**Zhang Research Group**

**Home (12-pictures cycle)**

We study the synthesis, structural analysis and properties of conjugated polymers, nanomaterials and polymer nanocomposites with various emerging applications of smart coatings and energy conversions. Students will receive multidisciplinary training in chemistry, biology, physics, engineering and materials science. Our current research is focused on the following areas:

* Multi-scale assembly of conjugated polymers
* Kinetics and thermodynamics of solutions of conjugated polymers
* Liquid crystal assembly of anisotropic nanomaterials including graphene, nanotubes, and nanowires
* Protein aggregation
* Functional polymer nanocomposites for coatings and energy conversions
* Coatings and Printings of flexible polymer electronics
* Reverse osmosis membranes for seawater desalination and purification

Research is supported by

National Science Foundation, American Chemical Society-Petroleum Research Fund, CSU-Water Resources and Policy Initiatives, Cal Poly-Extramural Funding Initiatives, Cal Poly-State Faculty Support Grant, Cal Poly-Research, Scholarship and Creative Activities (RSCA)

**Research (pictures)**

**Conjugated Polymers**

Semiconducting conjugated polymers are promising for the development of cost-effective flexible electronic devices. The structures and morphologies of the conjugated polymer in solution are determinative to the device performance.

We use a spectroscopic methodology to study the dynamic process of multi-scale assembly of the polymers controlled by surfactants and nanoparticles. In particular, we are interested in the kinetics and thermodynamics of structural changes of the conjugated polymer in solution.

**Anisotropic Nanomaterials**

1-D and 2-D anisotropic semiconducting nanomaterials such as graphene, carbon nanotubes and nanowires possess unique anisotropy of optoelectronic properties. The ability to assembly of such nanomaterials into macroscopically ordered structures is crucial to fully exploit such excellent properties for various applications.

We apply a liquid crystal route to organize anisotropic nanomaterials into useful material forms such as thin films and fibers. We focus on the phase diagram, alignment control and property optimization.

**Polymer Nanocomposites**

Polymer nanocomposites consist of a polymer having nanofillers incorporated into the polymer matrix. They not only combine the intrinsic properties of each component but also exhibit unprecedented intriguing properties due to the synergistic effect of their components.

We use both chemical and physical approaches to prepare novel multi-functional nanocomposites for coatings and energy conversions. Currently, we are interested in the interfacial structures and their effect on the physical properties.

**Biological Polymers**

The native structure of the protein possesses chain folding that allows its functional shape or conformation. When the protein folds incorrectly, the misfolded protein may aggregate into amyloid fibrils. The latter is associated with neurodegenerative diseases such as Parkinson’s, Alzheimer’s and prison disease.

We utilize a microfluidic technology to study the misfolded protein aggregation. In particular, we are interested in the dynamic process of the aggregation.

**Smart Coatings/Printings**

Wet coatings and printings are cost-effective techniques for the fabrication of large-scale thin films. We utilize such industrially viable processing techniques to fabricate polymer photovoltaic devices, reverse osmosis membranes, and anticorrosion films for demanding applications.

**Group members (photo of group member)**

**Principle Investigator**

Dr. Shanju Zhang

Advisor

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Selected Awards and Honors

* NSF-CBET research grant (2015-2018)
* ACS-PRF research grant (2014-2017)
* NSF-EAGER research grant (2013-2015)
* Humboldt Travel Award to Lindau Nobel Laureate Meeting (2001)
* Alexander von Humboldt Research Fellowship (2000)
* Baosteel Education Award (1997)

**Current Members**

Michaela Pfau (Jan. 2015-now)

Graduate Student

Research interest: graphene/nanotube hybrids

mpfau@calpoly.edu

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Ryan Cox (Jan. 2014-now)

Undergraduate Student

Research interest: Organic/inorganic hybrid nanocomposites

Rcox02@calpoly.edu

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Evan Scherzinger (Jun. 2014-now)

Undergraduate Student

Research interest: Synthesis of liquid crystalline polymers

escherzi@calpoly.edu

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Danielle Chun (Jun. 2014-now)

Undergraduate Student

Research interest: Wet synthesis of graphene; conjugated polymers

Dchun01@calpoly.edu

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Karina Reynolds (Jan. 2015-now)

Undergraduate Student

Research interest: Wet synthesis of graphene; single fiber composites

Dchun01@calpoly.edu

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David Bilger (Mar. 2015 – now)

Undergraduate Student

Research interest: assembly of conjugated polymers

dbilger@calpoly.edu

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Christopher Kasprzak (Jun. 2015-now)

Undergraduate Student

Research interest: liquid crystal/nanotube composites for water desalination

ckasprza@calpoly.edu

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Nima Eshaghi (Jun. 2015 – now)

Undergraduate Student

Research interest: Solvothermal synthesis of semiconductor nanowires

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**Group Alumni**

Alexandra Stevenson (Jan. 2014-Aug. 2015)

Justin van Staden (Jan. 2015-Jul. 2015)

John Abdou (Jan. 2014-Jun. 2015)

Jacob Parkinson (Jan. 2014-Jun. 2015)

Gregory Braggin (Jan. 2014-Jun. 2015)

Dania Ramirez (Jun. 2014-Mar.2015)

Kyle Barcus (Jul. 2014-Dec. 2014)

Dani Barsa (Jun. 2014-Dec. 2014)

Eric Brougham (Sep. 2014 – Dec. 2014)

Grace Luo (Mar. 2013-Sep. 2014)

Shawn Gu (Aug. 2014, Jul-Aug. 2015)

Ricardo Arenas (Jun. 2014-Aug. 2014)

Roberto Rodriguez (Jun. 2014-Aug. 2014)

Grant Olson (Jan. 2013-Jun. 2014)

Wanda Ruan (Sep. 2013-Jun. 2014)

Neil Redeker (Sep.2011-Dec. 2013)

Taylor Wagner, M.S. (Jan. 2012-Dec. 2013)

Cameron Danesh, M.S. (Sep. 2011-Jun. 2013)

Franceska Santos (Sep. 2011-Jun. 2013)

Danielle Bonnet (Jun. 2013-Aug. 2013)

Ashley Bowman (Jun. 2013-Aug. 2013)

Karla Elias (Jun. 2013-Aug. 2013)

Shlomo Khmishon (Jun. 2012-Dec. 2012)

Ajay Jassal (Jun. 2012-Aug. 2012)

Dani May (Jun. 2012-Aug. 2012)

Nathn Starkweather (Sept. 2011-Jun. 2012)

Eric Tsoi (Jan. 2012-Jun. 2012)

Samuel Magill (Jan. 2012-Mar.2012)

**Teaching**

Fall 2015

CHEM 444-Polymers and Coatings

CHEM 447-Polymer and Coatings Laboratory

CHEM 544-Polymer Physical Chemistry and Analysis

CHEM 547-Polymer Physical Chemistry and Analysis Laboratory

Spring 2015

CHEM 470-Functional Polymer Materials

CHEM 352-Physical Chemistry II

Winter 2015

CHEM 128-General Chemistry II

CHEM 352-Physical Chemistry II

Fall 2014

CHEM 444-Polymers and Coatings

CHEM 447-Polymer and Coatings Laboratory

CHEM 544-Polymer Physical Chemistry and Analysis

CHEM 547-Polymer Physical Chemistry and Analysis Laboratory

Spring 2014

CHEM 129-General Chemistry III

Winter 2014

CHEM 128-General Chemistry II

CHEM 351-Physical Chemistry I

Fall 2013

CHEM351-Physical Chemistry I

CHEM 444-Polymers and Coatings

CHEM 447-Polymer and Coatings Laboratory

CHEM 544-Polymer Physical Chemistry and Analysis

CHEM 547-Polymer Physical Chemistry and Analysis Laboratory

Spring 2013

CHEM 129-General Chemistry III

Winter 2013

CHEM 128-General Chemistry II

Fall 2012

CHEM 444-Polymers and Coatings

CHEM 447-Polymer and Coatings Laboratory

CHEM 544-Polymer Physical Chemistry and Analysis

CHEM 547-Polymer Physical Chemistry and Analysis Laboratory

Spring 2012

CHEM 128-General Chemistry II

Winter 2012

CHEM 127-General Chemistry I

Fall 2011

CHEM 444-Polymers and Coatings

CHEM 447-Polymer and Coatings Laboratory

CHEM 544-Polymer Physical Chemistry and Analysis

CHEM 547-Polymer Physical Chemistry and Analysis Laboratory

**Facilities (pictures of facilities)**

* Polarized Optical Microscope (Leica DM2500P)
* UV-Vis Spectrophotometer (Jasco V-550 with temperature control)
* FT-Infrared Spectrophotomer with ATR 380 (Nicolet)
* Differential Scanning Calorimeter Q-1000 (TA Instruments)
* Thermal Gravimetric Analyzer Q-500 (TA Instruments)
* Dynamic Mechanical Analyzer Q-800 (TA Instruments)
* Discovery Hybrid (DHR-2) Rheometer (TA Instruments)
* SECurity GPC System (Agilent Instruments)
* KW-4A Spin Coater (Chemat)
* Four-Point Resistance Probe (Signatone)
* Ultrasonication Bath (Branson 2510)
* Micro-Centrifuge (Biotechnical)

**Contact**

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Research Laboratory:

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Polymers and Coatings Program

Baker Center (Bldg. 180) – 540

**Publications**

***Cal Poly-San Luis Obispo***

1. J. P. Abdou, G. A. Braggin, Y. Q. Luo, A. R. Stevenson, D. Chun, S. J. Zhang, “Graphene-induced oriented interfacial microstructures in single fiber polymer composites”, *ACS Applied Materials & Interfaces*, **2015**, 7, 13620-13626.
2. Y. Q. Luo, G. A. Braggin, G. T. Olson, A. R. Stevenson, W. L. Ruan, S. J. Zhang, “Nematic order drives macroscopic patterns of graphene oxide in drying drops”, *Langmuir*, **2014**, 30, 14631-14637.
3. Y. Q. Luo, F. A. Santos, T. W. Wagner, E. Tsoi, S. J. Zhang, “Dynamic interactions between poly(3-hexylthiophene) and single-walled carbon nanotubes in marginal solvent”, *The Journal of Physical Chemistry B*, **2014**, 118, 6038-6046.
4. T. W. Wagner, Y. Q. Luo, N. D. Redeker, C. E. Immoos, S. J. Zhang, “Effect of surface-modified zinc oxide nanowires on solution crystallization kinetics of poly(3-hexylthiophene)”, *Polymer*, **2014**, 55, 2008-2013.
5. N. D. Redeker, C. D. Danesh, Y. Ding, S. J. Zhang, “Anisotropic core-shell nanocomposites by direct covalent attachment of a side-functionalized poly(3-hexylthiophene) onto ZnO nanowires ”, *Polymer*, **2013**, 54, 7004-7008.
6. C. D. Danesh, N. S. Starkweather, S. J. Zhang, “In-situ study of dynamic conformation transitions of a water-soluble poly(3-hexylthiophene) derivative by surfactant complexation”, *Journal of Physical Chemistry B,* **2012**, 116, 12887-12894.

***Pre-Cal Poly***

1. S. J. Zhang, C. I. Pelligra, G. Keskar, J. Jiang, P. W. Majewski, A. D. Taylor, S. Ismail-Beigi, L. D. Pfefferle, C. O. Osuji, “Directed self-assembly of hybrid oxide/polymer core-shell nanowires with transport optimized morphology for photovoltaics”, *Advanced Materials*, **2012**, 24, 82-87.
2. S. J. Zhang, P. W. Majewski, G. Keskar, L. D. Pfefferle, C. O. Osuji, “Lyotropic self-assembly of high-aspect-ratio semiconductor nanowires of single crystal ZnO”, *Langmuir*, **2011**, 27, 11616-11621. ***(Cover story)***
3. S. J. Zhang, C. Pelligra, G. Keskar, P. W. Majewski, F. Ren, L. D. Pfefferle, C. O. Osuji, “Liquid crystalline order and magnetocrystalline anisotropy in magnetically doped semiconducting ZnO nanowires”, *ACS Nano*, **2011**, 5, 8357-8364
4. S. J. Zhang, Z. Liu, D. G. Bucknall, L. H. He, K. L. Hong, J. W. Mays, M. G. Allen, “Thermally switchable thin films of an ABC triblock copolymer of poly(n-butyl methacrylate)-poly(methyl methacrylate)-poly(2-fluoroethyl methacrylate)”, *Applied Surface Science*, **2011**, 257, 9173-9177.
5. L. H. He, J. P. Hinestrosa, J. M. Pickel, S. J. Zhang, D. G. Bucknall, S. M Kilby II, J. W. Mays, K. L. Hong, “Fluorine-containing linear block terpolymers: synthesis and self-assembly in solution”, *Journal of Polymer Science: Part A: Polymer Chemistry*, **2011**, 49, 414-422.
6. S. J. Zhang, L. D. Pfefferle, C. O. Osuji, “Lyotropic hexagonal columnar ordering in a hydrogel of hairy-rod complexes of conjugated polymers”, *Macromolecules****,* 2010**,43, 7549-7555.
7. S. J. Zhang, Q. W. Li, I. A. Kinloch, A. H. Windle, “Ordering in a droplet of an aqueous suspension of single-wall carbon nanotubes on a solid substrate”, *Langmuir****,*** **2010**, 26, 2107-2112.
8. S. J. Zhang, W. Lin, X. W. Lin, C. P. Wong, S. Z. D. Cheng, D. Bucknall, “Surface-induced crystallization in high volume fraction aligned carbon nanotube polymer composites ”, *Macromolecular Chemistry and Physics,***2010**, 211, 1003-1011.
9. S. J. Zhang, W. Lin, L. B. Zhu, C. P. Wong, D. Bucknall, S. Kumar, “Nanocomposites of carbon nanotube fibers by polymer crystallization”, *ACS Applied Materials and Interfaces****,* 2010**, 2, 1642-1647.
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13. S. J. Zhang, S. Kumar, “Carbon nanotubes as liquid crystals”, *Small*, **2008**, 4: 1270-1283. (***Invited review article)***. ***(Top 3 most accessed article in Sep. 2008)***
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33. S. J. Zhang, L. X. Fu, D. C. Yang, Z. H. Gao, M. J. Jia, Y. B. Zheng, Z. W. Wu, “Synthesis and thermotropic liquid crystalline behavior of the novel poly(aryl ether ketone)s with a methoxy group” *Macromolecular Chemistry and Physics* **2000,** 201: 649-655.
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43. S. J. Zhang, Y. B. Zheng, Z. W. Wu, M. W. Tian, D. C. Yang, R. Yosomiya, “The new class of thermotropic liquid crystalline polymers: poly(ether ether keotne ketone)s based on a chloro-side group” *Journal of Materials Science Letters* **1997**, 16:1813-1815.
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45. S. J. Zhang, Y. B. Zheng, Z. W. Wu, M. W. Tian, D. C. Yang, “A full aromatic thermotropic liquid crystalline poly(aryl ether ketone)” *Chemical Journal of Chinese Universities* **1997**, 18: 484-485.
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