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| Title: | Development of Bioactive Carbon-Based Nanomaterials for Healthcare Application |
| Authors: | Sharma, Anjana |
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| Abstract: | In the present era where scientific technology is growing and developing at an enormous pace, nanoscience provides innumerable opportunities in material engineering. Nanomaterial science involves the study of structures in which atleast one of the dimensions is in the nano size range. Carbon nanomaterial (CBN) is an important member in the field of material sciences and continues to be an area of interest for the scientists in the field of electronics, optical and biomedical sciences. The exceptionally good physicochemical properties, durability and sensitivity of CBN has been explored in various healthcare applications. Because of novel optical and electronic properties and their ease of functionalization, carbon nanostructures are expected to be used in several biomedical applications such as nanoelectronics, live cell imaging, drug delivery, theranostics, tissue engineering and drug delivery. Realizing the enormous potential of carbon-based nanomaterials nanomaterials for their applications in the field of medicine, I synthesized different carbon nanomaterials and established their activity in cancer theanostics and wound healing dressings. In the present study, my focus will be on the development of two types of carbon nanomaterials i.e carbon dots and graphene nanohybrid composites and exhibiting its application in healthcare. The first part of the thesis focuses on the synthesis, characterization and biomedical application of carbon dots. In the first study, I explored the possibility of overcoming some of the limitations of natural compounds in bio-medical applications. I had used curcumin as a model, as the molecule, despite its well-known therapeutic activity, has limited clinical application in view of poor solubility and low bioavailability. The curcumin derived carbon dots (CurCD) were synthesized with curcumin, with ethylenediamine, as a nitrogen source. i \| PageThe CurCD was superior to curcumin in terms of improved solubility, photostability and fluorescent properties, while the anti-cancer activity of CurCD was comparable to curcumin. The strategy of converting phytopigments into carbon dots in order to improve their physicochemical properties can be used for the compounds whose usage is limited otherwise. In another study, we established the wound healing activity of CurCD. To enable its sustained release at the wound site, it was incorporated as a cross-linker in a protease responsive hydrogel dressing. The hydrogel had shown excellent antibacterial efficiency and the rate of wound was faster than curcumin alone. Carbon dots are being explored extensively for drug delivery applications. However, there is limited information available about their interaction with different systems of the body. In most applications, the carbon dots are administered into the biological system by an intravenous route where they interact with endothelial cells. To evaluate the effect of carbon dots on endothelial system, we used carbon dots synthesised from the commonly used precursors (citric acid/urea). The as-synthesised carbon dots exhibited pro-angiogenic activity both in the in- vitro and ex-vivo angiogenesis model. As the endothelial cells are the first line of contact for intravenously administered carbon dots, its pro-angiogenic activity might be detrimental to anti-cancer therapies. Our studies suggest the importance of evaluating the response of multiple cells that might come in contact with the carbon nano materials. The second part of the thesis focuses on one of the most important and less explored applications of carbon nanomaterials which is its conductivity. As carbon nanomaterials have excellent electrical conductivity, I utilized this feature to develop a self-powered, user-friendly and wearable device using carbonised nanomaterials for the healing of chronic wounds. In this application, carbonised polydopamine (CPDA) was used to assign conductivity to the hydrogel. As the structure of CPDA was similar to graphitic sheets, it was used as a conductive ii \| P a g ematerial in the hydrogel. The hydrogel was fabricated in close proximity to PVDF membrane to serve as a piezo-responsive triboelectric nanogenerator (PTENG) for providing electrical stimulation to the underlying wound bed. The fabricated wound dressing was evaluated for its ability to support various phases of wound healing using in vitro and in vivo wound model. To summarise, I have been able to synthesize and explore the bioactivity of carbon-based nanomaterials for healthcare applications. Provided the easy method of synthesis, biocompatibility and non-toxic nature of these synthesised materials, I propose that these nanostructures hold great promise in the field of medicine. Based on the above studies it was inferred that the developed different carbon-based smart nanomaterials hold a bright future for healthcare applications, further studies are needed to be carried out with higher animal models. |
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