large current due to charging of the electrical double layer as well as surface faradaic reactions. However, fluctuations in this background current often occur with changes in the electrode state or ionic environment, leading to nonspecific contributions to the FSCV data that confound data analysis. Here, we both explore the origin of such shifts seen with local changes in cations and develop a model to account for their shape. Further, we describe a convolution-based method for removal of the differential capacitive contributions to the FSCV current. The method relies on the use of a small-amplitude pulse made prior to the FSCV sweep that probes the impedance of the system. To predict the nonfaradaic current response to the voltammetric sweep, the step current response is differentiated to provide an estimate of the system's impulse response function and is used to convolute the applied waveform. The generated prediction is then subtracted from the observed current to the voltammetric sweep, removing artifacts associated with electrode impedance changes. The technique is demonstrated to remove select contributions from capacitive characteristics changes of the electrode both in vitro (i.e., in flow-injection analysis) and in vivo (i.e., during a spreading depression event in an anesthetized rat).

Electroactive polymers for sensing.

https://www.ncbi.nlm.nih.gov/pubmed/27499846

Electromechanical coupling in electroactive polymers (EAPs) has been widely applied for actuation and is also being increasingly investigated for sensing chemical and mechanical stimuli. EAPs are a unique class of materials, with low-moduli high-strain capabilities and the ability to conform to surfaces of different shapes. These features make them attractive for applications such as wearable sensors and interfacing with soft tissues. Here, we review the major types of EAPs and their sensing mechanisms. These are divided into two classes depending on the main type of charge carrier: ionic EAPs (such as conducting polymers and ionic polymer-metal composites) and electronic EAPs (such as dielectric elastomers, liquid-crystal polymers and piezoelectric polymers). This review is intended to serve as an introduction to the mechanisms of these materials and as a first step in material selection for both researchers and designers of flexible/bendable devices, biocompatible sensors or even robotic tactile sensing units.

Synthesis of Dimethyl-Substituted Polyviologen and Control of Charge Transport in Electrodes for High-Resolution Electrochromic Displays.

https://www.ncbi.nlm.nih.gov/pubmed/30970765

Electrochromic (EC) polymers such as polyviologens have been attracting considerable attention as wet-processable electrodes for EC displays, thanks to their brilliant color change accompanied with reversible redox reactions. To establish wider usage, achieving multicolor and high-resolution characteristics is indispensable. In this paper, we demonstrated that the introduction of substituents such as methyl groups into bipyridine units changed the stereostructure of the cation radicals, and thus shifted the color (e.g., ordinary purple to blue). Also, by relaxing excessive Ï€-stacking between the viologen moieties, the response rate was improved by a factor of more than 10. The controlled charge transport throughout the polyviologen layer gave rise to the fabrication of EC displays which are potentially suitable for the thin film transistor (TFT) substrate as the counter electrodes with submillimeter pixels. The findings can be versatilely used for the new design of polyviologens with enhanced electrochemical properties and high-resolution, multicolor EC displays.

Enzyme mediated synthesis of polypyrrole in the presence of chondroitin sulfate and redox mediators of natural origin.

https://www.ncbi.nlm.nih.gov/pubmed/27040261

Polypyrrole (PPy) was synthesized by enzyme mediated oxidation of pyrrole using naturally occurring compounds as redox mediators. The catalytic mechanism is an enzymatic cascade reaction in which hydrogen peroxide is the oxidizer and soybean peroxidase, in the presence of acetosyringone, syringaldehyde or vanillin, acts as a natural catalysts. The effect of the initial reaction composition on the polymerization yield and electrical conductivity of PPy was analyzed. Morphology of the PPy particles was studied by scanning electron microscopy and transmission electron microscopy whereas the chemical structure was studied by X-ray photoelectron and Fourier transformed infrared spectroscopic techniques. The redox mediators increased the polymerization yield without a significant modification of the electronic structure of PPy. The highest conductivity of PPy was reached when chondroitin sulfate was used simultaneously as dopant and template during pyrrole polymerization. Electroactive properties of PPy obtained from natural precursors were successfully used in the amperometric quantification of uric acid concentrations. PPy increases the amperometric sensitivity of carbon nanotube screen-printed electrodes toward uric acid detection.

3D Printing of Aniline Tetramer-Grafted-Polyethylenimine and Pluronic F127 Composites for Electroactive Scaffolds.

https://www.ncbi.nlm.nih.gov/pubmed/28045217

Electroactive hydrogel scaffolds are fabricated by the 3D-printing technique using composites of 30% Pluronic F127 and aniline tetramer-grafted-polyethylenimine (AT-PEI) copolymers with various contents from 2.5% to 10%. The synthesized AT-PEI copolymers can self-assemble into nanoparticles with the diameter of â‰ˆ50 nm and display excellent electroactivity due to AT conjugation. The copolymers are then homogeneously distributed into 30% Pluronic F127 solution by virtue of the thermosensitivity of F127, denoted as F/AT-PEI composites. Macroscopic photographs of latticed scaffolds elucidate their excellent printability of F/AT-PEI hydrogels for the 3D-printing technique. The conductivities of the printed F/AT-PEI scaffolds are all higher than 2.0 Ã— 10-3 S cm-1 , which are significantly improved compared with that of F127 scaffold with only 0.94 Ã— 10-3 S cm-1 . Thus, the F/AT-PEI scaffolds can be considered as candidates for application in electrical stimulation of tissue regeneration such as repair of muscle and cardiac nerve tissue.

Magneto-electro-responsive material based on magnetite nanoparticles/polyurethane composites.

https://www.ncbi.nlm.nih.gov/pubmed/26838855

Multi-functional materials in actuator applications have been developed toward reversibility and sensitivity under various actuating fields. In this work, magneto-electro-responsive materials consisting of a polyurethane (PU) matrix and its composites embedded with magnetite nanoparticles (MNP) as a dispersed phase were fabricated to tailor the electromechanical properties and bending performance under electric, magnetic, and electromagnetic fields. Due to the superior characteristics of MNP over other magnetic materials, the composites fabricated with electronic polarization were highly responsive under electric field. The highest storage modulus sensitivity belonged to the 1.0% v/v MNP/PU composite which possessed the value of 3.46 at the electric field 2 kV mm(-1). Moreover, all of the PU composites behaved as an electrostrictive material in which the stress depended quadratically on the electric field. It was demonstrated that the PU composites also possessed very good recoverability, fast response (<15s) and large bending angle relative to that of pristine PU under applied electric field. Interestingly, the steady state storage modulus response was attained within the first electrical actuation cycle and the PU composite was a fully reversible material. In addition, it was shown that superparamagnetism was a common characteristic of all fabricated composites under magnetic field. The 3.0%v/v MNP/PU composite provided the largest

bending distance up to 23.60mm, and 14.10mm under the magnetic field of 5000 G, and the electromagnetic field of 320 G, respectively. In summary, the MNP/PU composite material is a potential candidate to be used as a smart material under the influences of electric and/or magnetic fields over other existing dielectric materials.

Electroactive biodegradable polyurethane significantly enhanced Schwann cells myelin gene expression and neurotrophin secretion for peripheral nerve tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/26897537

Myelination of Schwann cells (SCs) is critical for the success of peripheral nerve regeneration, and biomaterials that can promote SCs' neurotrophin secretion as scaffolds are beneficial for nerve repair. Here we present a biomaterials-approach, specifically, a highly tunable conductive biodegradable flexible polyurethane by polycondensation of poly(glycerol sebacate) and aniline pentamer, to significantly enhance SCs' myelin gene expression and neurotrophin secretion for peripheral nerve tissue engineering. SCs are cultured on these conductive polymer films, and the biocompatibility of these films and their ability to enhance myelin gene expressions and sustained neurotrophin secretion are successfully demonstrated. The mechanism of SCs' neurotrophin secretion on conductive films is demonstrated by investigating the relationship between intracellular Ca(2+) level and SCs' myelination. Furthermore, the neurite growth and elongation of PC12Â cells are induced by adding the neurotrophin medium suspension produced from SCs-laden conductive films. These data suggest that these conductive degradable polyurethanes that enhance SCs' myelin gene expressions and sustained neurotrophin secretion perform great potential for nerve regeneration applications.

High-Performance Electrochromic Devices Based on Poly[Ni(salen)]-Type Polymer Films.

https://www.ncbi.nlm.nih.gov/pubmed/27175794

We report the application of two poly[Ni(salen)]-type electroactive polymer films as new electrochromic materials. The two films, poly[Ni(3-Mesalen)] (poly[1]) and poly[Ni(3-MesaltMe)] (poly[2]), were successfully electrodeposited onto ITO/PET flexible substrates, and their voltammetric characterization revealed that poly[1] showed similar redox profiles in LiClO4/CH3CN and LiClO4/propylene carbonate (PC), while poly[2] showed solvent-dependent electrochemical responses. Both films showed multielectrochromic behavior, exhibiting yellow, green, and russet colors according to their oxidation state, and promising electrochromic properties with high

electrochemical stability in LiClO4/PC supporting electrolyte. In particular, poly[1] exhibited a very good electrochemical stability, changing color between yellow and green (Î» = 750 nm) during 9000 redox cycles, with a charge loss of 34.3%, an optical contrast of Î”T = 26.2%, and an optical density of Î”OD = 0.49, with a coloration efficiency of Î· = 75.55 cm(2) C(-1). On the other hand, poly[2] showed good optical contrast for the color change from green to russet (Î”T = 58.5%), although with moderate electrochemical stability. Finally, poly[1] was used to fabricate a solid-state electrochromic device using lateral configuration with two figures of merit: a simple shape (typology 1) and a butterfly shape (typology 2); typology 1 showed the best performance with optical contrast Î”T = 88.7% (at Î» = 750 nm), coloration efficiency Î· = 130.4 cm(2) C(-1), and charge loss of 37.0% upon 3000 redox cycles.

Electroactive polyurethane/siloxane derived from castor oil as a versatile cardiac patch, part II: HL-1 cytocompatibility and electrical characterizations.

https://www.ncbi.nlm.nih.gov/pubmed/26822463

In first part of this experiment, biocompatibility of the newly developed electroactive polyurethane/siloxane films containing aniline tetramer moieties was demonstrated with proliferation and differentiation of C2C12 myoblasts. Here we further assessed the cytocompatibility of the prepared samples with HL1-cell line, the electrophysiological properties and the patch clamp recording of the seeded cells over the selected electroactive sample. Presence of electroactive aniline tetramer in the structure of polyurethane/siloxane led to the increased expression of cardiac-specific genes of HL-1 cells involved in muscle contraction and electrical coupling. Our results showed that expression of Cx43, TrpT-2, and SERCA genes was significantly increased in conductive sample compared to tissue culture plate and the corresponding non-conductive analogous. The prepared materials were not only biocompatible in terms of cellular toxicity, but did not alter the intrinsic electrical characteristics of HL-1 cells. Embedding the electroactive moiety into the prepared films improved the properties of these polymeric cardiac construct through the enhanced transmission of electrical signals between the cells. Based on morphological observation, calcium imaging and electrophysiological recordings, we demonstrated the potential applicability of these materials for cardiac tissue engineering.

Multi-input and -output logic circuits based on bioelectrocatalysis with horseradish peroxidase and glucose oxidase immobilized in multi-responsive copolymer films on

electrodes.

https://www.ncbi.nlm.nih.gov/pubmed/26901460

Herein, poly(N-isopropylacrylamide-co-N,N'-dimethylaminoethylmethacrylate) copolymer films were polymerized on electrode surface with a simple one-step method, and the enzyme horseradish peroxidase (HRP) was embedded in the films simultaneously, which were designated as P(NiPAAm-co-DMEM)-HRP. The films exhibited a reversible structure change with the external stimuli, such as pH, CO2, temperature and SO4(2-), causing the cyclic voltammetric (CV) response of electroactive K3Fe(CN)6 at the film electrodes to display the corresponding multi-stimuli sensitive ON-OFF behavior. Based on the switchable CV property of the system and the electrochemical reduction of H2O2 catalyzed by HRP in the films and mediated by Fe(CN)6(3-) in solution, a 5-input/3-output logic gate was established. To further increase the complexity of the logic system, another enzyme glucose oxidase (GOD) was added into the films, designated as P(NiPAAm-co-DMEM)-HRP-GOD. In the presence of oxygen, the oxidation of glucose in the solution was catalyzed by GOD in the films, and the produced H2O2 in situ was recognized and electrocatalytically reduced by HRP and mediated by Fe(CN)6(3-). Based on the bienzyme films, a cascaded or concatenated 4-input/3-output logic gate system was proposed. The present work combined the multi-responsive interface with bioelectrocatalysis to construct cascaded logic circuits, which might open a new avenue to develop biocomputing elements with more sophisticated functions and design novel glucose biosensors.

Molecularly Imprinted Electropolymer for a Hexameric Heme Protein with Direct Electron Transfer and Peroxide Electrocatalysis.

https://www.ncbi.nlm.nih.gov/pubmed/26907299

For the first time a molecularly imprinted polymer (MIP) with direct electron transfer (DET) and bioelectrocatalytic activity of the target protein is presented. Thin films of MIPs for the recognition of a hexameric tyrosine-coordinated heme protein (HTHP) have been prepared by electropolymerization of scopoletin after oriented assembly of HTHP on a self-assembled monolayer (SAM) of mercaptoundecanoic acid (MUA) on gold electrodes. Cavities which should resemble the shape and size of HTHP were formed by template removal. Rebinding of the target protein sums up the recognition by non-covalent interactions between the protein and the MIP with the electrostatic attraction of the protein by the SAM. HTHP bound to the MIP exhibits quasi-reversible DET which is reflected by a pair of well pronounced redox peaks in the cyclic voltammograms (CVs) with a formal

potential of -184.4 Â± 13.7 mV vs. Ag/AgCl (1 M KCl) at pH 8.0 and it was able to catalyze the cathodic reduction of peroxide. At saturation the MIP films show a 12-fold higher electroactive surface concentration of HTHP than the non-imprinted polymer (NIP).

Pigmented Silk Nanofibrous Composite for Skeletal Muscle Tissue Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/27226037

Skeletal muscle tissue engineering (SMTE) employs designed biomaterial scaffolds for promoting myogenic differentiation of myoblasts to functional myotubes. Oxidative stress plays a significant role in the biocompatibility of biomaterials as well as in the fate of myoblasts during myogenesis and is also associated with pathological conditions such as myotonic dystrophy. The inherent electrical excitability of muscle cells inspired the use of electroactive scaffolds for SMTE. Conducting polymers attracted the attention of researchers for their use in muscle tissue engineering. However, poor biocompatibility, biodegradability and development of oxidative stress associated immunogenic response limits the extensive use of synthetic conducting polymers for SMTE. In order to address the limitations of synthetic polymers, intrinsically electroactive and antioxidant silk fibroin/melanin composite films and electrospun fiber mats were fabricated and evaluated as scaffolds for promoting myogenesis in vitro. Melanin incorporation modulated the thermal stability, electrical conductivity of scaffolds, fiber alignment in electrospun mats and imparted good antioxidant properties to the scaffolds. The composite electrospun scaffolds promoted myoblast assembly and differentiation into uniformly aligned high aspect ratio myotubes. The results highlight the significance of scaffold topography along with conductivity in promoting myogenesis and the potential application of silk nanofibrous composite as electoractive platform for SMTE.

Engineered hybrid cardiac patches with multifunctional electronics for online monitoringÂ and regulation of tissue function.

https://www.ncbi.nlm.nih.gov/pubmed/26974408

In cardiac tissue engineering approaches to treat myocardial infarction, cardiac cells are seeded within three-dimensional porous scaffolds to create functional cardiac patches. However, current cardiac patches do not allow for online monitoring and reporting of engineered-tissue performance, and do not interfere to deliver signals for patch activation or to enable its integration with the host. Here, we report an engineered cardiac patch that integrates cardiac cells with flexible, freestanding electronics and a 3D nanocomposite scaffold. The patch exhibited robust electronic properties,

enabling the recording of cellular electrical activities and the on-demand provision of electrical stimulation for synchronizing cell contraction. We also show that electroactive polymers containing biological factors can be deposited on designated electrodes to release drugs in the patch microenvironment on demand. We expect that the integration of complex electronics within cardiac patches will eventually provide therapeutic control and regulation of cardiac function.

Glial progenitor cell migration promotes CNS axon growth on functionalized electroconducting microfibers.

https://www.ncbi.nlm.nih.gov/pubmed/26884276

Electroactive systems that promote directional axonal growth and migration of glial progenitor cells (GPC) are needed for the treatment of neurological injuries. We report the functionalization of electroconducting microfibers with multiple biomolecules that synergistically stimulate the proliferation and migration of GPC, which in turn induce axonal elongation from embryonic cerebral cortex neurons. PEDOT doped with poly[(4-styrenesulfonic acid)-co-(maleic acid)] was synthesized on carbon microfibers and used for covalent attachment of molecules to the electroactive surface. The molecular complexes that promoted GPC proliferation and migration, followed by axonal extension, were composed of polylysine, heparin, basic fibroblast growth factor (bFGF), and matricellular proteins; the combination of bFGF with vitronectin or fibronectin being indispensable for sustained glial and axonal growth. The rate of glial-induced axonal elongation was about threefold that of axons growing directly on microfibers functionalized with polylysine alone. Electrical stimuli applied through the microfibers released bFGF and fibronectin from the polymer surface, consequently reducing GPC proliferation and promoting their differentiation into astrocytes, without causing cell detachment or toxicity. These results suggest that functionalized electroactive microfibers may provide a multifunctional tool for controlling neuron-glia interactions and enhancing neural repair.

A paper based graphene-nanocauliflower hybrid composite for point of care biosensing.

https://www.ncbi.nlm.nih.gov/pubmed/27209574

We demonstrate the first report of graphene paper functionalized with fractal platinum nanocauliflower for use in electrochemical biosensing of small molecules (glucose) or detection of pathogenic bacteria (Escherichia coli O157:H7). Raman spectroscopy, scanning electron microscopy and energy dispersive spectroscopy show that graphene oxide-coated nanocellulose

was partially reduced by both thermal treatment, and further reduced by chemical treatment (ascorbic acid). Fractal nanoplatinum with cauliflower-like morphology was formed on the reduced graphene oxide paper using pulsed sonoelectrodeposition, producing a conductive paper with an extremely high electroactive surface area (0.29Â±0.13cm(2)), confirmed by cyclic voltammetry and electrochemical impedance spectroscopy. The platinum surface was functionalized with either glucose oxidase (via chitosan encapsulation) or a RNA aptamer (via covalent linking) for demonstration as a point of care biosensor. The detection limit for both glucose (0.08Â±0.02Î¼M) and E. coli O157:H7 (â‰ˆ4 CFUmL(-1)) were competitive with, or superior to, previously reported devices in the biosensing literature. The response time (6s for glucose and 12min for E. coli) were also similar to silicon biochip and commercial electrode sensors. The results demonstrate that the nanocellulose-graphene-nanoplatinum material is an excellent paper-based platform for development of electrochemical biosensors targeting small molecules or whole cells for use in point of care biosensing.

Softworms: the design and control of non-pneumatic, 3D-printed, deformable robots.

https://www.ncbi.nlm.nih.gov/pubmed/26963596

Robots that can easily interact with humans and move through natural environments are becoming increasingly essential as assistive devices in the home, office and hospital. These machines need to be safe, effective, and easy to control. One strategy towards accomplishing these goals is to build the robots using soft and flexible materials to make them much more approachable and less likely to damage their environment. A major challenge is that comparatively little is known about how best to design, fabricate and control deformable machines. Here we describe the design, fabrication and control of a novel soft robotic platform (Softworms) as a modular device for research, education and public outreach. These robots are inspired by recent neuromechanical studies of crawling and climbing by larval moths and butterflies (Lepidoptera, caterpillars). Unlike most soft robots currently under development, the Softworms do not rely on pneumatic or fluidic actuators but are electrically powered and actuated using either shape-memory alloy microcoils or motor tendons, and they can be modified to accept other muscle-like actuators such as electroactive polymers. The technology is extremely versatile, and different designs can be quickly and cheaply fabricated by casting elastomeric polymers or by direct 3D printing. Softworms can crawl, inch or roll, and they are steerable and even climb steep inclines. Softworms can be made in any shape but here we describe modular and monolithic designs requiring little assembly. These modules can be combined to make

multi-limbed devices. We also describe two approaches for controlling such highly deformable structures using either model-free state transition-reward matrices or distributed, mechanically coupled oscillators. In addition to their value as a research platform, these robots can be developed for use in environmental, medical and space applications where cheap, lightweight and shape-changing deformable robots will provide new performance capabilities.

A Review on Electroactive Polymers for Waste Heat Recovery.

https://www.ncbi.nlm.nih.gov/pubmed/28773605

This paper reviews materials for thermoelectric waste heat recovery, and discusses selected industrial and distributed waste heat sources as well as recovery methods that are currently applied. Thermoelectric properties, especially electrical conductivity, thermopower, thermal conductivity and the thermoelectric figures of merit, are considered when evaluating thermoelectric materials for waste heat recovery. Alloys and oxides are briefly discussed as materials suitable for medium- and high-grade sources. Electroactive polymers are presented as a new group of materials for low-grade sources. Polyaniline is a particularly fitting polymer for these purposes. We also discuss types of modifiers and modification methods, and their influence on the thermoelectric performance of this class of polymers.

Electroactive poly(sulfobetaine-3,4-ethylenedioxythiophene) (PSBEDOT) with controllable antifouling and antimicrobial properties.

https://www.ncbi.nlm.nih.gov/pubmed/29899920

This paper reports a multifunctional zwitterionic poly(sulfobetaine-3,4-ethylenedioxythiophene) (PSBEDOT), which could be facilely synthesized by electropolymerization in aqueous solution. The PSBEDOT surface exhibits excellent conductivity, stability and switchable antifouling/antimicrobial properties. It shows great promise for applications in organic bioelectronics. This new material may significantly increase the performance and service life, minimize the foreign body reaction, improve the biocompatibility and reduce the infection of bio-electronic devices.

Conducting polymer-silk biocomposites for flexible and biodegradable electrochemical sensors.

https://www.ncbi.nlm.nih.gov/pubmed/26985581

Approaches to form flexible biosensors require strategies to tune materials for various biomedical applications. We report a facile approach using photolithography to fabricate poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (

Injectable, degradable, electroactive nanocomposite hydrogels containing conductive polymer nanoparticles for biomedical applications.

https://www.ncbi.nlm.nih.gov/pubmed/26792990

Injectable electroactive hydrogels (eGels) are promising in regenerative medicine and drug delivery, however, it is still a challenge to obtain such hydrogels simultaneously possessing other properties including uniform structure, degradability, robustness, and biocompatibility. An emerging strategy to endow hydrogels with desirable properties is to incorporate functional nanoparticles in their network. Herein, we report the synthesis and characterization of an injectable hydrogel based on oxidized alginate (OA) crosslinking gelatin reinforced by electroactive tetraaniline-graft-OA nanoparticles (nEOAs), where nEOAs are expected to impart electroactivity besides reinforcement without significantly degrading the other properties of hydrogels. Assays of transmission electron microscopy, (1)H nuclear magnetic resonance, and dynamic light scattering reveal that EOA can spontaneously and quickly self-assemble into robust nanoparticles in water, and this nanoparticle structure can be kept at pH 3~9. Measurement of the gel time by rheometer and the stir bar method confirms the formation of the eGels, and their gel time is dependent on the weight content of nEOAs. As expected, adding nEOAs to hydrogels does not cause the phase separation (scanning electron microscopy observation), but it improves mechanical strength up to ~8 kPa and conductivity up to ~10(-6) S/cm in our studied range. Incubating eGels in phosphate-buffered saline leads to their further swelling with an increase of water content <6% and gradual degradation. When growing mesenchymal stem cells on eGels with nEOA content â‰¤14%, the growth curves and morphology of cells were found to be similar to that on tissue culture plastic; when implanting these eGels on a chick chorioallantoic membrane for 1 week, mild inflammation response appeared without any other structural changes, indicating their good in vitro and in vivo biocompatibility. With injectability, uniformity, degradability, electroactivity, relative robustness, and biocompatibility, these eGels may have a huge potential as scaffolds for tissue regeneration and matrix for stimuli responsive drug release.

Development and Characterization of Organic Electronic Scaffolds for Bone Tissue

Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/27111453

Bones have been shown to exhibit piezoelectric properties, generating electrical potential upon mechanical deformation and responding to electrical stimulation with the generation of mechanical stress. Thus, the effects of electrical stimulation on bone tissue engineering have been extensively studied. However, in bone regeneration applications, only few studies have focused on the use of electroactive 3D biodegradable scaffolds at the interphase with stem cells. Here a method is described to combine the bone regeneration capabilities of 3D-printed macroporous medical grade polycaprolactone (PCL) scaffolds with the electrical and electrochemical capabilities of the conducting polymer poly(3,4-ethylenedioxythiophene) (PEDOT). PCL scaffolds have been highly effective in vivo as bone regeneration grafts, and PEDOT is a leading material in the field of organic bioelectronics, due to its stability, conformability, and biocompatibility. A protocol is reported for scaffolds functionalization with PEDOT, using vapor-phase polymerization, resulting in a conformal conducting layer. Scaffolds' porosity and mechanical stability, important for in vivo bone regeneration applications, are retained. Human fetal mesenchymal stem cells proliferation is assessed on the functionalized scaffolds, showing the cytocompatibility of the polymeric coating. Altogether, these results show the feasibility of the proposed approach to obtain electroactive scaffolds for electrical stimulation of stem cells for regenerative medicine.

Electrically conductive gold nanoparticle-chitosan thermosensitive hydrogels for cardiac tissue engineering.

https://www.ncbi.nlm.nih.gov/pubmed/27040204

Injectable hydrogels that resemble electromechanical properties of the myocardium are crucial for cardiac tissue engineering prospects. We have developed a facile approach that uses chitosan (CS) to generate a thermosensitive conductive hydrogel with a highly porous network of interconnected pores. Gold nanoparticles (GNPs) were evenly dispersed throughout the CS matrix in order to provide electrical cues. The gelation response and electrical conductivity of the hydrogel were controlled by different concentrations of GNPs. The CS-GNP hydrogels were seeded with mesenchymal stem cells (MSCs) and cultivated for up to 14 days in the absence of electrical stimulations. CS-GNP scaffolds supported viability, metabolism, migration and proliferation of MSCs along with the development of uniform cellular constructs. Immunohistochemistry for early and mature cardiac markers showed enhanced cardiomyogenic differentiation of MSCs within the

CS-GNP compared to the CS matrix alone. The results of this study demonstrate that incorporation of nanoscale electro-conductive GNPs into CS hydrogels enhances the properties of myocardial constructs. These constructs could find utilization for regeneration of other electroactive tissues.

Bare and Polymer-Coated Indium Tin Oxide as Working Electrodes for Manganese Cathodic Stripping Voltammetry.

https://www.ncbi.nlm.nih.gov/pubmed/26980322

Though an essential metal in the body, manganese (Mn) has a number of health implications when found in excess that are magnified by chronic exposure. These health complications include neurotoxicity, memory loss, infertility in males, and development of a neurologic psychiatric disorder, manganism. Thus, trace detection in environmental samples is increasingly important. Few electrode materials are able to reach the negative reductive potential of Mn required for anodic stripping voltammetry (ASV), so cathodic stripping voltammetry (CSV) has been shown to be a viable alternative. We demonstrate Mn CSV using an indium tin oxide (ITO) working electrode both bare and coated with a sulfonated charge selective polymer film, polystyrene-block-poly(ethylene-ran-butylene)-block-polystyrene-sulfonate (SSEBS). ITO itself proved to be an excellent electrode material for Mn CSV, achieving a calculated detection limit of 5 nM (0.3 ppb) with a deposition time of 3 min. Coating the ITO with the SSEBS polymer was found to increase the sensitivity and lower the detection limit to 1 nM (0.06 ppb). This polymer modified electrode offers excellent selectivity for Mn as no interferences were observed from other metal ions tested (Zn(2+), Cd(2+), Pb(2+), In(3+), Sb(3+), Al(3+), Ba(2+), Co(2+), Cu(2+), Ni(3+), Bi(3+), and Sn(2+)) except Fe(2+), which was found to interfere with the analytical signal for Mn(2+) at a ratio 20:1 (Fe(2+)/Mn(2+)). The applicability of this procedure to the analysis of tap, river, and pond water samples was demonstrated. This simple, sensitive analytical method using ITO and SSEBS-ITO could be applied to a number of electroactive transition metals detectable by CSV.

A Stimuli-Responsive Biosensor of Glucose on Layer-by-Layer Films Assembled through Specific Lectin-Glycoenzyme Recognition.

https://www.ncbi.nlm.nih.gov/pubmed/27104542

The research on intelligent bioelectrocatalysis based on stimuli-responsive materials or interfaces is of great significance for biosensors and other bioelectronic devices. In the present work, lectin protein concanavalin A (Con A) and glycoenzyme glucose oxidase (GOD) were assembled into

{Con A/GOD}n layer-by-layer (LbL) films by taking advantage of the biospecific lectin-glycoenzyme affinity between them. These film electrodes possess stimuli-responsive properties toward electroactive probes such as ferrocenedicarboxylic acid (Fc(COOH)â‚‚) by modulating the surrounding pH. The CV peak currents of Fc(COOH)â‚‚ were quite large at pH 4.0 but significantly suppressed at pH 8.0, demonstrating reversible stimuli-responsive on-off behavior. The mechanism of stimuli-responsive property of the films was explored by comparative experiments and attributed to the different electrostatic interaction between the films and the probes at different pH. This stimuli-responsive films could be used to realize active/inactive electrocatalytic oxidation of glucose by GOD in the films and mediated by Fc(COOH)â‚‚ in solution, which may establish a foundation for fabricating novel stimuli-responsive electrochemical biosensors based on bioelectrocatalysis with immobilized enzymes.

Electrochemical Characterization of Layer-By-Layer Assembled Ferrocene-Modified Linear Poly(ethylenimine)/Enzyme Bioanodes for Glucose Sensor and Biofuel Cell Applications.

https://www.ncbi.nlm.nih.gov/pubmed/26999756

Ferrocenylhexyl- and ferrocenylpropyl-modified linear poly(ethylenimine) (Fc-C6-LPEI, Fc-C3-LPEI) were used with periodate-modified glucose oxidase (p-GOX) in the layer-by-layer assembly of enzymatic bioanodes on gold. Fc-C6-LPEI/p-GOX and Fc-C3-LPEI/p-GOX films of 16 bilayers were capable of generating up to 381 Â± 3 and 1417 Â± 63 Î¼A cm(-2), respectively, in response to glucose. These responses are greater than those of analogous bioanodes fabricated using conventional cross-linking techniques and are extremely high for planar, low surface area, single-enzyme electrodes. (Fc-C3-LPEI/p-GOX)8 films generated 86 Â± 3 Î¼W cm(-2) at pH 7.0 and 149 Â± 7 Î¼W cm(-2) at pH 5.0, when poised against an air-breathing platinum cathode in a compartment-less biofuel cell. An increase in power output with decreasing pH was shown to be a result of increases in the platinum cathode performance, indicating it is the rate-limiting electrode in the biofuel cells. The effect of fabrication wash time on the buildup of material at the electrode's surface was probed using cyclic voltammetry (CV) and constant potential amperometry. The use of electrochemical techniques as a diagnostic tool for studying the material deposition process is discussed. CV peak separation (Î”E), surface coverage of the electroactive ferrocene (Î“Fc), and amperometric sensitivity of the enzyme to glucose (Jmax), studied as a function of numbers of bilayers, showed that physisorption of materials onto the surface results from initial patchy deposition, rather than in distinctly uniform layers.

Direct Mechanical Stimulation of Stem Cells: A Beating Electromechanically Active Scaffold for Cardiac Tissue Engineering.

https://www.ncbi.nlm.nih.gov/pubmed/27126086

The combination of stem cell therapy with a supportive scaffold is a promising approach to improving cardiac tissue engineering. Stem cell therapy can be used to repair nonfunctioning heart tissue and achieve myocardial regeneration, and scaffold materials can be utilized in order to successfully deliver and support stem cells in vivo. Current research describes passive scaffold materials; here an electroactive scaffold that provides electrical, mechanical, and topographical cues to induced human pluripotent stem cells (iPS) is presented. The poly(lactic-co-glycolic acid) fiber scaffold coated with conductive polymer polypyrrole (PPy) is capable of delivering direct electrical and mechanical stimulation to the iPS. The electroactive scaffolds demonstrate no cytotoxic effects on the iPS as well as an increased expression of cardiac markers for both stimulated and unstimulated protocols. This study demonstrates the first application of PPy as a supportive electroactive material for iPS and the first development of a fiber scaffold capable of dynamic mechanical actuation.

Electroactive and Optically Adaptive Bionanocomposite for Reconfigurable Microlens.

https://www.ncbi.nlm.nih.gov/pubmed/27163166

This paper introduces an electroactive bionanocomposite based on poly(diethylene glycol adipate) (PDEGA) and cellulose nanocrystals (CNCs). The bionanocomposites were made using CNCs extracted from cotton and by optimizing its concentration in terms of the optical transmittance and viscosity. The characteristic properties of the materials were analyzed using contact angle measurements and Fourier transformation infrared spectra. Using the PDEGA/CNC bionanocomposite at a very low concentration of CNCs, a configurable lens having a robust, self-contained tunable optical structure was developed. The shape and curvature of the soft PDEGA/CNC device were controlled by applying voltage, and the focal length was measured. The simple structure, high optical transparency, biodegradability, thermal stability, high durability, and low power consumption make the new material particularly useful in fabricating a reconfigurable lens for future electronic and optical devices.

Functionalization of Oxide-Free Silicon Surfaces with Redox-Active Assemblies.

https://www.ncbi.nlm.nih.gov/pubmed/27064580

This review provides a comprehensive survey of the derivatization of hydrogen-terminated, oxide-free silicon surfaces with electroactive assemblies (from molecules to polymers) attached through strong interactions (covalent, electrostatic, and chimisorption). Provided that surface modification procedures are thoroughly optimized, such an approach has appeared as a promising strategy toward high-quality functional interfaces exhibiting excellent chemical and electrochemical stabilities. The attachment of electroactive molecules exhibiting either two stable redox states (e.g., ferrocene and quinones) or more than two stable redox states (e.g., metalloporphyrins, polyoxometalates, and C60) is more particularly discussed. Attention is also paid to the immobilization of electrochemically polymerizable centers. Globally, these functional interfaces have been demonstrated to show great promise for the molecular charge storage and information processing or the elaboration of the electrochemically switchable devices. Besides, there are also some relevant examples dealing with their activity for other fields of interest, such as sensing and electrochemical catalysis.

Silver nanoparticles formation by extracellular polymeric substances (EPS) from electroactive bacteria.

https://www.ncbi.nlm.nih.gov/pubmed/26797954

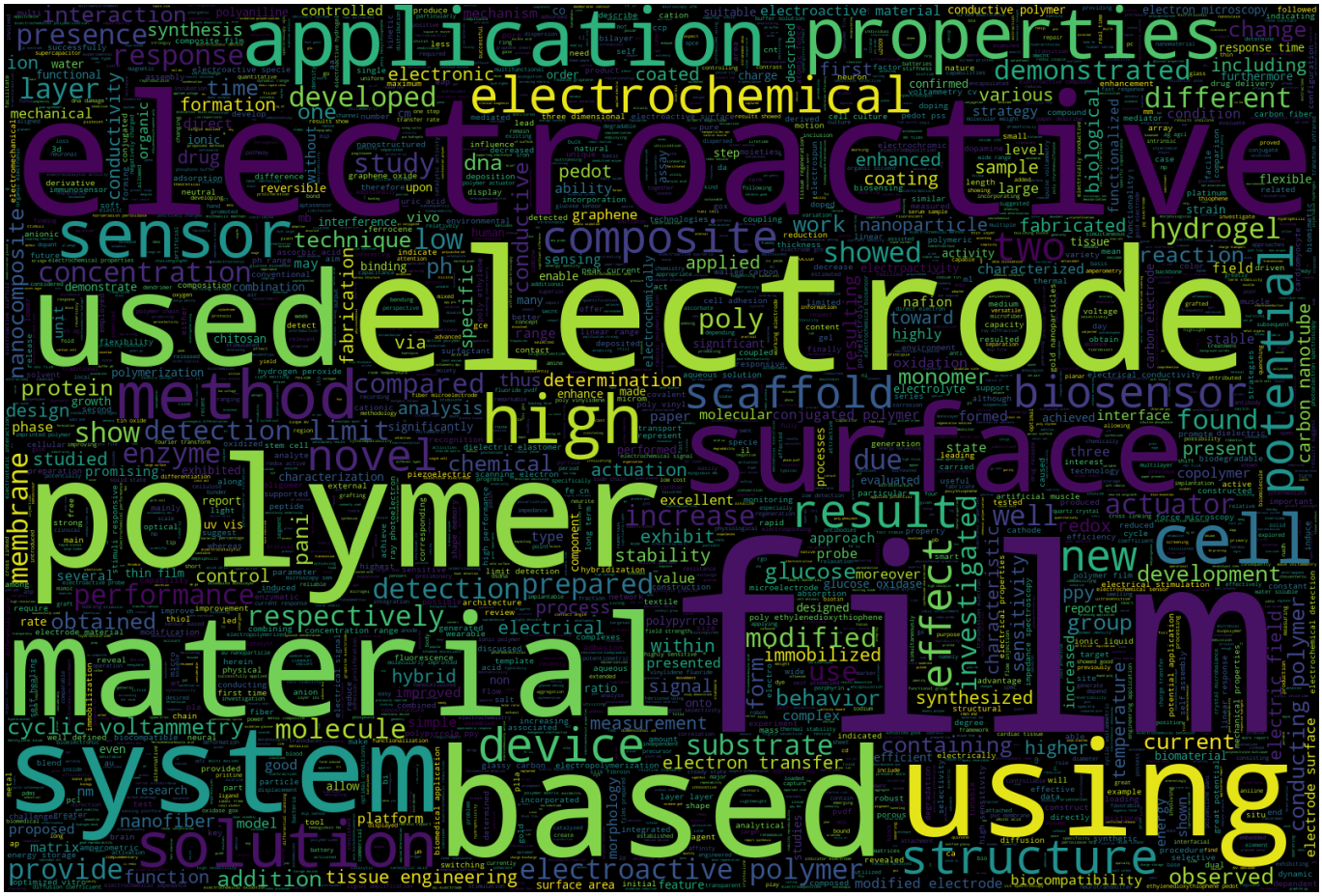
Microbial extracellular polymeric substances (EPS) excreted from microorganisms were a complex natural biological polymer mixture of proteins and polysaccharides, which played an important roles in the transport of metals, such as Ag(+). Electroactive bacteria, is an important class of environmental microorganisms, which can use iron or manganese mineral as terminal electron acceptors to generate energy for biosynthesis and cell maintenance. In this work, the EPS extracted of three electroactive bacteria (Shewanella oneidensis, Aeromonas hydrophila, and Pseudomonas putida) were used for reducing Ag(+) and forming silver nanoparticles (AgNPs). Results showed that all the three microbial EPS could reduce Ag(+) to AgNPs. The formed AgNPs were characterized in depth by the UV-visible spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, and high-resolution transmission electron microscopy. The main components in the EPS from the three electroactive bacteria were analyzed. The presence of cytochrome c in these EPS was confirmed, and they were found to contribute to the reduction of Ag(+) to AgNPs. The results indicated that the EPS of electroactive bacteria could act as a reductant for AgNPs synthesis and could provide new information to understand the fate of metals and their metal nanoparticles in the natural environments.

Optimized dendrimer-encapsulated gold nanoparticles and enhanced carbon nanotube nanoprobes for amplified electrochemical immunoassay of E. coli in dairy product based on enzymatically induced deposition of polyaniline.

https://www.ncbi.nlm.nih.gov/pubmed/26908184

A highly sensitive immunosensor was reported for Escherichia coli assay in dairy product based on electrochemical measurement of polyaniline (PAn) that was catalytically deposited by horseradish peroxidase (HRP) labels. Herein, the immunosensor was developed by using poly(amidoamine) dendrimer-encapsulated gold nanoparticles (PAMAM(Au)) as sensing platform. Importantly, the optimal HAuCl4/PAMAM ratio was investigated to design the efficient PAMAM(Au) nanocomposites. The nanocomposites were proven to not only increase the amount of immobilized capture antibody (cAb), but also accelerate the electron transfer process. Moreover, the {dAb-CNT-HRP} nanoprobes were prepared by exploiting the amplification effect of multiwalled carbon nanotubes (CNTs) for loading detection antibody (dAb) and enormous HRP labels. After a sandwich immunoreaction, the quantitatively captured nanoprobes could catalyze oxidation aniline to produce electroactive PAn for electrochemical measurement. On the basis of signal amplification of the PAMAM(Au)-based immunosensor and the {dAb-CNT-HRP} nanoprobes, the proposed strategy exhibited a linear relationship between the peak current of PAn and the logarithmic value of E. coli concentration ranging from 1.0 Ã— 10(2) to 1.0 Ã— 10(6) cfu mL(-1) with a detection limit of 50 cfu mL(-1) (S/N=3), and the electrochemical detection of E. coli could be achieved in 3h. The electrochemical immunosensor was also used to determine E. coli in dairy product (pure fresh milk, infant milk powder, yogurt in shelf-life and expired yogurt), and the recoveries of standard additions were in the range of 96.8-108.7%. Overall, this method gave a useful protocol for E. coli assay with high sensitivity, acceptable accuracy and satisfying stability, and thus provided a powerful tool to estimate the quality of dairy product.

Top Words Cloud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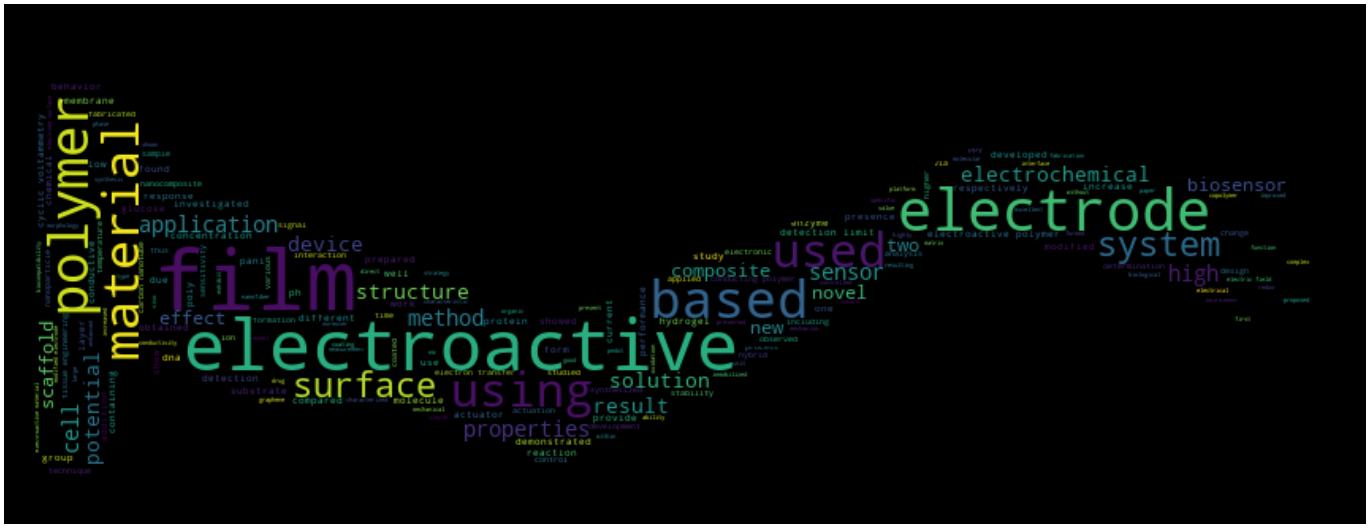
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reaction
control
substrate
comparing
graphene
mechanical
stability
development
dna
ion
detection
avg
electronic
study
applied
detection limit
enzyme
presence
electroactive polymer
modified
respectively
increase
developed
interface
platform
copolymer
improved
determination
design
electrical
electric field
complex
prepared
function
change
biological
sensor
cyclic voltammetry
chemical
nanoparticles
conductive
layer
containing
group
technique
tissue engineering
conductivity
sensitivity
polymer
cell
potential
scaffold
material
film
application
device
structure
method
effect
surface
using
properties
solution
result
based
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composite
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biosensor
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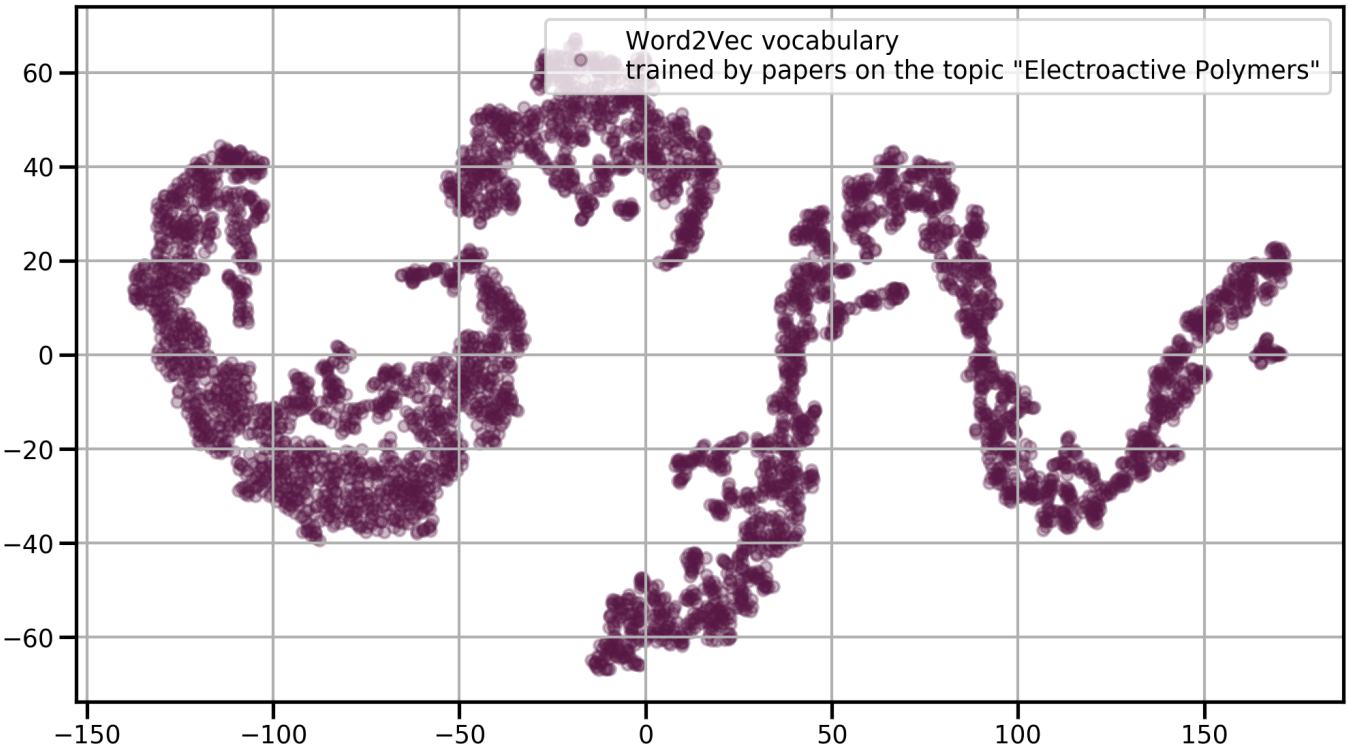
detection limit
enzyme
presence


Word2Vec vocabulary
trained by papers on the topic "Electroactive Polymers"
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−40
−60
−150
−100
−50
0
50
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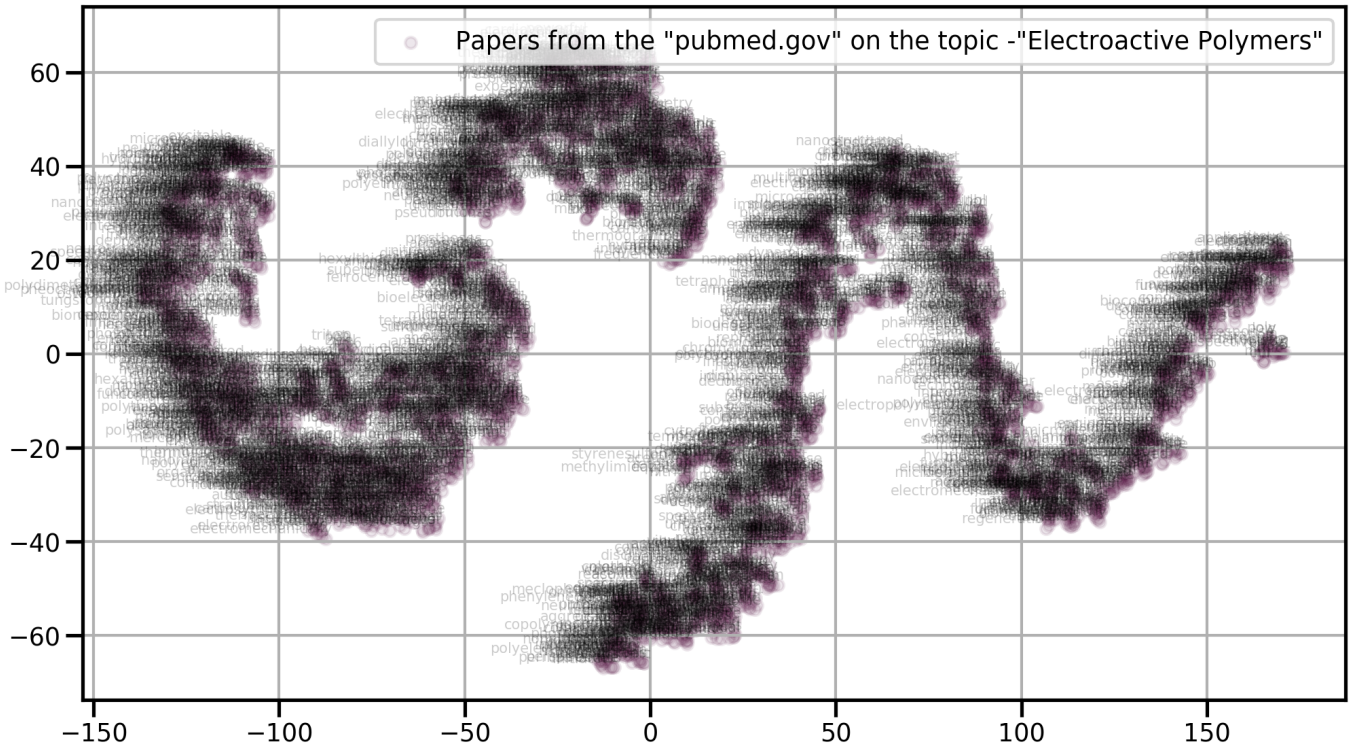
150


Papers from the "pubmed.gov" on the topic -"Electroactive Polymers"
60
40
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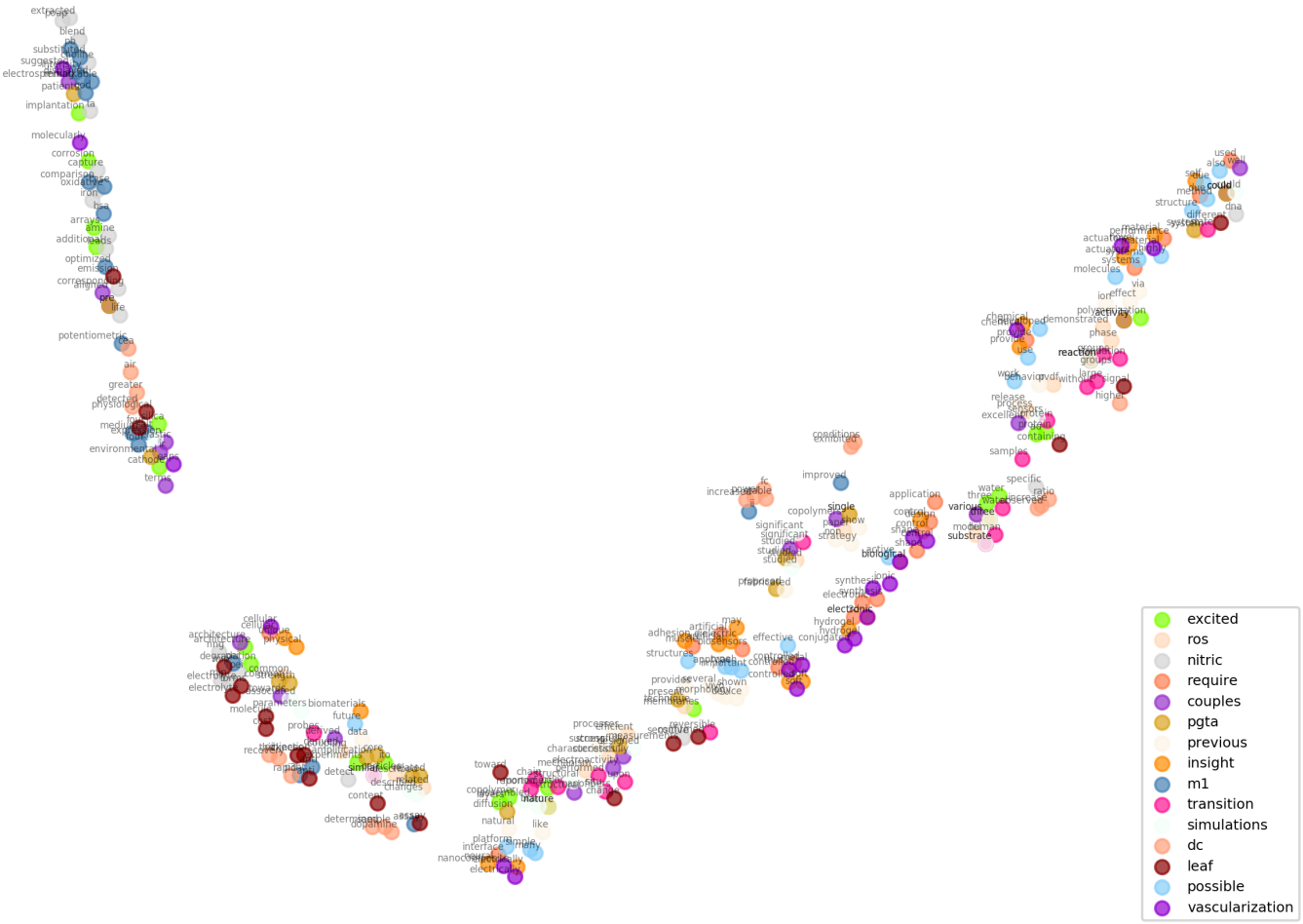
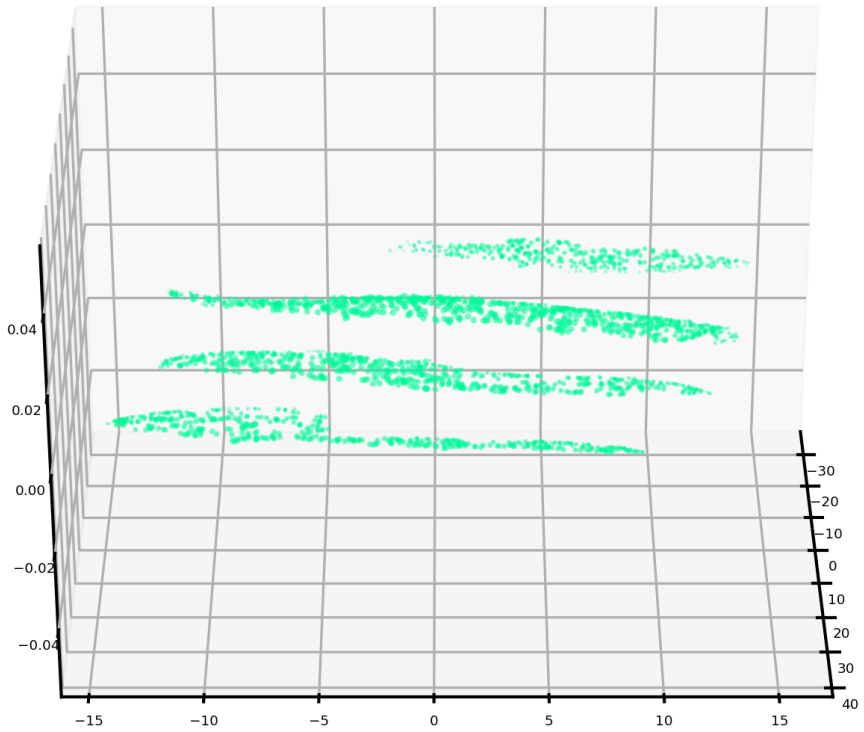
Similar words from PubMed on the topic "Electroactive Polymers"



Visualizing Word Embeddings using t-SNE



Papers from the "pubmed.gov" on the topic -"Electroactive Polymers"