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POLYMERS FOR TISSUE ENGINEERING

Biodegradable polyurethanes as scaffolds for spinal cord repair

This project will develop an innovative approach for the treatment of spinal cord injuries, through the use of advanced nanostructured biodegradable scaffolds. An appropriate cellular microenvironment for axonal elongation and growth will be generated within a scaffold consisting of biologically-functional polyurethane nanofibres. The materials will consist of novel polymer structures capable of incorporating and releasing neuronal growth factors and signalling molecules to encourage regeneration of spinal cord cells post trauma, followed by biodegradation of the scaffold. Biodegradable polyurethanes will be produced by incorporating labile moieties susceptible to hydrolysis (such as esters) into the polymer soft segment. The project will primarily involve design and synthesis of these functional polymers. Polymer characterisation and fabrication techniques will be used to assist in the development and production of the scaffolds.

Enrolling School: School of Chemistry & Molecular Biosciences (SCMB)

Suitable academic background: BSc Chemistry or Biotechnology

Skills obtained in project: Advanced materials science, polymer science, biomaterials science

Publication & postgraduate career potentials: All of our projects will lead to refereed publications and prepare the student for postgraduate studies.

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Sulfamethazine-based hydrogels network and potential application for protein release and wound healing

The aim of this project is to develop new responsive polymeric hydrogels to deliver growth factors and other therapeutic molecules to assist in the healing of wounds. Specifically the polymeric hydrogel will be designed to treat deep and chronic wounds for example diabetic skin ulcers. The approach is innovative and simple in concept; the novel hydrogel will be responsive to the wound environment, swelling and releasing the therapeutic drugs as the pH of the fluid in the wound becomes more acidic, a natural condition in chronic wounds.

The sulfonamide group is known as a pH-sensitive moiety and has been exploited for the synthesis of several anionic pH-responsive polymers, with application as hydrogel scaffolds for drug delivery or tissue engineering applications. In this project, the hydrogel networks contained sulfonamide pH-sensitive moieties and PEG will be synthesized. The ionization and de-ionization of sulfonamide groups (controllable pKa) are responsible for the responsive properties of the hydrogel. At pH>pKa, the sulfonamide groups in the copolymer are charged, resulting in the swelling and loading of growth factor (GF) into the copolymer network hydrogels. In contrast, within the acidic pH of the wound environments (usually below pKa), the sulfonamide groups become insoluble leading to de-swelling of the hydrogel and release of the GF, thus assisting healing of tissue. The new hydrogel system will be characterized by different techniques (NMR, FTIR, SEM and TEM) and protein concentration will be examined using ELISA assays. The researcher in this project will receive training in a very broad range of important scientific disciplines.

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Skills obtained in project: Advanced materials science, polymer science, biomaterials science

Publication & postgraduate career potentials: All of our projects will lead to refereed publications and prepare the student for postgraduate studies.

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Peptide Hydrogels for Cell Delivery

This project will characterize hydrogels formed by short α-helical peptides as a medium for growth and delivery of stem cells. These designer peptides self-assemble to form hollow fibrils of ca. 3 nm diameter, which cross-link at physiological pH to form low weight percentage (0.1-0.5%) self-healing hydrogels. The project will characterize the effects of variable levels of covalent cross-linking, and the resulting varying gel strengths, on the differentiation of stem cells within the hydrogel matrix, and also explore the possibility of encapsulating hydrophobic drugs in the fibril core for co-delivery. The project will employ techniques including rheology, electron microscopy, fluorescence microscopy, electronic circular dichroism, dynamic light scattering and mammalian cell culture.

Enrolling School: School of Chemistry & Molecular Biosciences (SCMB)

Suitable academic background: BSc Chemistry or Biotechnology or B Eng Chemical Engineering

Skills obtained in project: Advanced materials science, physical chemistry, biomaterials science

Publication & postgraduate career potentials: All of our projects will lead to refereed publications and prepare the student for postgraduate studies.

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POLYMER DEVICES

MRI Imaging Agents for Disease Detection

The aim of this project is to develop new magnetic resonance (MR) molecular imaging strategies that will enable the in vivo monitoring of biological processes. Specifically we shall develop novel polymers for imaging of early markers of diseases such as melanoma, prostate cancer, malignant glioma and Alzheimer's disease. Specifically the project involves the synthesis of new partly-fluorinated polymers having controlled architecture for the rapidly developing field of 19F MRI. The project aims to relate the structure of the macromolecules, determined carefully using advanced techniques such as NMR, light scattering, GPC, AFM and electron microscopy, to the performance as imaging agents. The agents will be tested in small animal (mouse) models of disease already developed by this group and our collaborators.

Enrolling School: School of Chemistry & Molecular Biosciences (SCMB)

Suitable academic background: BSc Chemistry or Biotechnology

Skills obtained in project: Advanced materials science, polymer science, biomaterials science

Publication & postgraduate career potentials: All of our projects will lead to refereed publications and prepare the student for postgraduate studies.

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Novel Block Copolymer for Lithographic Application

In recent years, block copolymers have created new opportunities as alternative nano-scale pattern templates for lithography applications. Block copolymers are particularly attractive because the self directed assembly of domain structures in thin films can produce an array of template patterns in the range of 5-50nm. It is well established that the ideal block copolymer must exhibit both a high value of polymer-polymer interaction parameter (c) and one highly etch resistant block. We have identified from the structure-property models that we have developed, that the polystyrene-block-polyester copolymer is a good candidate. Hence in this project, a range of interesting chemistries will be utilized for the synthesis of the block copolymer including ring opening polymerisation, living radical polymerization and some monomer preparation, in addition to characterization by various advanced techniques such as NMR, GPC, thermal analysis and vibrational spectroscopy. The thin film phase separated morphology will be investigated with respect to the surface interaction between the substrate and block copolymer by using high resolution scanning electron microscopy and XPS.

Enrolling School: School of Chemistry & Molecular Biosciences (SCMB)

Suitable academic background: BSc Chemistry or Biotechnology

Skills obtained in project: Advanced materials science, polymer science

Publication & postgraduate career potentials: All of our projects will lead to refereed publications and prepare the student for postgraduate studies.

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