ARC Centre for Functional Nanomaterials

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NanoMatters

The Newsletter of the ARC Centre for Functional Nanomaterials

Life Long Research Recognised

Centre chief investigator Professor Mick Wilson from UWS has been awarded the Australian Organic Geochemist Medal for 2006 for his lifetime research commitment to organic geochemistry.

The award, presented at this years conference of the Australian Association of Geochemists on Rottnest Island WA, was given to Professor Wilson for his contribution to the development of molecular and structural analytical methods of analysis of soils, kerogens and coals and an understanding of nanoscale organisation.

Professor Wilson has been the mentor and inspiration behind the careers of many organic geochemists in Australia and he will also be recognised for his international contribution to soil organic chemistry, by the American Chemical Society, later this year.

Professor Mick Wilson (right) is presented the Australian Organic Geochemist Medal for 2006 for his lifetime research commitment to organic geochemistry by Associate Professor Barry Batts.

Inside This Issue

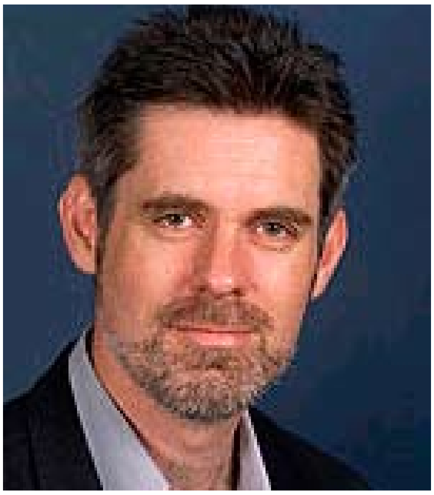
Program leader receives prestigious German award

Congratulations to Professor Sean Smith, ARCCFN program leader and Director of the Centre for Computational Molecular Science, who has been awarded the Friedrich Wilhelm Bessel Research Award of the Alexander von Humboldt Foundation, one of Germany's most prestigious international fellowships.

The Friedrich Wilhelm Bessel prize is awarded to top international scientists and scholars who are recognized as outstanding researchers in their field.

The Alexander von Humboldt Foundation grants only 20 Friedrich Wilhelm Bessel Research Awards annually across all disciplines worldwide. The research award is funded by the German Federal Ministry of Education and Research in recognition of research achievements to date and is equivalent to an Australian professorial salary.

Award-winners are invited to work on research projects of their own choice in cooperation with colleagues in Germany for periods between six months and one year. Professor Smith will be spending his year in Germany in the city of Göttingen at the Max Plank Institute for Biophysical Chemistry.



Professor Sean Smith

Loaded Nanoparticles for Drug Delivery

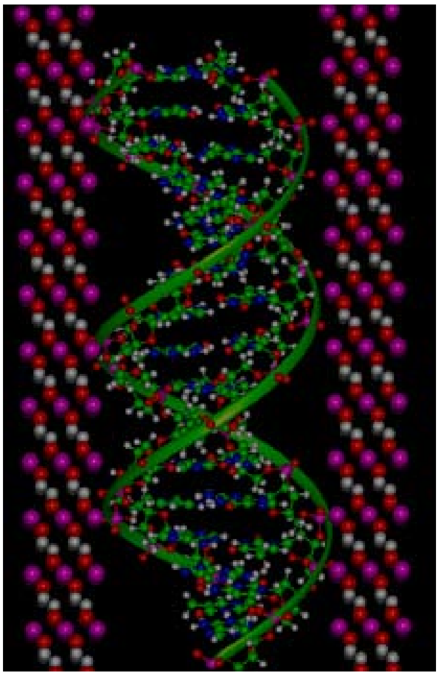
The Computational Nanomaterials Science Program of the Centre supports experimental work by developing molecular simulation capabilities for studying the interactions between DNA strands, Layered Double Hydroxide (LDH) nanoparticle architectures and the cell membrane.

LDH nanoparticles are a promising new technology for gene therapy as they provide a selective delivery system of DNA into cells. Finding highly efficient and selective methods for molecular delivery to cells is a key challenge for bio-manufacturing and drug delivery applications. The nature of the interactions between DNA (or other target molecules) and the LDH nanoparticles is, however, poorly understood.

A computational team including Dr Pierre Tran, Professor Sean Smith, Dr Qing-Hua Zeng and Professor Aibing Yu are presently working on assembling and trialling relevant software packages to model and ultimately understand these interactions.

To date they have successfully modelled the structure of the LDH containing NO_3^- ions, using brucite cell parameters. A combination of different molecular modelling software, is also being used to study the interlayer complex system in real time molecular dynamics.

This pioneering calibration study compares favourably with a previous experimental study of the LDH containing NO_3^- and serves as test for molecular modelling software parameters for other bio-nanohybrid complex structures.



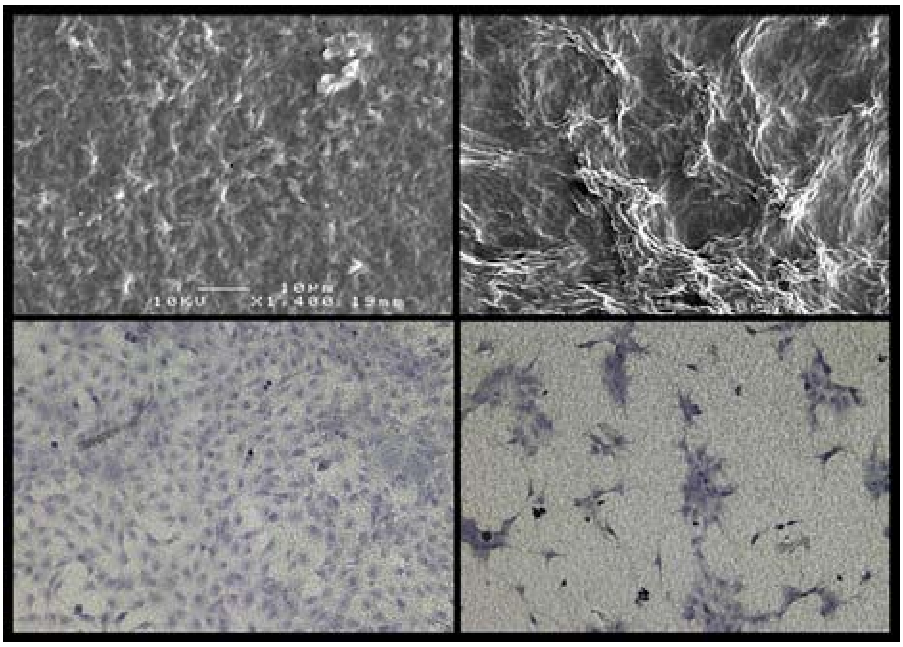
Model of the DNA/LDH nanoparticle complex

Engineered Bone

Each year Australians experience approximately 90 million bone fractures, of which 13.5 million are difficult to heal. Research from the Nanobiomaterials Program of the Centre aims to develop a series of nanocomposite materials for artificial bone implants, which then encourage natural bone regeneration.

Bone cells are sensitive when it comes to surfaces and don't like to proliferate when an 'ideal' surface is not encountered. A research team led by researchers at the University of Queensland are investigating surface characteristics of biomaterials for optimum bone (or osteoblast) cell proliferation and growth. These biomaterials can be used as a temporary scaffold for bone tissue engineering.

Their research has shown that surface roughness and topographical features are the two most important surface characteristics which determine growth and proliferation of osteoblast cells.



Surfaces with similar roughness but with different topographical patterns

Poly(hydroxybutyrate-co-hydroxyvalerate) PHBV solvent cast films were produced with different surface roughness and topographical features (SEM micrographs; top images) using different solvents. The differences in surface characteristics are due to the condensation of the water droplets on the surface as the solvent evaporates, and the different evaporation rates of the solvents.

Osteoblast cells cultured on the materials for a period of 4 days (bottom images) displayed different responses to the different surfaces. The morphology of the cells on some surfaces (left image) were flat and spread while the cells on other materials (right image) were less spread and clumping together and indeed not populating the entire surface.

These are promising results in understanding bone cell proliferation and an important step to develop a therapy for bone injuries for which there is currently no real effective treatment. This research has been submitted for publication of the journal Biomaterials. For further information please contact Dr Grondahl at l.grondahl@uq.edu.au.

Excited Electrons Do the Cleaning – Part of our 'Future World'

Is a self-cleaning bathroom part of our future world? Research, led by Professor Rose Amal and Professor Michael Brungs of the ARC-CFN at the UNSW, focuses on modifying tiny particles of titanium dioxide, currently used on self-cleaning outdoor surfaces and windows, for application in the bathroom.

So, how does it work? When UV light (with its shorter wavelength and greater energy) shines upon a titanium dioxide (TiO_2) surface, an electron absorbs the light and is excited to a higher energy level. This process, or 'excitement of the electron', gives the particle a highly oxidising characteristic, which is capable of degrading organic contaminants and killing bacteria.

TiO_2 coated glass (left) exhibits superhydrophilicity when compared to uncoated glass (right).

As only 4% of the sunlight reaching the earth's surface contains the UV light needed to activate the TiO_2, and even less indoors, this research is aimed at developing materials which can become 'self-cleaning' using indoor light.

By adding Nitrogen (N) or Iron (Fe) to the TiO_2 structure (or 'doping' the TiO_2 particles) light of longer wavelengths (i.e. indoor light) is able to excite these electrons and facilitate the 'self-cleaning' process.

An added advantage to these TiO_2 coatings is their characteristic of superhydrophilicity – a great attraction to water molecules. This results in a droplet-free surface, where a uniform water film is formed allowing an easier removal of contaminants.

Potential applications include using these materials on bathroom tiles and hospital benches to reduce the chemical agents required to keep them clean and free from bacteria.

A Sweet Look at Hydrogen Sourcing

La Dolce Vita may soon take on new meaning, with research that investigates hydrogen sourcing from sugar for use as fuel. With the slow but inevitable move towards the widespread use of hydrogen as a fuel, the search is on for means to produce hydrogen.

Traditional technologies to source hydrogen such as steam reforming of natural gas produce large quantities of carbon dioxide, while water electrolysis is energy intensive. Attention has now shifted to renewable sources of hydrogen.

Inspired by exciting results from researchers at the University of Wisconsin, where hydrogen was produced from catalytic decomposition of glucose and other simple carbohydrates in water, Akshat Tanksale, a Centre PhD student has set out to produce novel nanocatalysts for this process.

His catalysts, which employ Nickel, Palladium and Platinum, have been tested for the liquid phase reforming of glucose, fructose and sucrose, with some promising results.

All of the catalysts demonstrated superior performance to commercial catalysts in terms of the hydrogen yield, however there are some differences in the performance of the different sugars. Glucose reacted quite slowly to produce hydrogen while fructose reformed much faster. Sucrose was similar to both sugars but tended to deactivate the catalyst. The overall yield of hydrogen from glucose and fructose was similar.

Further work will test the catalysts for the decomposition of ethylene glycol, allowing for a careful comparison with the results of the Wisconsin group, and evaluating the use of cheaper metals.

Centre PhD student Akshat Tanksale

This simple technology, operating at moderate temperatures and pressures, could potentially be employed to produce hydrogen from carbohydrates extracted from renewable biomass.

World's Smallest Sieves

Until renewable energies such as solar and wind power become more feasible, other clean energy options are being explored. Clean coal technology is one such option which enhances efficiency and reduces environmental pollution through a process that can capture and store carbon dioxide emissions.

Researchers from the Centre are creating nano-sieves, which can be fitted to existing power stations and petrochemical plants. These 'worlds smallest sieves' separate carbon dioxide from hydrogen – the hydrogen can then be converted into electricity in fuel cells and the CO_2 buried (a process known as geological sequestration).

Dr Mikel Duke creating a prototype membrane for gas separation

These nano-sieves are created by coating a porous substrate with a thin film of zirconium and titanium oxides. These coatings act like a sieve with tiny nano-holes, one billionth of a metre in diameter, and allow the smaller hydrogen molecules to pass through, while capturing the carbon dioxide, leaving water as the only by-product of coal power stations.

Further funding for this research, led by Prof Max Lu and Dr Joe da Costa, was announced by the Queensland government earlier this year with a contribution of $1.05 million under its Smart State National and International Alliance program. Scientists and engineers from the ARCCFN will be working together with researchers from the German Industrial Research Institute, Forschungszentrum Jülich (FZJ), as the first project to come from a 2004 energy technology agreement signed between Queensland and North Rhine Westphalia (Germany). The research is also being supported by the Centre for Low Emission Technology.

Further Funding for Nanotechnology Network

ARCCFN researchers of the UWS Nanotechnology group have received a new grant of over $100,000 to expand their Nanotechnology Network, established three years ago.

The UWS Nanotechnology Network is a forum to share ideas and expand on nanotechnology knowledge from UWS researchers with industry, and to investigate opportunities for research, development, consultancy and business. The Network meets quarterly to showcase innovative ideas linking university with industry through nanotechnology.

Mr. Pat Farmer (Federal Member of Macarthur) said the program would include the development of a TV segment for high school science students, to get them thinking about careers in nanotechnology, and an intensive two-week nanotechnology research project for science teachers.

For further information visit the UWS Nanotechnology website at www.uws.edu.au/nano

Nanoparticle Scientists in Top 5 List

A top 25 list from 'ScienceDirect' has ranked a paper, co-authored by Centre researchers Mr. Wey Yang Teoh and Professor Rose Amal, in its list of most downloaded articles.

The paper, 'Direct (one-step) synthesis of TiO_2 and Pt/TiO_2 nanoparticles for photocatalytic mineralisation of sucrose,' published in 2005, was ranked the fifth-most downloaded article within the journal Chemical Engineering Science.

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