Imperial College
London

Chemical Photography

Seeing in a different light

Vibrational Spectroscopy & Chemical Imaging Research Group

Department of
Chemical Engineering

Selected 2010

The Royal Society's 350th anniversary
Summer Science Exhibition

Chemical Imaging

We develop new approaches in chemical imaging for taking “chemical photographs” of materials at the microscopic level. For example, we can now see the processes inside tablets when they dissolve, which could help pharmaceutical companies to develop better products. We can also analyse the chemistry of fingerprints, benefitting police forensics; biomedical samples for advances in healthcare diagnostics; and objects of cultural heritage, for the preservation of important artworks.

Multidisciplinary collaborations with colleagues from universities, industry and government institutions play an important role in our research focusing on solving problems with implications for health, the environment and security as well as those of significant industrial interest.

Interdisciplinary Research

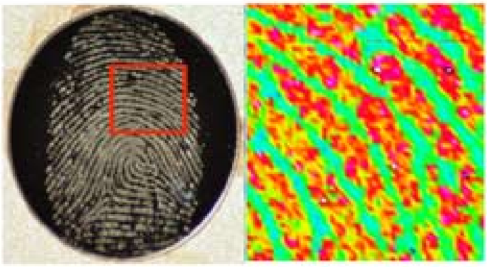
- Advanced vibrational spectroscopy
- FTIR spectroscopic imaging
- Novel developments in ATR imaging
- Imaging for high-throughput analysis
- Imaging of microfabricated devices and microfluidics
- Raman Spectroscopy (Confocal Raman microscopy, FT-Raman and Tip-enhanced Raman spectroscopy)
- High-pressure FTIR spectroscopy
- Characterisation of complex materials
- Intermolecular interactions
- Novel solvents (supercritical fluids and ionic liquids)
- Biomaterials and polymeric materials
- Pharmaceutical and biomedical applications
- Forensic science and art conservation

http://www.imperial.ac.uk/vsci

Developing a New Forensic Approach

Chemical imaging with a high spatial resolution offers a unique opportunity for forensic research. For example, FTIR imaging is used to analyse samples of forensic interest: such as the surface of human skin (e.g. finger), textile materials (clothing), paper, trace evidence (e.g. in soil), tablets, drugs, fibres, biological samples and biomaterials.

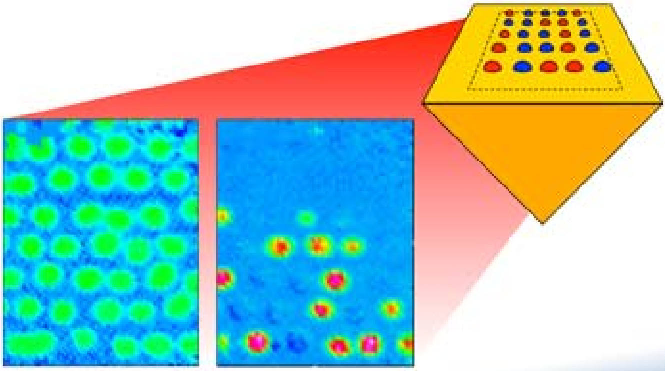
Crime scene evidence, for example fingerprints, collected from different surfaces can be analysed using a tape-lift method combined with Attentuated Total Reflection (ATR) imaging



Analysing Samples More Efficiently

In this research we have demonstrated the applicability of FTIR spectroscopic imaging to study many samples simultaneously for high-throughput analysis.

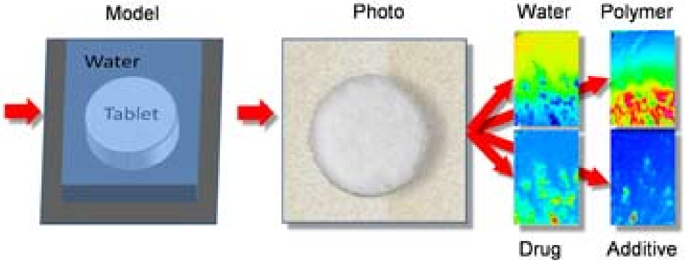
The developed macro ATR-FTIR imaging approach has allowed us to analyse more than 100 samples under controlled environment simultaneously. Using this approach, it was possible to obtain "chemical snapshots" from an array of many different samples simultaneously all under identical conditions or from microfluidic channels on the crystal.



Developing Improved Pharmaceuticals

Attenuated Total Reflection (ATR) spectroscopic imaging is particularly well suited to studying pharmaceutical formulations.

Unlike other techniques, this approach allows us to see the physical and chemical processes which occur inside the tablet during events such as compaction and dissolution. Understanding these processes is necessary for developing more effective formulations.

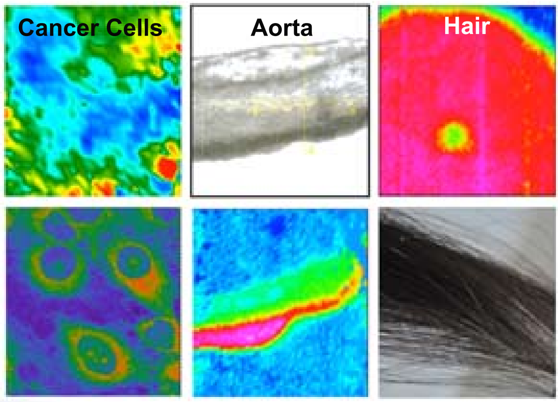


Seeing Cells and Tissues Better

ATR-FTIR imaging enables one to obtain chemical images of microscopic biomedical objects specifically cells and tissue.

Our research in this area includes the imaging of atherosclerosis, imaging protein crystallisation, imaging of skin and transdermal drug delivery, chemical imaging of live cancer cells, imaging of the cross-section of a human hair without recourse to a synchrotron source of infrared radiation.

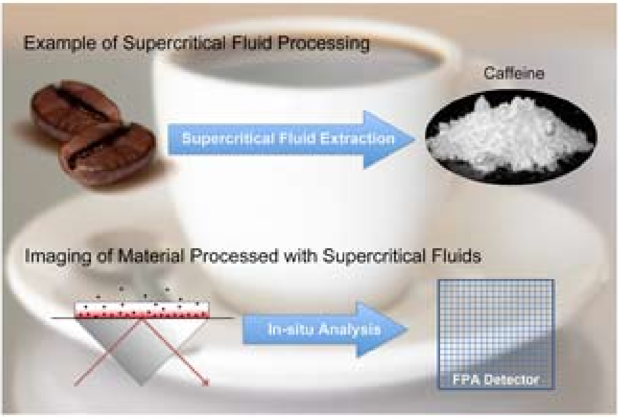
It is possible using large inverted prism crystals to obtain chemical images of arterial tissue in contact with aqueous solutions and study the diffusion of model drug molecules into live tissue samples.



Engineering New Products and Processes

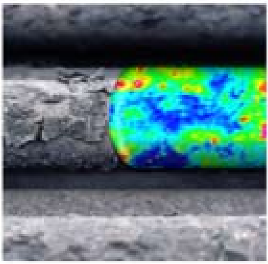
We use spectroscopy to discover and understand molecular interactions to help us engineer new products and processes (e.g. impregnation or extraction of various substances such as caffeine).

We apply high-pressure spectroscopic techniques in situ to study interactions between polymers and supercritical fluids, and to study the processing of polymeric materials. We have developed several novel in situ spectroscopic approaches to study materials and ionic liquids under high-pressure gases using ATR and transmission FTIR spectroscopy and imaging.



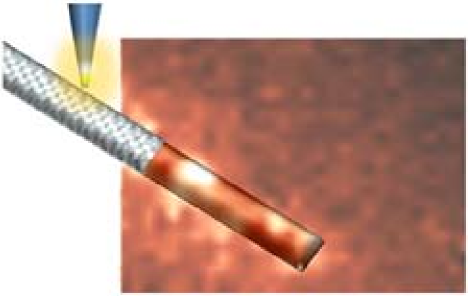
Understanding Complex Materials

One of the examples of our research in this area is the application of FTIR imaging and Raman microscopy to understand fouling in heat exchangers, which is a major economic problem. The total cost of crude oil fouling in the UK is of the order of USD$2.5 billion. Spectroscopic analysis of deposits is valuable in gaining an insight into mechanism of crude oil fouling.



Improving Nanostructures

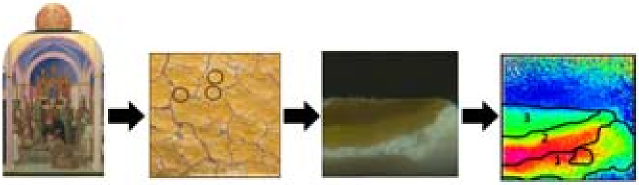
We have used confocal Raman microscopy for the elucidation of the morphology of semi-crystalline polymers modified with supercritical CO_2 and to study the behaviour of pharmaceutical drugs under controlled humidity.



Tip-enhanced Raman spectroscopy (TERS) is a novel technique that combines the high spatial resolution of atomic force microscopy (AFM) with the chemical information of Raman spectroscopy, thus breaking the diffraction limit associated with confocal Raman microscopy. We apply this to study carbon nanotubes and other nanostructured materials.

Conserving our Cultural Heritage

Analysis of materials of cultural heritage collections has a vital role in a responsible modern approach to conservation. We apply ATR-FTIR spectroscopic imaging to cross-sections from cultural heritage paintings and objects to reveal the chemical composition and to understand the degradation processes in paintings from the National Gallery and other museums. This information is crucial for conservation practices and our ability to preserve our national collections for future generations



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