

Institute for Photonics & Advanced Sensing (IPAS)

# Surface Science & Synthetic Chemistry

## Theme Leaders



**Prof Andrew Abell**

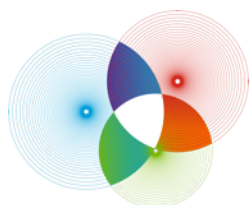


**Dr Chris Sumbly**

Our chemistry teams develop novel chemical surface coatings and surface functionalisation strategies to enable the realisation of sensors for specific chemicals and biomolecules. This includes the synthesis of novel compounds for ion trapping and fluorescence based sensing architectures.

Other programs focus on the study of electron transfer within surface bound peptides, and the development of new materials for catalysis and efficient separation of gases essential for renewable energy and environmental applications.

Our researchers in this space include ARC Future and Super Science Fellows. This expertise spans from fundamental chemistry to analyte-specific sensor development, highlighting this as an identified strength of IPAS.



## Biological & Chemical Surface Functionalisation

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## Novel Materials Synthesis

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## Functional Organic Materials

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## Charge Transfer & Bioelectronics

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## IPAS Large Scale Facilities

### Bragg Crystallography Facility

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### Peptide Synthesis & Purification Facility

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### Australian National Fabrication Facility (ANFF) Optofab

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## Biological & Chemical Surface Functionalisation

The Biological & Chemical Surface Functionalisation work at IPAS combines organic synthesis, supramolecular chemistry and surface science to functionalise the surface of a glass optical fibre or waveguide, enabling the detection of specific chemicals and biomolecules. Where conformation control of the sensing molecule is required, we attach peptide-based ionophores that contain an appended fluorophore and a light dependent actuator to a surface. This construct is then able to bind, sense, and release specific ions.

Ionophores, actuators, fluorophores and other molecular tools are designed and synthesised in-house. These are tailored to the requirements of the sensor being developed and the analyte under detection.

## Novel Materials Synthesis

Our Novel Materials Synthesis group design and synthesise supramolecular structures and nanostructured materials. Some of these compounds display novel interactions which we then exploit to develop sensors. Research is focussed on the design and construction of these new materials, including molecular assemblies and solid-state materials, which can be utilised as the next generation of functional materials, such as porous materials, catalysts, molecular devices and sensors.

## Functional Organic Materials

IPAS researchers working on groundbreaking research in the area of Functional Organic Materials are developing the chemistry of 'networked polymers'. This emerging field has tremendous potential for new, more efficient catalysis platforms, sensing, storage and separation solutions. Specifically, the group are developing covalent organic frameworks (COF) that are synthesised from high symmetry building blocks, linked via strong, irreversible covalent bonds, to give open 3D extended polymer materials.

## Charge Transfer & Bioelectronics

Our Charge Transfer & Bioelectronics work concerns the design and synthesis of peptides with specific secondary structures, whose electronic properties we then evaluate using both theoretical and experimental strategies. Experimental work includes the investigation of charge transfer mechanisms through surface attachment approaches, while computational techniques provide theoretical rationalisation of experimental results using Marcus Theory. This research provides invaluable information and understanding on the exact nature of charge transfer occurring in biological processes and moves us closer to the realisation of peptides and protein-based electronics and

## IPAS Large Scale Facilities

The **Bragg X-ray Crystallography facility** (predominately ARC LIEF funded) provides IPAS with extensive molecular and crystal structure determination capabilities, including high throughput, small molecule, protein and macromolecule structure determination and screening for large protein samples.

The facility is equipped with a variety of characterisation tools, including an STA (DSC/TGA), an adsorption analyser, two state-of-the-art diffractometers, a Mo-target Oxford Diffraction X-Calibur X-ray diffractometer for small molecule structure determination, and a Cu-target Rigaku Hiflux Homelab rotating anode X-ray diffractometer for macromolecular structure determination.

We use our **Peptide Synthesis & Purification facility** to conduct surface studies and synthetic chemistry research. This facility is equipped with a CEM liberty peptide synthesiser for solid phase synthesis and a semi-preparative and analytical HPLC machine.

Forming part of the **Australian National Fabrication Facility (ANFF)** Optofab node (which is headquartered at Macquarie University), our sub-node includes a surface science capability that supports IPAS research in this area and will soon be extended, due to recent additional South Australian State funding.

## Case Study: Fibre-bound Nanomachines (ARC Super Science Fellowship)

In 2010 IPAS was awarded 6 ARC Super Science Fellowships, worth over \$2.4M. One of these Fellows, Dr Sabrina Heng, is creating light-based nanomachines for the detection of biologically relevant ions (such as  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{PO}_4^{3-}$ ,  $\text{NO}_3^-$ ,  $\text{Cl}^-$ ). These fibre-bound nanomachine sensors include supramolecular compounds that can change their conformation via an external stimulus. In these sensors, light has a twofold role. Firstly, light drives the change in geometric conformation of the supramolecular compounds, controlling the binding of specific ions and conferring reversibility. Secondly, light is the medium for detecting and quantifying the binding of analytes via absorption or fluorescence.