Engineering and Innovation Research Studentship
October 2020

Project title:	Medical applications of silicon nanoparticles
Discipline	**Engineering & Innovation/Life, Health, Chemical Sciences**
Key words:	Health; medicine; nanotechnology; particle technology; soft matter
Supervisory team:	**James Bowen (E&I); Peter Taylor (LHCS); Jon Golding (LHCS)**
URL for lead supervisor's OU profile	**http://www.open.ac.uk/people/jb36559**

Project Highlights:

- Nanoparticles are a bridge between bulk materials and atomic or molecular structures.
- Industries which utilize nanoparticles include the agriculture, automotive, cosmetic, electronics, environment and food industries.
- New methods for drug delivery and the fabrication of materials for regenerative medicine.

Project Description:

In a recent study Bowen et al. [1] described a novel, efficient method for the synthesis of 3D radially symmetrical biomolecule-POSS hybrids. POSS stands for polyhedral oligomeric silsesquioxane, a symmetrical, three-dimensional cubic molecule, which is a unique nanometer-sized hybrid inorganic–organic material with the formula $(RSiO_{3/2})_8$, also known as T_8. POSS contains an inorganic inner siloxane nanocore, with the possibility of chemical functionalisation at each of the eight corners of the cubic unit.

POSS units have been used extensively as scaffolds for the development of liquid crystals, biocompatible materials, catalysts, and dendrimers. They can also be used in cross-linking polymers. Functionalisation of T_8 with different substituents has usually been achieved by hydrosilylation, Heck, and cross-metathesis reactions.

A one-step synthesis of an octa-alkyne terminated POSS from commercially available octakis(3-aminopropyl)octa-silsesquioxane, with high yield (90%), has recently been reported [1]. The octa-alkyne terminated POSS was efficiently and regioselectively octafunctionalised with two azido-R species, where R are Fmoc-Leu and thymidine, by copper(I)-catalysed 1,3-dipolar azide–alkyne cycloaddition (CuAAC) under biphasic conditions. This led to new hybrid biofunctional nanocages in high yield.

This new strategy of functionalisation of terminated alkyne-POSS via CuAAC opens many possibilities for the efficient and controlled assembly of new hybrid materials for drug delivery biological applications with a high degree of symmetry and with carefully tailored functional properties.

Collaborative research is already underway which seeks to utilise these nanocages (i) through the attachment of peptide sequences, and (ii) for their incorporation into peptide hydrogels. The intention is to increase the density of crosslinks with the hydrogel network, and hence increase the Young's modulus of this otherwise soft material.

Further, Golding et al. [2] recently reported on the uptake and interaction of gold nanoparticles, and their potential toxicity towards carcinomas. This project will explore the use of silicon nanoparticles for similar purposes.

Research Methods:

This project will explore the synthesis and purification of novel silicon nanoparticles. The nanoparticles will present one or more functional groups at their outer surface. Their biocompatibility, toxicity, and application areas will be assessed. The possibility of producing biosurfactants will be considered. The use of selected nanoparticle designs towards the creation of supramolecular hydrogels will also be considered.

Indication of project timeline:

Year 1: Synthesis and purification.
Year 2: Biocompatibility and toxicity studies.
Year 3: Applications and further development.

Background reading:

[1] El Aziz, Y.; Mehrban, N.; Taylor, P.G.; Birchall, M.A.; Bowen, J.; Bassindale, A.R.; Pitak, M.B.; Coles, S.J.; Facile synthesis of novel hybrid POSS biomolecules via a "click" reaction. *RSC Advances* **2017**, *7*, 37474-37477.

[2] Tzelepi, K.; Espinosa Garcia, C.; Williams, P.; Golding, J.; Galactose:PEGamine coated gold nanoparticles adhere to filopodia and cause extrinsic apoptosis. *Nanoscale Advances* **2019**, *1*, 807–816.

[3] Healy, M.G.; Devine, C.M.; Murphy, R.; Microbial production of biosurfactants, *Resources, Conservation Recycling*, **1996**, *18*, 41-57.

Candidate Applications:

Students should have a strong background in materials, chemistry, engineering, or pharmaceutical sciences, coupled with an enthusiasm for discovery and innovative thinking. The student will join a well-established group which explores fundamentals and applications of materials engineering at the Open University.
Please contact **James Bowen** for further information (**james.bowen@open.ac.uk**).

Applications should include:

- A 1000 word cover letter outlining why the project is of interest to you and how your skills match those required
- an academic CV containing contact details of three academic references
- Open University application form
- Applicants will need to demonstrate good competence in the English language. To be eligible for a full award a student must have no restrictions on how long they can stay in the UK and have been ordinarily resident in the UK for at least 3 years prior to the start of the studentship.

Applications should be sent to **STEM-EI-PhD@open.ac.uk** **by 31.03.20**