UNIVERSITY OF BIRMINGHAM

College of Engineering and Physical Sciences

School of Chemical Engineering

Energy and Chemical industries

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Improving the quality of life demands the supply of increasing amounts of energy and consumer chemicals, whilst at the same time global warming has become a major cause for concern.

The Energy research theme addresses the challenges of introducing the hydrogen economy to replace the current reliance on carbon based fuels. Fuel cells, hydrogen generation, storage and use are being investigated.

The production of chemicals such as pharmaceuticals, vitamins, personal and household products is the traditional business of the chemical industry but new challenges are being addressed to manufacture such products more efficiently. Novel production routes using catalysis or supercritical fluids, reduction of waste by-products and control of product formulation are some of the key challenges which are being addressed by the Group. The group has three main research areas;

1 Hydrogen Energy Research

A major integrated programme on Hydrogen Energy is carried out within the School which covers hydrogen generation, storage, use and socio economics of technology development.

2 Catalysis and Reaction Engineering

Catalysis and chemical reaction engineering lie at the core of many chemical and biochemical processes. Research activities cover the fundamental catalyst design, through formulation and catalyst manufacture to operational issues and reactor design. The group aims to optimise reactor type, design and operating conditions to achieve the best performance and product selectivity in a particular reactor. The Group also carries out studies on the impact of fluid dynamics upon catalytic and chemical processes.

3 Supercritical Fluids

Research in supercritical fluids encompasses the development of chemical, biochemical and bio-processes. In principle the unique properties of critical fluids have the potential to foster the development of environmentally benign and therefore sustainable processes. As such the group is multi disciplinary and encompasses sustainable green chemistry and industrial biotechnology. The group also works on the extraction of bio active and high value compounds from plants, seeds and fruits, the supercritical gasification of biomass to produce hydrogen for fuel cells and the manufacture of nanoparticles and the destruction of toxic compounds.

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Bio – Industries

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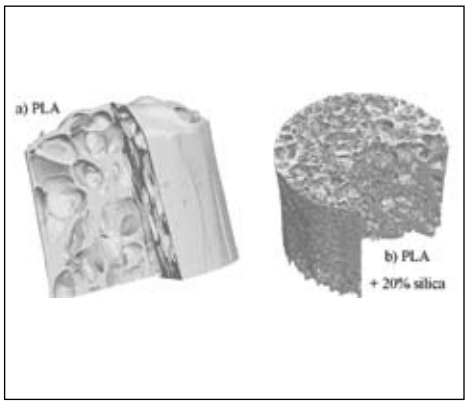
Our ever expanding knowledge of how biological systems function and interact mean that we are finding new ways to exploit and artificially replicate them.

There is currently a worldwide drive to use this new knowledge in a diverse range of different applications. In Biochemical Engineering we are currently working on a number of fronts with the aim of exploiting biological molecules, cells and tissues to develop a range of high value products. Current themes progressed by the School are listed below.



1 Bioprocessing (manufacture and purification)

Biomanufacture: Cells can be used in the production of a range of chemicals and high value biopharmaceuticals eg. recombinant proteins, antibodies, plasmid DNA, major histocompatibility complex class I molecules and designer carbohydrates. In Biochemical Engineering we aim to optimise production processes by using a combination of traditional reaction engineering and modern systems biological approaches to maximise product yield. Specifically we are investigating how the effect of micro and macro mixing can influence production processes and how process conditions can affect the mechanical properties of single cells.

With the advent of genome sequencing and advances in high through put methodologies it has become possible to consider organisms as a whole rather than their individual components. This has opened up the possibility of targeting specific pathways to intensify the production of biopharmaceuticals while maintaining optimal cell yields.

Downstream processing: a current limiting factor in the commercialisation of many biopharmaceuticals is the economical isolation and purification of the product from the reaction medium. The group is currently developing novel methods to achieve this by; intensifying downstream process sequences, magnetic particle based separations, re-design and scale of up expanded bed adsorption chromatography, inclusion body processing, crystallisation of industrial enzymes and synthesis of new support designs and nano bio-structures.

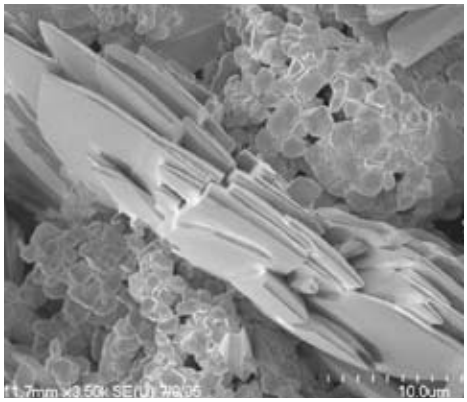
2 Tissue repair

Enhanced life expectancy in the UK has created significant demand for new strategies to replace diseased and damaged tissues. Many of the established methods replace damaged tissues with the patients own tissue or tissue harvest from a cadaver.

Ethical issues associated with the application of tissue grafts and practical difficulties linked with the harvesting procedure eg. donor site morbidity, pain have driven research into the development of novel approaches to repair damaged tissues.

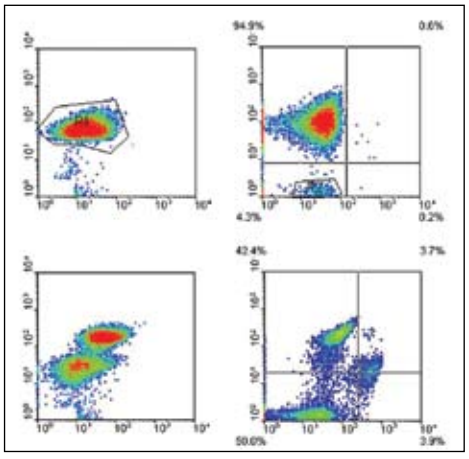
Our current research has two major themes; Tissue engineering. The application of engineering and biological principles to the ex vivo and in vivo production of new tissues.

Synthetic replacements. This involves the application of materials to act as a filler and support the tissue healing process. As our knowledge of biological systems improves we are moving from the use of materials as crude compositional mimics to designing materials that can interact with specific biological processes to enhance tissue formation.



3 Environmental Engineering

A range of biological organisms and molecules can be used in the catalysis of industrial processes, the generation of biofuels and hydrogen and the purification of polluted wastewater.



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Speciality Products

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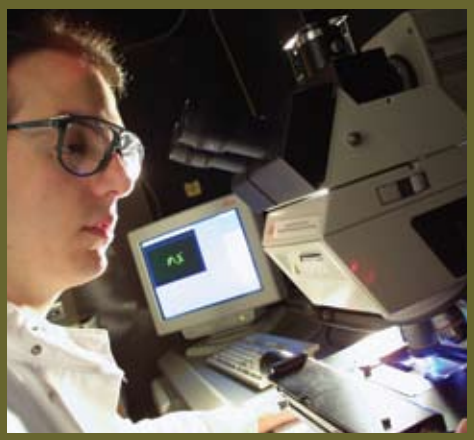
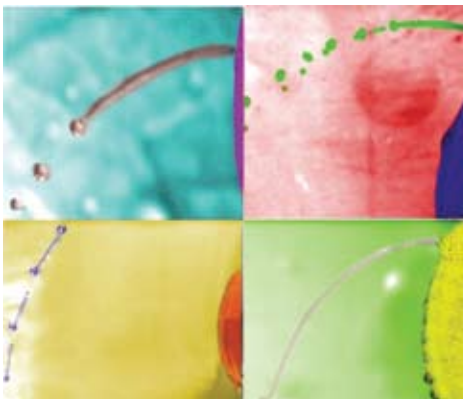


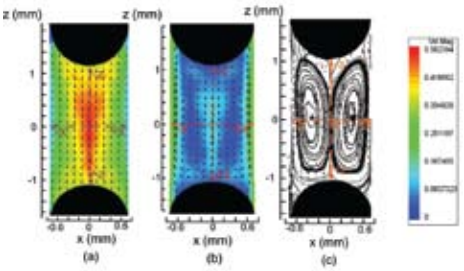
Research in this area underpins the creation, development and improvement of many industrially important products. Here our research activities have been grouped into three main areas;

Fundamental Engineering Science

Within this theme there are three main areas of research.

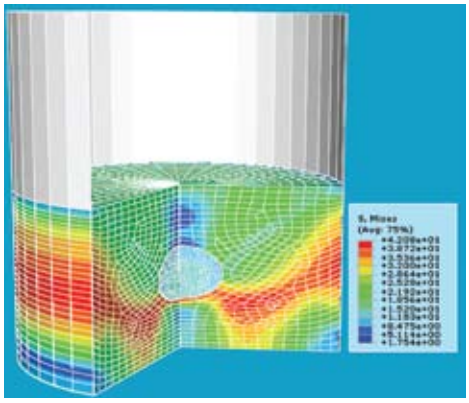


1 Understanding interfacial phenomena is the key to controlling the microstructure of solids and fluids and for ensuring stability.



2 In particle processing the application of Discrete Element Method and Birmingham's unique Positron Emission Particle Tracking equipment are key techniques for providing fundamental scientific insight into particulate behaviour.

3 Flow and mixing research covers both conventional and micro scales and is key to examining everything from in process behaviour of materials through to cellular interactions with the human body.



Processing and Structuring Component Materials

The creation of functional materials from both organic and inorganic materials is well established group within the School and is supported by strong industrial links. Areas of interest include

1 Novel processing and formulations for investment casting including the rapid shell process, new formulations for advanced alloy casting at high temperature in both ceramic shells and cores and development of formulations for pattern –less cored systems.

2 Extrusion of ceramics for refractory tubes and catalytic materials

3 New routes to nano catalyst powders using supercritical processing

4 Understanding polymer extrusion using Positron Emission Particle Tracking

5 Intensification of materials processing using microwaves

Understanding and Improving Products and Processes

This is a particular hot topic in the pharmaceutical industry where the demand for increased process efficiency, understanding and innovation is at the forefront on the Industry's priorities. New opportunities in biopharmaceuticals, nanotechnology and drug delivery coupled with the need to embrace Process Analytical Technology are key drivers for the School.

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Food, Health and Nutrition

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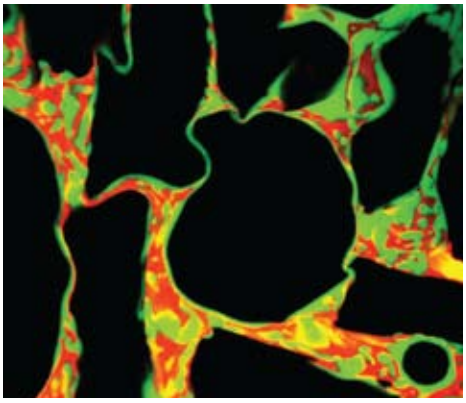
Foods should be safe, optimised for health benefits and enjoyable to prepare and eat. A number of these criteria are conflicting as a food that is totally stable and safe will not breakdown and deliver sensory responses and flavours when consumed.

Thus foods are formulated to be in kinetically trapped states. These products deliver the sensory requirements, but are inherently unstable and a challenge to the scientists and engineers involved in new developments and production. The design of food processes and microstructures is a major research activity in the School. Within this theme we carry out research to provide underpinning support to the food industry and to drive research forward in the new areas that are demanded by consumers and policy makers eg, healthy foods that are convenient, safe, and still fit into a normal diet or are even seen as indulgent (healthy indulgent) and the design of food processes with zero waste and thus lower environmental impact. The Birmingham group is the largest of its type in any UK Engineering Department and has developed world leading skills in three critical areas required for food formulation engineering;

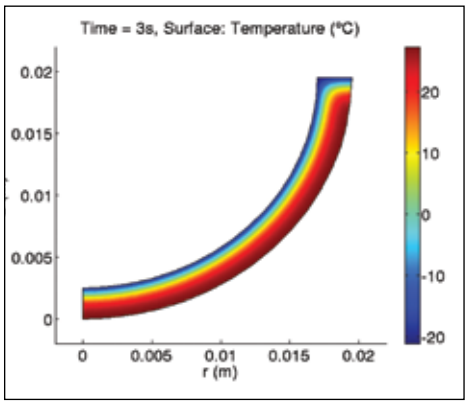


1 Food, health and nutrition

Dietary related diseases such as obesity and hypertension are major 21st century chronic diseases reaching epidemic levels and still increasing.

The problems caused threaten to overwhelm the health service and is already costing the economy billions of pounds per year. It is commonly accepted that a major part of the solution is to get the general population to change their diet and to reduce their calorific intake by reducing fat, sugar and salt. A major thrust of out work is to design foods which deliver 'unhealthy' functionality, whilst being significantly healthier than current convenience foods.

Current efforts are focussed on understanding and manipulating the food microstructure to engineer products to deliver all the desired consumer attributes but with controlled energy and salt delivery so as to give a dramatic reduction in the amounts of fat, sugar and salt consumed in the diet. In order to do this we are developing an engineering understanding of eating and digestion and how the design of foods can be used to get specific performance in the human process including consumer psychology and sensory attributes.



2 Product structure and function

Many foods are structured solids, whose microstructure determines their taste and texture. For these products it is critical that manufacture is designed to deliver product attributes. Thus the process design is critical and challenging as companies look for more energy efficient, new product attributes and the use of more natural and environmentally friendly ingredients eg, fats from sustainable sources rather than leading to the destruction of the rainforest. A major component of many fabricated foods is an emulsion phase.

The University group is unique in that it investigates the process engineering aspects of emulsions, how they are formed, how materials get to interfaces and how emulsions breakdown and release bio actives when consumed. We are also working on the design of foods such as chocolate in which the solidification of the material is critical.

3 Food safety and hygiene

Our aim is to develop fundamental understanding both of how to ensure safety through process design and equipment cleanliness. This will involve the development of computational models to predict thermal and flow fields in processes, the formation and removal of fouling deposits and their combination with models for microbial behaviour, as well as the use of process probes such as Positron Emission Particle Tracking and Time Temperature Indicators in validation.