06
Annual Review
and IRC DIRECTORY

polymer IRC

bringing UK polymer researchers together

Polymer IRC Universities
Leeds/Bradford/Durham/Sheffield
www.polymerirc.org

Contents

Director's Report 2005/06

Is it a triangle? Is it a square? Is it a micelle? Is it a piece of the jigsaw? Is it a tree? It's the POLYMER IRC! I've been reflecting on this series of visual metaphors (all true!) used by IRC directors and others over the last 16 years, and have been amused at their variety. They also tell a fascinating story of change and about what we want to be for the polymer and soft materials community in the UK and more widely.

Whatever we are, however we are symbolised, and whatever we are doing, something is going right – over the last 2 years the "IRC Club" has doubled in size: an unprecedented growth, exceeded only by the increase in the number of people participating in IRC workshops, meetings, training courses and other events. The current model of the IRC seems to be meeting the need: no longer a limited research-council funded group of academics with industrial links, rather a network of equally-represented (and equally subscribing!) industrial and academic partners constantly talking, sharing the science and technology and looking for connections. The final element in the move to an equally co-owned network organisation for the IRC was the inauguration of the new board in April. If you are thinking that a diagram might help at this point, then have a look at page 6.

So if the IRC is a tree-like network rooted equally in fundamental world-class science and in forward-looking industrial practice, then its "fruit" are the projects that grow from it. There have been plenty of "fruitful" events over the past year. Especially exciting are the projects that begin with people across the IRC network talking about a new idea, perhaps at an IRC workshop, identifying the right team and working this up into a successful proposal. Two exciting new DTI technology projects started this way over the year (more on those later), and a new project on self-assembling peptides funded by our sister institution, the Dutch Polymer Institute (DPI).

This brings me to the role that the IRC is playing nationally and internationally! The DTI's Knowledge Transfer Network in Materials now includes the IRC as a partner, and we are exploring ways in which our unique access to science and research teams can help the aims of the KTN. The international dimension begins with the reciprocal strategic link we have with the DPI: mutual representation on steering boards, and mutual participation in projects. Within Europe we are also exploring links with CNRS centres in France. Links with groups in the USA at the project level are now made easier by the ESPRC-NSF joint proposal scheme. Within the IRC, the first project to do this is the large "MuPP" collaboration, funded to link with Virginia Tech, Michigan and Penn State. On the other side of the globe, Phil Coates has spearheaded our links with the State Key Laboratory in Polymer Science, Beijing.

Our main annual event, the UK Polymer Showcase, is becoming a healthily international affair. We will not forget the beautiful lecture from Marcus Antonietti of Potsdam at the 2005 meeting, and look forward to an American accompanying theme within the 2006 Showcase “Materials by Design”, featuring among others Eric Amis (NIST), Tony Cheetham (UCSB) and Terri Jordan (Victrex). The meeting will give us a chance to welcome new Club members Arizona Chemical, Bayer Material Science, BITECIC, Huntsman Polyurethanes and Huntsman Advanced Materials, review the exciting science themes, and take a look at the 2006 strategic topic of “Managing Science and Innovation”. My interest in this has increased with every instance of people questioning the session title with “but you can’t!”.

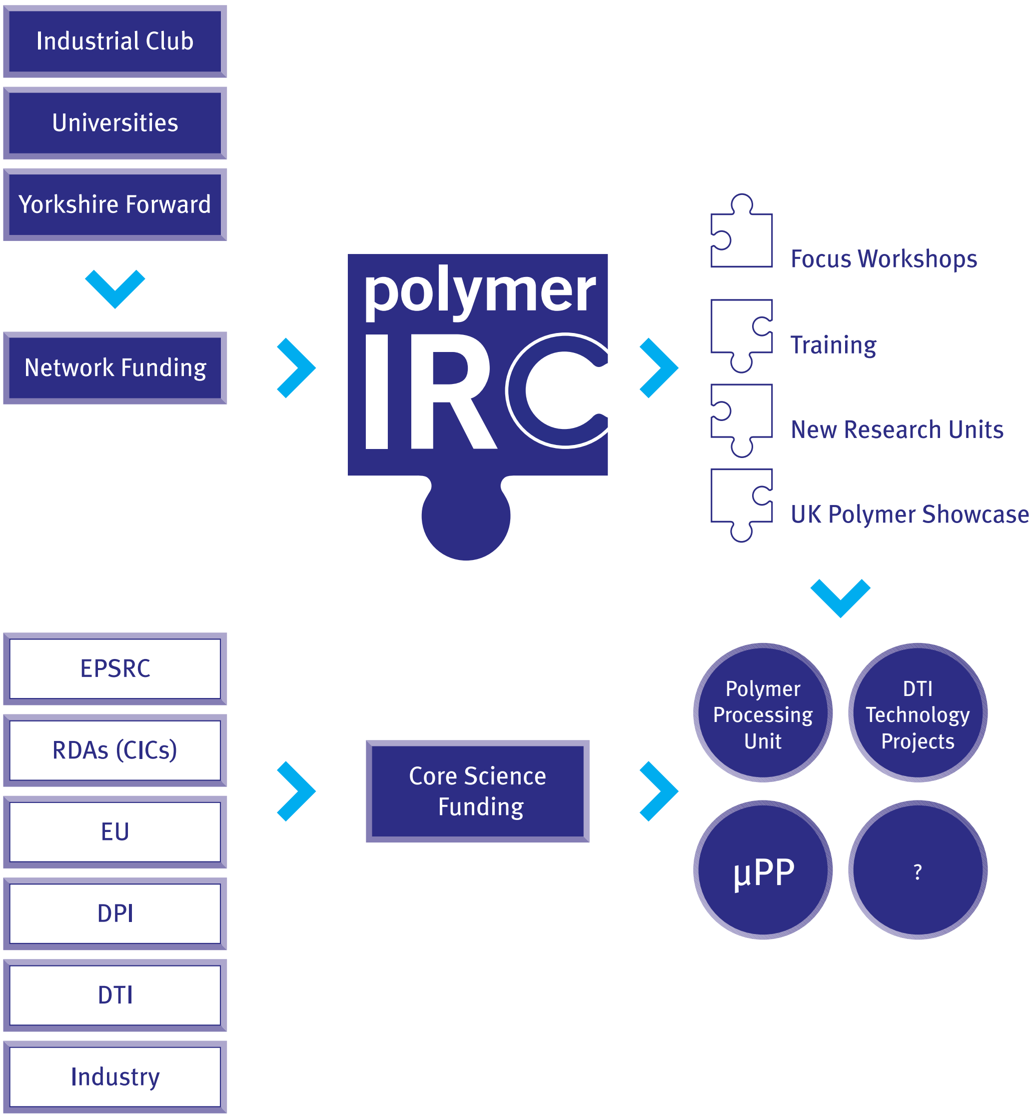
Tom McLeish with colleague John Embery
Examining polymer viscoelasticity at the Royal Society’s Summer Exhibition 2006

At its foundation the IRC is of course about people. The most important of those are the research students, new industrial research scientists and technologists and post-doctoral research fellows across the IRC collaborations. They are an extraordinary group of talented and interesting people, as we found out at the new IRC training courses held in November at the Sheffield Polymer Centre and other gatherings. I often have cause to confess my greatest joy in the academic life: seeing a PhD student grow from those hesitant beginnings into a full member of the scientific community, thesis, publications, conference presentations and new challenges in hand. Congratulations to them all! We also celebrate the successes of some of the “more senior” members of the IRC this year. Notably, Tony Ryan was awarded an OBE in the Queen’s New Year’s honours list, Phil Coates was awarded the Plastics Industry Award for Personal Contribution to the Plastics Industry and Richard Jones was elected a Fellow of the Royal Society. Quite a clutch of well-deserved plaudits – we are very proud of them. The IRC also featured at the Royal Society’s Summer Exhibition in the guise of a wonderful display of the μPP project ably organised by a project group from the MuPP team.

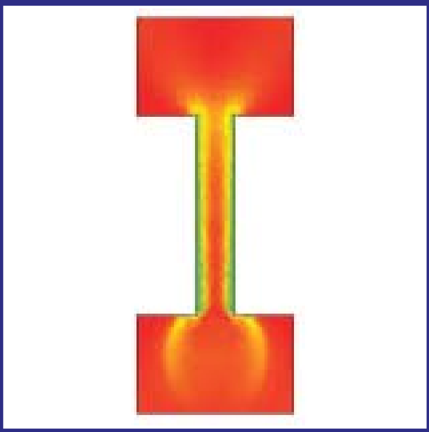
To mirror all the new activity around the IRC network, we have written our annual report, now renamed annual review, in a new format! Enjoy the report – and we’ll meet up during the year at a workshop, training course, spring meeting, showcase – or even better in the lab (or at the blackboard!).

Tom McLeish
July 2006

Structure of IRC Diagram

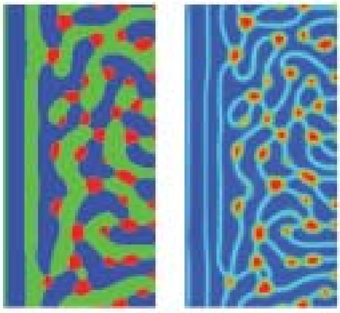


IRC Interactions:
Networking in action



In this section of the report we give you a flavour of the types of activities going on around the network that involve more than one member. In referring to a member of the IRC we include not just the academics at the four university sites, but also our industrial colleagues in the Polymer IRC Club. Confidentiality issues prevent us from giving details of all the industrially linked activities and we are grateful to those companies who have allowed us to profile their work.

The largest current collaboration is the μPP2, involving 6 universities and 7 industrial companies (see page 12), but there are many other instances of partnerships. For example, the University of Bradford has joined with the White Rose Universities to secure £4.7m HEIF3 funding for Healthcare Technologies; groups at Leeds, Bradford are working with Smith & Nephew on bioresorbable materials in a project partially funded by Yorkshire Forward. Club members involved in joint projects with IRC academics include ICI, Cytec, Unilever, Mitsubishi, DSM, Arizona Chemical and Smith & Nephew. New collaborative projects such as the new DTI Technology programmes are getting underway. The following examples give a snap shot of selected multiparty projects that are running around the network.



Morphology Development in Multi-Component Polymer Mixtures

Nigel Clarke & Ian Henderson, Durham University, Cytec Engineered Materials

We have recently concluded a successful collaboration with Cytec Engineered Materials aimed at modelling phase separation in multi-component polymer mixtures. The work we undertook ranged from developing a minimal model for the process of reaction-induced phase separation (RIPS), a self-assembly process widely utilised in a number of technologies, to modelling the impact of surfaces on phase separation, a subject of particular relevance to adhesion science.

In RIPS, one component undergoes in-situ polymerisation, leading to phase separation, driven by the reduction in entropy as molecular weight increases. In many mixtures, morphology development at some stage becomes significantly slowed by simultaneous cross-linking. Consequently, phase separation involves a complex interplay between both thermodynamic and kinetic processes, and the study[1] has incorporated effects such as reaction kinetics, polydispersity and gelation to the extent that has enabled the model to accurately predict useful scenarios.

Many commercial adhesives are toughened multi-phase materials; hence, an understanding of the interplay between the wetting of a surface and phase separation in the bulk is essential if the adhesive properties are to be optimised. We have been developing predictions of the behaviour based on measurable quantities such as surface tensions and solubility of the various components[2].

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1. Henderson, I. C.; Clarke, N. "Journal of Chemical Physics", **2005**, *123*.
2. Henderson, I. C.; Clarke, N. "Macromolecular Theory and Simulations", **2005**, *14*, 435.

Advanced Bioresorbable Polymers for Orthopaedic Tissue Repair

Ian Ward, University of Leeds, Phil Coates, University of Bradford, Smith & Nephew

Bioresorbable polymers are increasingly being used to replace metals in orthopaedic devices where only temporary fixation of tissue is required. Applications include fracture fixation and sports medicine (e.g. ligament repair, meniscal repair etc). Major advantages of bioresorbables over metal implants are that they: are replaced by host tissue; do not require a second surgical procedure to remove them; avoid metal-related complications such as stress shielding and corrosion; allow targeted delivery of bioactives. However, current applications of resorbables are limited by their low load-bearing capacity and concerns over long-term response to the implants.

Building on initial work carried out by Smith & Nephew, a new project funded by Yorkshire Forward and involving collaboration between Smith & Nephew and the Universities of York, Bradford and Leeds has been initiated. This project will exploit developments in chemistry, biomaterials, self-assembly and processing to create advanced bioresorbable polymers for orthopaedic tissue repair and replacement that address the limitations of current materials. The project aims to develop resorbable materials with a range of novel properties including ultra-high strength, osteoconductivity, injectability and bioactivity. Such materials will open up huge opportunities for the wider adoption of bioresorbable devices and the benefits these bring to patients.

Smith & Nephew are co-ordinating the project, and undertaking synthesis and detailed evaluation of materials and products for biomedical applications. The IRC at Bradford and Leeds is playing a major role in the processing and development of structure/property relationships for these new materials for which novel chemistry is being undertaken by York University. The IRC activities are very broad and range from injection moulding, micromoulding, fibre spinning and die drawing to studies of structure and molecular dynamics using X-ray diffraction and solid state NMR. Mike Martyn and Phil Coates are leading the Bradford effort with Mike Ries and Ian Ward at Leeds.

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Properties of Membranes that Comprise Skin

Peter Olmsted, University of Leeds, Chinmay Das, University of Leeds, Unilever, EU Framework VI

Through the EU Framework VI programme “SOFTCOMP”, Leeds is collaborating with Unilever on a simulation/theory project to study the properties of the membranes that comprise skin. These membranes are fundamentally different from those in most other cells, and their properties are fundamental for giving the skin its unique features of elasticity and control of moisture. In the project a post-doctoral research associate will spend half of his time at Unilever and the other half in Leeds. The project is funded by the EU, and follows on from SOFTCOMP collaborations with several project partners (Institute Curie in Paris, University of Twente in the Netherlands, Forschungszentrum Juelich in Germany, CNRS Bordeaux in France).

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Glycopolymers

Neil Cameron Durham IRC and ICI

Glycopolymers are sugar-containing polymers with a non-carbohydrate backbone, and are attracting interest for a variety of applications including targeted drug delivery and as cryoprotectants. Under the Strategic Research Fund initiative, ICI are working with Dr Neil Cameron at Durham to develop novel glycopolymers for a range of applications that are of interest to ICI. The SRF project leader is Dr Andrew Burgess of ICI Strategic Technology Group, and the project involves staff from other ICI businesses including Dr Derek Irvine (Uniqema) and Dr Martin Crossman (National Starch). The work has focussed on using a green chemical, one-pot route to a glucose-functional methacrylate monomer and its subsequent controlled polymerisation by reversible addition fragmentation transfer (RAFT) polymerisation. A range of molecular weights has been produced, and in particular it has been shown that controlled oligomers (average degree of polymerisation 10 or above) can be prepared efficiently.

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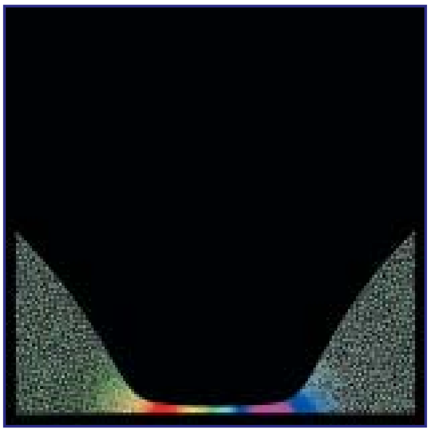
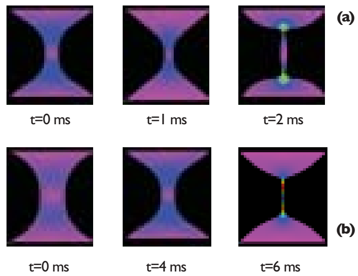
Next-Generation Inkjet Technology

Universities of Leeds, Cambridge, Durham, Manchester, Wales
Oliver Harlen, Tom McLeish, University of Leeds



Polymer IRC groups at the Universities of Leeds and Durham are members of a research consortium together with the universities of Cambridge, Manchester and Wales at Aberystwyth funded by the EPSRC and industry, which is studying generic issues in industrial inkjet printing. Although the principle of inkjet printing dates back to Lord Kelvin in 1867, the higher accuracy and higher speeds required in the new applications of inkjet make demands beyond the current state of the art. In many printing applications the fluids contain significant amounts of polymer and/or particulates and can show strongly non-Newtonian properties at the extremely high shear and extension rates found in inkjet printers.

The project objectives are to improve understanding, characterisation and modelling of inkjet fluid flow and the effects of nozzle design and substrate properties. To date the work at Leeds has concentrated on developing a numerical simulation tool capable of predicting the time dependent free surface flows for viscoelastic fluids in the regime where viscoelastic, inertial and capillary forces are competing with one another. This is being applied to the study of droplet break-up in inkjet printing and the filament stretching experiments developed at the Chemical Engineering department in Cambridge used to characterise the rheology of the inks.
IRC Staff involved: Dr Oliver Harlen, Prof Tom McLeish, Prof Colin Bain.



Simulation of the break-up of a fluid thread, (a) low viscosity Newtonian fluid (b) same fluid wuth addition of 5% polystyrene. Time is measured in milliseconds

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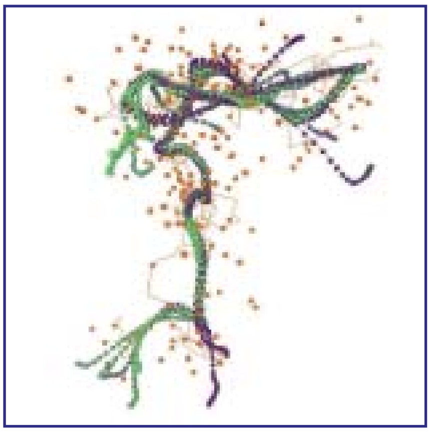


Figure 1
Simulation of an Entangled Polymer

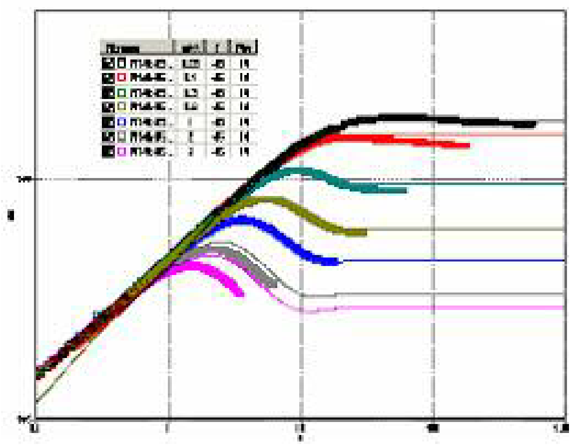
Microscale Polymer Processing (μPP2)

During the last year the IRC's largest single project has accelerated to full speed (it's also the largest single project ever funded by the EPSRC Materials Programme under responsive mode). The project's overall aim is to deliver a set of molecular design tools that will enable a *predictive* approach to polymer processing, linking engineering at the level of polymer architecture to engineering at the level of process flow conditions to optimise the performance of products.

The project team consists of more than 25 post-doctoral fellows and students together with the collaborating team of scientists from six universities (IRC plus Oxbridge this one!) and seven industrial partners.

It starts with detailed molecular theories of polymer dynamics, including now both tube and "sliplink" models (Figure 1).

The next stage is detailed rheological experimentation using highly monodisperse and well-characterised melts synthesised within the collaboration. These are compared in quantitative detail with the calculations from the molecular theories. The chart below shows the most complete set of "shear overshoot" data on shear stress from any monodisperse polymer ever measured! This set is from Dietmar Auhl, Leeds, on a polyisoprene synthesised by Christine Fernyhough and Pierre Chambon, Sheffield. It's displayed using the special μPP2 project software REPTATE by Alexei Likhtman and Jorge Ramirez, Leeds. The tool allows advanced manipulation of rheological data sets and calculation with several of the projects theoretical tools. REPTATE is also able to provide input files for the other central software tool of the project, the viscoelastic flow finite element predictor *flowSolve*.



An example of a stress-field prediction from this programme for a linear polymer melt flowing through a constriction, from Harley Klein, Leeds, (Figure 2).

The year has seen some remarkable discoveries. The modelling kit for polydisperse long chain branched (LCB) polymers is now so faithful to real flows that it is sometimes hard to see which half of the picture is the experiment, David Hassell, Cambridge, and which the simulation, Nat Inkson, Leeds, (Figure 3)!

Flows with rounded corners, and containing the new metallocene families of LCB polymers are being investigated intensively in the project.

Some carefully-chosen experiments are investigated by our unique capability to scan these process flows with a neutron beam, picking up small angle scattering from molecules distorted by their actual process histories, and comparing the measurements with the theoretical predictions. Over the year, some beautiful off-axis and re-entrant corner scattering was completed by Eduardo de Luca and Nigel Clarke, Durham (Figure 4).

As well as the TOOLBOX stream of the project, there are two more specialised streams. One, CRYSTAL, aims do employ the project methodology of using theoretically-based experiments on model polymers to solve some of the many riddles of flow-induced crystallisation. The figure below of SAXS patterns from a polymer crystallising after a strong shear flow, from Ellen Heeley and Tony Ryan, Sheffield, illustrates the strange way in which flow can accelerate crystallisation (Figure 5) but without leaving any orientation in the structure. This appears in the same system but at a lower temperature (Figure 6).

Similarly, the 2-PHASE stream of the project is directed at filled and blended polymer flows. Fibre and particulate filled polymers have been compared with calculations of the rheology, and a systematic study of the role of extension-hardening in the matrix is under way.

The project has had several other successes during the year. The first major paper on flow-modelling of linear polymer melts won the *Journal of Rheology* publication prize for 2004 and 2005. For the avid readers, the reference is:

Collis, M.W.; Lele, A.K.; Mackley, M.R.; Graham, R.S.; Groves, D.J.; Likhtman, A.E.; Nicholson, T.M.; Harlen, O.G.; McLeish, T.C.B.; Hutchings, L.R.; Fernyhough, C.M.; Young, R.N. "Constriction Flows of Monodisperse Linear Entangled Polymers: Multiscale Modelling and Flow Visualisation", Rheol, J., **2005**, *49*, *501-522*.

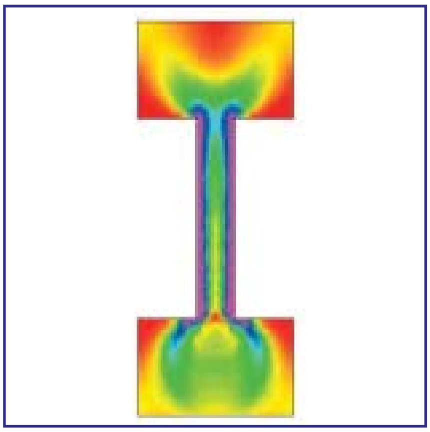


Figure 2
Stress-field prediction for a linear polymer melt flowing through a constriction

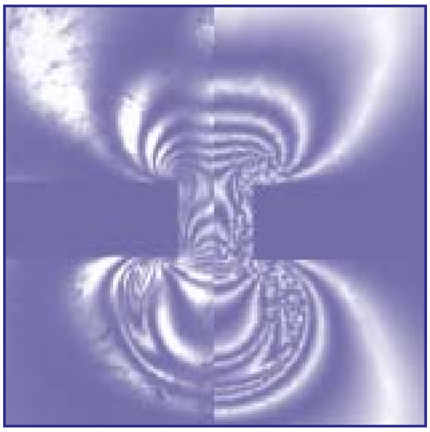


Figure 3
Rounded corner flows containing families of LCB polymers

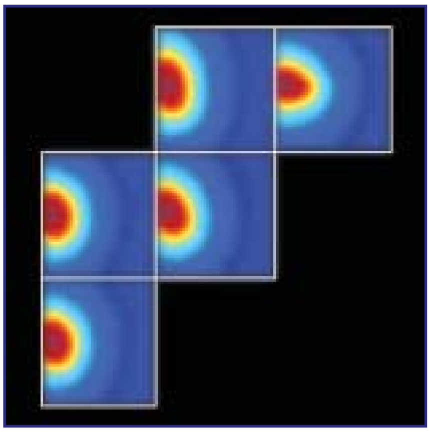


Figure 4
Off-axis and re-entrant corner scattering

We were told that the judges were impressed by the length of the author list! Then this year the project was invited to mount an exhibition at the Royal Society's summer exhibition. Ably managed by John Embery, the indefatigable team demonstrated slime, stress birefringence and neutron scattering from flowing polymer (simulated!) to thousands of school children during the days and hundreds of evening-dressed dignitaries by night.

Watch this space for more results.

http://www.irc.leeds.ac.uk/mupp2

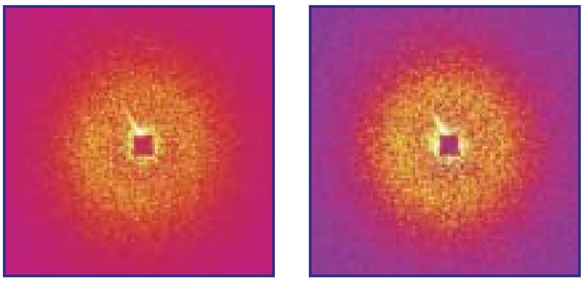


Figure 5

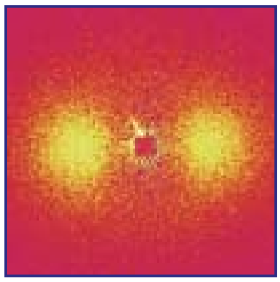


Figure 6

Centres and Spin Outs

The academic members of the IRC use a variety of mechanisms to make expertise, facilities and knowledge available to the wider community. These can lead to new patents, as at Bradford with a recently completed project FujiSeal into reactive processing for shrink films, spin-outs or collaborative projects. Many of these projects are channelled through specialist centres created to focus on niche research areas or to assist industry in finding points of contact for access to university skills. The following examples give a snap shot of knowledge transfer activities across the network.

Sheffield Polymer Centre

Malcolm Butler

The Polymer Centre was established at Sheffield in 2000, joining the Polymer IRC network in 2003. Since March 2003 it has had a dedicated team working on 'innovation and enterprise' to expand the interaction of this world class research base with industry and to exploit opportunities to commercialise the research. The Polymer Centre offers a wide range of options for a company to interact with this expertise base from a few days consultancy to a three year PhD study.

The Polymer Centre team at Sheffield have been kept busy in the last year with a continuing high level of interest from industrial contacts with projects often undertaken in collaboration with FaraPack Polymers Ltd.

Over a 12 month period to March 2006 the Polymer Centre:

- Over 300 specific enquiries have been generated from companies and organisations seeking research and development collaboration.
- The database of contacts has been expanded to over 1400 individuals.
- Consultancy and testing work has generated revenue of £52k.
- Notable major project successes are: a Collaborative DTI Project (PostDoc), Corus/YFIRD project (PostDoc), Amcor Flexibles (PostDoc), Sun Chemical (PhD CASE award) and Walker Bros (MSc Project).
- One new spin out company (Wild Fire Snowsports Ltd, outlined below, with Dr P Styring) that started as a "demonstrator project".
- Around 20 further technologies are being worked up into business plans ranging from water purification to novel particulate emulsifiers.

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Centres for Industrial Collaboration

The development of direct access facilities for industry has been assisted at Leeds and Bradford by the continued investment by Yorkshire Forward into Centres for Industrial Collaboration (CICs).

The **Polymer CIC** at Bradford is one of the UK's largest centres for research into advanced polymer processing, addressing needs in processing, applications, product supply chain and raw materials. The Polymer CIC provides bespoke R&D solutions; collaborative R&D; design analysis; consultancy; computer modeling; materials characterization and PolyLAB, a unique troubleshooting facility for short-term problems. The CIC serves companies in advanced engineering and materials; chemicals; aerospace; automotive; medical and healthcare; electronics; communication and defence

www.polycic.com

A **CIC Digital Print** has been established in Colour and Polymer Chemistry at Leeds, headed by Dr Long Lin, to help related businesses improve profitability and enhance performance. The centre will use training, seminars and consultancy to transfer knowledge to the sector, solving technical and development queries, identifying efficient printing processes, refining systems and troubleshooting problems that arise during print. The CIC aims to use a collaborative approach to developing the most efficient and cost effective print solutions to save both time and money

www.cic-digitalprinting.com

FaraPack Polymers – Planning for Growth

Dr Malcolm Butler

FaraPack Polymers Ltd undertakes short to medium term proof-of-concept and trouble-shooting work in the area of polymeric materials supported by the expertise and facilities of the Polymer IRC. FaraPack Polymers' services include:

- feasibility studies
- polymer testing and analysis
- literature searches
- technical problem-solving
- speciality polymer synthesis
- design of new materials
- evaluation and development of new materials
- formulation
- process optimisation

The company celebrated its second birthday in July and the festivities are in full swing after another successful year. At the close of the second year of trading FaraPack Polymers Ltd has reported a profit. This coupled with the addition of such companies as RPC Containers, Arizona Chemical, Rosehill Polymers, Uponor, ITM Power and Huntleigh Healthcare to the list of customers in the past year has placed the company in an excellent position for their third year of trading.

The model for FaraPack Polymers was to be able to fill the gap that often exists for Universities where they can do very short jobs (typically a few days) and longer projects (greater than a year) but struggle to resource projects spanning a few weeks to a few months. Having firmly established that there is a market for this service, FaraPack is looking to publicise its capabilities to a wider audience and grow the company over the next twelve months.

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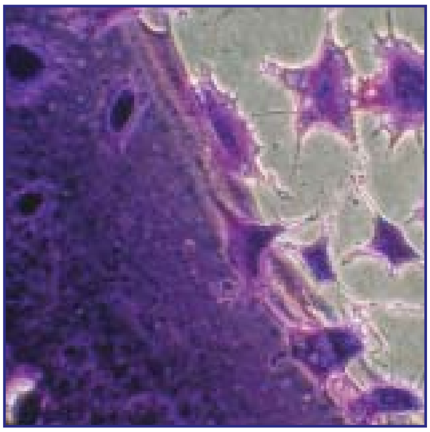
Centre for Self-Organising Molecular Systems (SOMS)

Robert Kelsall, Director, SOMS Centre

The SOMS Centre at Leeds has a 13 year history of research in molecular self-organisation and self-assembly. The activity includes the 3 well-established themes of self-assembling peptides, supported and suspended lipid membranes, and discotic liquid crystals. SOMS strategy is to enhance all three areas by scaling up both the scope of the research and, where possible, the volume or throughput for materials processing or analysis. In addition, the Centre is developing 4 new, interrelated research themes, which will, themselves, provide a strong emphasis on scale-up and applications. All 7 themes are summarised below:



SELF-ASSEMBLING PEPTIDES

Self-Assembling peptides have been shown to form a variety of structures including fibres, fibrils, tapes and gels. Synthesis of artificial peptides is now under development, to act as building blocks for the self-assembly of new nanostructures. Scale-up of production volume is being pursued via non-food crops. Applications in templating, porous nanostructures, coatings, scaffolds, biomineralisation and antimicrobials are under investigation.

SUPPORTED & SUSPENDED LIPID MEMBRANES

The underlying motivation for this activity is for biosensor and biochip development. Fundamental research involves improving membrane stability and tethering, and to develop new surface modification routes. Scale-up of the scope of the research will be achieved by systematically populating artificial lipid membrane surfaces with biomembrane proteins, to create a complete range of model membrane systems. Scale-up of volume will involve arraying and delivery techniques and development of high-throughput systems.

DISCOTIC LIQUID CRYSTALS

The SOMS Centre has been a pioneer in discotic liquid crystal research: these materials are now used commercially in flat panel display coatings. The work is now being expanded into related hybrid organic-inorganic structures and interfaces, and photoaddressable/photochromic surfaces.

MOLECULAR SELF-ASSEMBLY

This theme concerns the synthesis of molecular 'building-blocks' which will self-assemble into larger molecular entities such as cages, synthetic zeolites and block co-polymers. Applications will involve nanopatterning by self-assembly, and the role of patterned surfaces in stimulating self-assembly.

DIRECTED ASSEMBLY

The motivation of this theme is to investigate the use of external stimuli to exercise control over self-assembly/self-organisation processes and thereby achieve scale-up by increasing the rate of assembly.

EXCITABLE BIOSYSTEMS ASSEMBLY

The aim of the theme is to investigate assembly on a cellular, rather than a molecular level, and specifically to understand how the principles of molecular self-assembly/organisation translate to the cellular level.

NANOPARTICLE TOXICITY

The SOMS lipid membrane biosensor technology offers considerable potential as a systematic nanotoxicity analysis tool for use alongside conventional toxicology methods.

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New Technology in a Spin

A major accomplishment from the Polymer IRC at Leeds, is the development of Curv®, a self-reinforced polypropylene single composite material produced under licence by Propex fabrics GmbH (www.curvonline.com), arising from work by Ian Ward and Peter Hine. This highly successful material has now been utilized by Samsonite in its range of X'Lite suitcases. It is already used by Nike for a range of soccer shinguards (BPS Contour). Curv® shows that major commercial products can happen from technology that began as University research. Innovations that have been transferred to companies this year, hoping to achieve similar success, include flexible lithium batteries, new skis and environmentally friendly technology for the preparation of a wide variety of light absorbing polymeric materials.

Leeds Lithium Power Ltd

Flexible Batteries with Polymer Gel Electrolytes

Dr Alison Voice and Prof Ian Ward, University of Leeds

leeds lithium power

Following the closure of Leeds Innovations the commercialisation of the Leeds polymer gel technology was in abeyance for two years, but is now moving forward again. A new spin off company, LEEDS LITHIUM POWER LTD has been set up under the auspices of TECHTRAN, with the aim of licensing the patented technology and know how previously assigned to BTG. Proving Trials are now under way with new commercial partners and TECHTRAN is providing the management structure to deal with the licensing and intellectual property issues.

The commercial interactions have already identified targets for future development of the gel electrolyte technology. A new EPSRC project was proposed by Alison Voice and Ian Ward to extend the range of applications as well as produce some exciting new science. This has already resulted in a successful bid to EPSRC to fund a post-doctoral researcher from India, to work at Leeds for a year, developing both the commercial and scientific angles of this project.

A web site www.leedslithiumpower.com is available for interested parties to contact for detailed information.

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Wildfire Snowsports Limited

Dr Peter Styring, Sheffield Polymer Centre

Wildfire Snowsports Limited is involved in the development of new skis and snowboards with improved glide and speed on snow and artificial surfaces. The technology relies on a unique pumping and fluid delivery system that is incorporated into existing skis as a retro fit. The technology is patent pending. Moves are afoot to incorporate the technology into new skis and we are in discussions with a major ski manufacturer to explore these possibilities. The skis have been tested and performance validated over a range of conditions from UK artificial and indoor snow arenas through to real alpine conditions. Peter was recently appointed an EPSRC Senior Media Fellow and will feature Wildfire Snowsports technology in some of his presentations.

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DyeCat

Dyecat Ltd

Preparation of Light Absorbing Polymers.

Prof Chris Rayner, School of Chemistry, Leeds

Dyecat Ltd. is a recently established spin out company from the University of Leeds, founded through the complementary expertise of Dr Patrick McGowan (catalysis), Dr Richard Blackburn (coloration technology), and Prof Chris Rayner (synthetic organic chemistry). The focus of the company is on patented environmentally friendly technology for the preparation of a wide variety of light absorbing polymeric materials (IR, visible, UV). Using a variety of approaches, the technology allows flexibility in polymer composition, polymer molecular weights, polydispersities, and coloration strength, for a range of light absorbing chromophores.

The Dyecat Process offers superior coloration technology, with homogeneous colorant throughout cross section of polymer, and increased wash and light fastness. It also offers a greatly improved polymer preparation method, giving significant cost reductions on comparable conventional approaches, and greatly reduced environmental impact. The technology is particularly applicable to sustainable, biodegradable polymers such as PLA and PHB.

The complementary expertise of the directors also allows the Company to offer a unique range of expertise for related consultancy and contract research projects.

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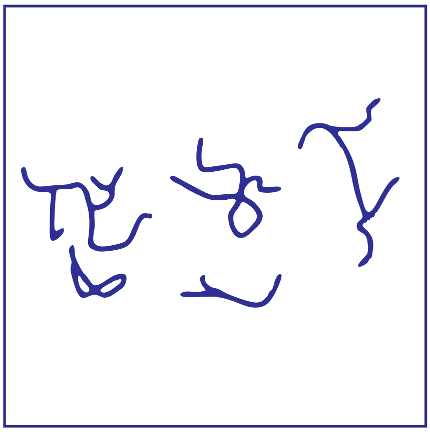
Research Highlights:
The Latest from Around the Network

All through the year we ask academic staff across the Polymer IRC to let us know what has been happening in their area so that we can distribute the news through newsletters, reports and our web site. As an extensive organisation it is impossible to represent all the projects being carried out at any particular time. The topics featured here show the work that the network members themselves consider major achievements in the past year.



Predictive Rheology of Complex Branched Melts

Daniel Read

Dr Chinmay Das, working with Dr Daniel Read, Prof Tom McLeish and Dr Mark Kelmanson has constructed a computer algorithm for calculating the linear rheology of arbitrarily branched entangled polymer liquids. The algorithm requires as input a representative set of branched polymer shapes for the liquid concerned, together with data such as the entanglement molecular weight and entanglement time. It has been successfully used to predict rheological properties of randomly branched polymers in the “metallocene” and “gellation” classes, as well as assymetric stars, combs and H-polymers.

The algorithm is freely available at http://sourceforge.net/projects/bob-rheology

d.j.read@leeds.ac.uk

“Computational Linear Rheology of General Branch-on-Branch Polymers” Das, C.; Inkson, N.J.; Read, D.J.; Kelmanson, M.A.; McLeish, T.C.B., Journal of Rheology, **2006**, *50*, *207-235*.

Substrates for Cell Culture and more…

Steve Rimmer

Stimulus responsive polymers such as poly(N-isopropyl acrylamide) are useful as substrates for cell culture, which can be "switched" between a cell adhesive and cell releasing states. In collaboration with Paul Hatton's and Mark Geohagen's groups at Sheffield we have been developing a new improved class of these materials, which both release the cultured cells faster than conventional systems and allow for diffusion of nutrients and growth factors. We are using the term hydrogel brushes to describe these materials that are composed of a hydrophilic cross-linked phase grafted with PNIPAM. In other work aimed at new scaffolds for skin tissue engineering (in collaboration with Sheila MacNeil) we have further investigated the surprising cell growth promoting abilities of poly(N-vinyl pyrrolidinone) hydrogels. Our results show that these materials do have an overall positive effect on cell proliferation although the mechanisms behind this effect remain elusive. Within the same programme we have also now discovered a new method for preparing amphiphilic porous conetworks that allows us to produce biomaterials that have identical chemical structure but change in the specific chemistry used in the synthesis allow us to produce either cell adhesive or non-adhesive forms. We have also continued to probe the properties of stimulus responsive highly branched polymers and we have reported a unique method for preparing highly branched poly(vinyl acetate), which can subsequently be converted into poly(vinyl alcohol). Another aspect that we think will be useful for the synthesis of functional polymers is our use of ab initio cationic polymerization. Ab initio cationic polymerizations include chain capping agents at the start of the polymerization and produce functional oligomers in non-living conditions. In our recent work we showed that as well as using the alkylation of a siliyl enol ether to cap the growing chain we can also use a difunctional silyl enol ether and simultaneously carry out a Mukiyama Aldol reaction on the second silyl enol ether group.

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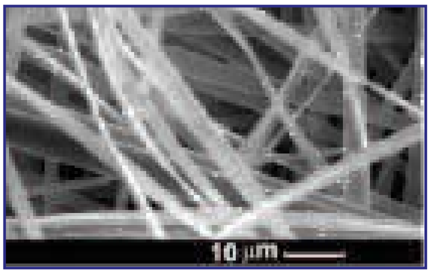

Synthesis and Peptide-Induced Degradation of Biocompatible Fibres

Steve Armes

Normally, vinyl polymers are considered to be non-biogradable, since they contain carbon-carbon bonds in their backbones. In this work we designed peptide-degradable fibres based on vinyl copolymers by taking advantage of the abrupt change in water solubility that occurs on reducing the molecular weight of poly(2-hydroxyethyl methacrylate). First, highly branched, **water-insoluble** poly(2-hydroxyethyl methacrylate) was prepared by copolymerising 2-hydroxyethyl methacrylate with a low level of a disulfide-based dimethacrylate comonomer. This branched copolymer is soluble in methanol and, more importantly, has a sufficiently high molecular weight to allow well-defined fibres to be produced by electro-spinning, which is a convenient and well established processing technique that is undergoing a recent renaissance. Although these copolymer fibres are water-insoluble, they are nevertheless highly swollen when immersed in aqueous solution, which allows rapid ingress of the naturally occurring tripeptide, glutathione. The glutathione rapidly cuts all the disulfide bonds within the fibres even under mild conditions (e.g. neutral pH and 37oC), which causes a catastrophic reduction in the mean molecular weight of the copolymer chains. This leads in turn to **water-soluble** low molecular weight poly(2-hydroxyethyl methacrylate) chains: hence addition of a simple tripeptide causes complete fibre dissolution under physiologically relevant conditions. Since the degradation products are both non-toxic and water-soluble, such fibres may have biomedical applications, e.g. as degradable sutures.

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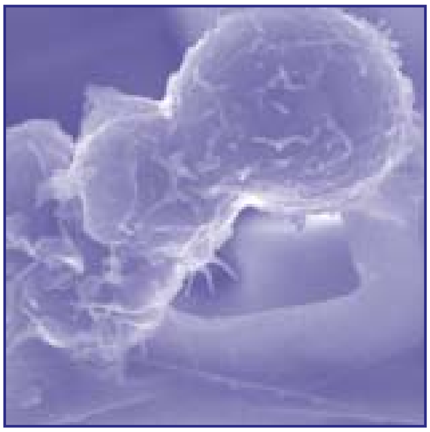
Generic Scaffolds for 3-Dimensional Cell Growth

Neil Cameron

Neil R. Cameron, Dept. of Chemistry, Durham University; Stefan A. Przyborski, School of Biological and Biomedical Sciences, Durham University



High resolution SEM image of hepatocyte growing on 90% porous polystyrene material prepared by emulsion templating

Cell biologists routinely grow cells on 2D substrates, however in vivo cells grow on a 3D protein network known as the extra-cellular matrix. Therefore it is reasonable to assume that cells grown on 3D porous materials will behave differently from those grown on flat surfaces. Initial experiments demonstrated that this is indeed the case[1,2]: neurons cultured on 3D porous polystyrene matrixes prepared by emulsion templating (PolyHIPEs) grew to a more advanced stage of development over 7 days than cells cultured in 2D. With the help of funding from EPSRC, this work has been extended recently to investigate other cell types (including hepatocytes and osteoblasts). It has been found that all cell types investigated grew more rapidly on porous polystyrene materials compared to those grown on tissue culture plastic. Additionally, cell function was enhanced in certain cases, as shown by biochemical assays for particular cellular markers (e.g. albumin secretion for hepatocytes). The work also highlighted interesting differences in cell growth depending on porosity: in all cases, cells grew much better on 90% porous materials compared to those of 95% porosity. The work has resulted in a UK patent application[3] and one scientific paper so far[4], with two further manuscripts currently in preparation.

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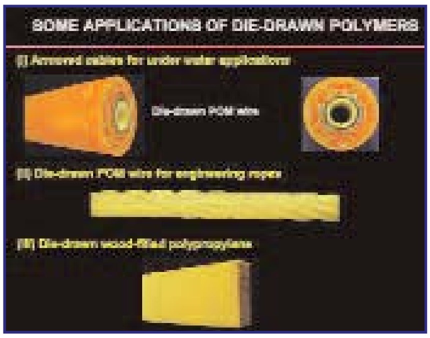

Developments in Die-Drawing

Ian Ward

Leeds die-drawing process is now the focus of several major industrial developments. In collaboration with the Schools of Mechanical Engineering and Physics and Astronomy at Leeds, Bridon and Du Pont have been involved in a major EPSRC project to produce wire ropes from polyoxymethylene (POM).

This collaborative project has shown how a combination of basic physics and careful engineering can lead to a viable production process, and the rates of production have been increased by several orders of magnitude.

Numerical simulations, in conjunction with detailed mechanical measurements, have provided detailed insight into the state of stress, strain rate and temperature in the polymer under different processing conditions, enabling these to be optimised. The final wire rope product is designed for mooring ropes in such applications as North Sea Oil installations where the strength to weight ratio of the rope is a key parameter. Taking the buoyancy effect into consideration, the oriented PoM is nine times better than mild steel under these conditions. Leeds has assisted in setting up a full scale production facility at Bridon's Willington Quay facility and the knowledge gained will also be used in future die drawing projects.

The die drawing research has now been successfully transferred to Bradford University where Ian Ward has been appointed to a Visiting Professorship in the School of Engineering.

On-going international collaborations resulting from the die drawing research include Prof G C G'Sell at Ecole des Mines, Nancy (France), Prof A Galeski at the Polish Academy of Sciences, Lodz (Poland), Dr A Ajji at Industrial Materials Institute, National Research Council, Boucherville, Quebec (Canada). The collaboration with the School of Mechanical Engineering continues.

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Tunable Crystallization Rates

Sharon Cooper

Tunable crystallization rates can be obtained by using emulsions containing polyether and polyol nonionic surfactants. The surfactants provide two key roles. Firstly, they can induce solute crystallization at the oil-water interface and secondly they cause the emulsions to invert from type water-in-oil to oil-in-water on cooling. At the phase inversion temperature (PIT), the emulsions have a low interfacial tension that inhibits solute adsorption, and hence crystallization, whereas at temperatures above or below the PIT, crystallization can occur readily. This allows crystallization to be induced in a system at the PIT either by cooling or heating. Changing the 'passive' oil phase can produce dramatically different crystallization rates, due to the concomitant change in droplet interfacial tension and PIT.

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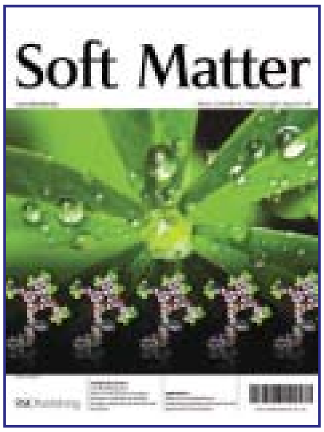
Novel Polymer Additives for Modifying Surfaces and Interfaces

Dr Lian Hutchings

Dr Lian Hutchings, Dr Richard Thompson and Dr Nigel Clarke, all of the Chemistry Dept, Durham University have recently filed two patent claims for novel polymeric materials that may be used as additives to modify the surface of bulk polymers.

The remit for the research, funded by One North East, was to develop new technologies with clear commercial potential. The Durham Team, in reply to this challenge, have developed a generic and versatile strategy to make polymer additives which consist of a linear polymer chain with a well defined multifunctional dendron end group.

The multiple functionalities 'X' provide a strong driving force to cause the additive to adsorb to a particular surface or interface and the pendant polymer chain serves to compatibilise the additive with the bulk sub phase, with the intention of providing a durable surface layer. A further key advantage of this technology is that the additive may be added to a bulk polymer during the processing step, eliminating the need for further potentially expensive post processing modification procedures.



Soft Matter (Vol 2(2), 2006 p 126-128)

HYDROPHOBIC/LOW ENERGY SURFACES

Initial work in which 'X' is a fluoroalkyl group have proved very effective at rendering polymer surfaces hydrophobic. Indeed when the additive is present in only a few weight percent, this additive is capable of generating PTFE like surface properties.

Work is ongoing to optimise both the structure and modifying properties of these additives and to broaden the scope of this technology to allow the generation of hydrophilic surfaces (the early indications are extremely encouraging) and much more.

APPLICATIONS

Applications for this type of surface modifying additive are numerous. Low energy polymer surfaces are particularly appealing in terms of their liquid repellence, chemical inertness and low coefficient of friction. Imparting these attributes to a surface can result in the polymers finding use in applications such as anti-fouling finishes, biomedical devices, release coatings and filter media. Hydrophilic surfaces offer increased wettability with desirable applications including film surface coating, printing, dyeability and for increased biocompatibility.

PUBLICATIONS

The Durham team have been working on this project for a little under two years and because of disclosure issues have only just begun to publish work from this project. The earliest concept proving results, whilst modest, have recently been published as a communication in Soft Matter The team provided artwork for the journal cover. A summary of work was also selected for inclusion in Chemical Science, an RSC research highlights supplement.

THE FUTURE

Early interest from the commercial community has been encouraging. Feasibility studies for a commercial application are underway and discussions with other industrial groups are ongoing. Interest from a consultancy/investment group has been secured and business models are being developed. Further collaborative partners to develop the technology in varying fields of application are sought.

http://www.rsc.org/Publishing/ChemScience/Volume/2006/02/surfacemodification.asp.

Micro and Nano-Technology: Big Molecules for a Small World

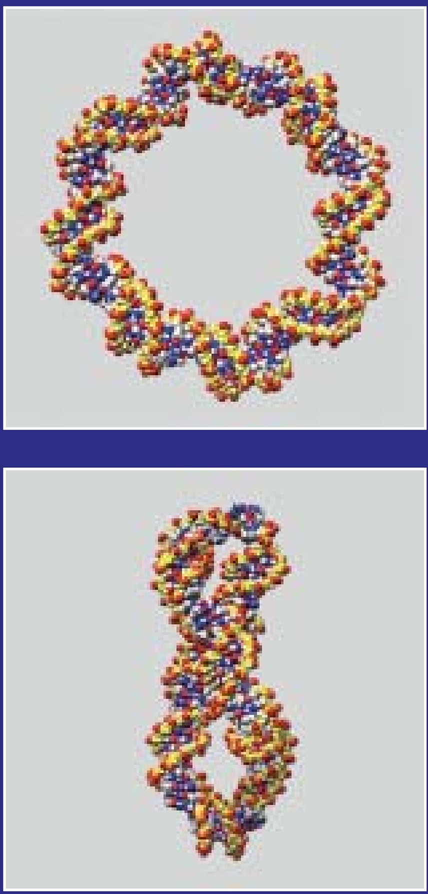


Figure 1

The Polymer IRC is committed to MNT research and the development of regional strategy for the area. Malcolm Butler (Sheffield) leads the IRC's efforts as part of the Yorkshire Forward MNT strategy that aims to "drive the transfer of MNT knowledge and techniques from academia to industry across the whole region, providing new technological processes and products". The project encourages technology push through steering pockets of academic excellence towards the generation of commercially relevant technologies and marketable products. It aims to boost the regional economy and market pull by raising the profile of MNT amongst industry as a new discipline to be exploited and engaging in a series of activities to overcome specific barriers to commercialisation in Yorkshire and Humberside. Events sponsored by the project include the "Bottom up or top down" networking event and sponsorship of the Nanotechnology 4 Chemists course held jointly with the RSC. A further event showcasing delivery technology (whether for drugs, food, or fragrances) is planned for November 2006. For further details on any of these activities contact Dr Butler on m.a.butler@sheffield.ac.uk

At Bradford there is major development in Micromoulding and MNT, with more than £3 million invested in infrastructure, including the new Micro & Nano Moulding Centre, funded by HEFCE SRIF3, and £330K specific High Impact Investment money from the DTI which is in addition to the substantial £790K grant already received from Yorkshire Forward for micro and nano moulding. Bradford now offers world class open-access facilities for those with an interest in MNT. The leading edge work has recently been presented in a keynote lecture by Phil Coates at the PPS international meeting in Japan. Research work continues with EPSRC funding Phil Coates and John Sweeney, as part of a consortium of Queens Belfast, Bradford and Oxford Universities, to look at the finite element analysis over multi length scales in a project studying the modelling of nanocomposites. Phil has also taken a lead roll in the establishment of the DTI **MNT Polymer Manufacturing Group**, whose overall goal is to assist industry in focusing effort in this area.

Work continues into the modelling of nano-structures at Leeds (Sarah Harris) and Durham (Mark Wilson and Nigel Clarke). Sarah Harris at Leeds is Exploring DNA Topology with Computer Simulation. Although DNA is most commonly depicted as a linear molecule, its topology *in vivo* is extremely diverse. Bacterial DNA is circular, but must be highly compacted by twisting into a superhelix before it can be accommodated within the small size of the cell nucleus. Relaxed DNA has a periodicity of around 10.5 base pairs per helical turn. However, if the duplex is either untwisted or overtwisted before the two ends are sealed into a circular structure, then the DNA will *supercoil* to relieve internal torsional stress. We have used massively parallel molecular dynamics simulations to observe supercoiling in DNA circles of

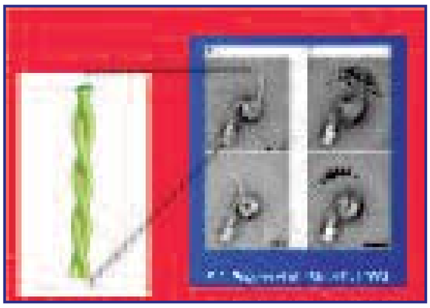


Figure 2

various sizes. Figure 1 shows an example of an initial circular configuration is shown above, and the final supercoiled structure below. These very detailed models are also being systematically coarse-grained to construct the new generation of polymer models of DNA which go beyond the homogeneous elastic rod theories currently employed. This multi-scale approach will enable the results of the simulations to be extrapolated to include whatever longer time or length scale is of interest.

Recent work by Rhoda Hawkins and Tom McLeish has helped explain mysterious results obtained by Leeds biologists Stan Burgess and Peter Knight on the tiny "molecular motor" dynein. By modelling the "arm" of dynein as a twisted pair of elastic rods the physicists showed how the arm could carry signals to bind and unbind from the motors "microtubule tracks" by changing its flexibility (Figure 2).

Efforts continue across the IRC to develop new soft nanotechnology, smart materials and biomimetic materials for drug delivery, substrates for tissue engineering, plastic electronic materials and devices. The Microscale Polymer Processing 2 project (see page 12) continues to thrive and expand; now bringing on board expertise from universities in the U.S.A. An especially welcome development is the addition of the SOMS centre (Self-Organised Molecular Systems) at Leeds University to the IRC network. SOMS already partners with departments in Leeds and Sheffield Universities to deliver the UKs widest portfolio of Masters' courses in nanotechnology, and with IRC physicists in a long-term project on polymeric structures from self-assembled peptides (Dr Amalia Aggeli). SOMS director Dr Rob Kelsall will be reporting on the activities and plans of the centre at the 2006 Showcase meeting.

Finally the IRC is pleased to recommend Prof Richard Jones' own "blog" on the future of nanotechnology (http://www.softmachines.org/wordpress). Richard regularly appears in public debates and committees concerned with regulating nanotechnology.

International Collaborations:
The Global Picture

The Polymer IRC is building on its considerable international reputation to develop collaborative relationships with research groups abroad. Members of the IRC have travelled globally to conferences to speak on leading edge research and to talk to those overseas with related interests about the work and facilities available within the network. Meetings with international audiences have been organised by IRC members throughout the year and include the International Conference on Coatings and the biennial Polymer Processing Engineering meetings at Bradford; the Polymer Networks Group Conference in Sheffield and our own Polymer Showcase Meetings.

Building Links with China and the East…

Phil Coates travelled to China in September 2005 to build links with research groups with polymer related interests. Phil met with Prof Charles Han at the Institute of Chemistry of the Chinese Academy of Science (ICCAS), Beijing. The group's major competences are synthesis & characterisation, environment, and theory and modelling which relate closely to the expertise in the IRC. The laboratories are some of the finest in China with a rapidly growing international reputation. During this visit Phil delivered a well received invited keynote lecture on Micromoulding at the International Polymer Materials Engineering Conference (IPMEC), Shanghai, run by 10 leading universities.

With EPSRC backing, Phil returned to China in July 2006 to visit two State Key labs in China; SKLPME Chengdu and ICCAS Beijing again to meet with Charles Han and Dujin Wang to discuss how links might be fostered, and what schemes might be pursued to encourage exchanges of staff and possible joint research. Contact with the Chinese Universities will be renewed once more in October 2006 when Tom McLeish delivers an invited lecture at the 1st International Congress on Modeling and Simulation in Polymer Engineering and Science in Henan.

Relationships with Japan continue to flourish with Mitsubishi Chemical becoming senior members of the IRC Industrial Club and joining the Microscale Polymer Processing 2 consortium. As part of his summer visit to the east Phil Coates delivered a number of lectures to Mitsubishi staff in Yokkaichi, whilst four scientists from Mitsubishi travelled to the UK to take part in a three-day workshop on the *flowSolve* and REPTATE software being developed by μPP2.

Malcolm Butler travelled to Japan with colleagues from Yorkshire Forward to attend the Nanotech 2006 Conference in Tokyo and visit a number of electronics companies as part of a team representing the Kroto Research Campus. The visit generated a number of enquiries about the work taking place at Sheffield and these are being followed up through the North of England Office in Tokyo.

…and Elsewhere

Under the National Science Foundation USA (NSF) – Europe Materials Collaboration scheme the Leeds/Durham/Imperial College elements of μPP2 have joined with Virginia Polytechnic and State University to successfully request funding for a project that will design the molecular architecture of polymer chains for desired processing performance. The result is that scientist from two U.S. universities (with expertise in non-linear rheology and reaction kinetics) will join forces with seven UK universities and one from Holland to make a truly international attack on the problem.

Work in Europe includes exploratory discussions with Didier Long, who is helping set up a new joint CNRS/Rhodia laboratory in Lyon, devoted to the properties of solid polymers. As part of the efforts of the new lab, Leeds has agreed to a partnership under which a post-doctoral researcher based in the Lyon lab will spend time in Leeds. New projects with the Dutch Polymer Institute will come on-line at Leeds towards the end of 2006. Nigel Clarke at Durham is working with Catedrático de Universidad, Madrid on blends with two-phase morphologies with the ultimate aim of developing nanostructured thermosets by size reduction of the initial morphology with better thermal and mechanical properties and better behaviour under humid conditions.

Phil Coates continued his summer travels by “Flying down to Rio” to present an invited lecture at the IUPAC MACRO 2006 in Rio de Janerio.

For the future, the IRC has put together a “hit list” of world-class international academics who they would like to invite to the UK to share their knowledge with the network. In the next twelve months invitations will be issued and applications made for funding to enable exchanges to be made.

Public Awareness and the Appreciation of Science

Flying the science flags to schools and the public is becoming increasingly popular across the IRC network!

A National Academy for Gifted and Talented Youth (NAGTY) summer school for 135 students is offered at the University of Leeds each year. The scheme aims to ensure that children have access to the learning opportunities they need to turn their potential into high achievement. In 2005, 20 children from around the UK in the age range 13-16 who have been identified as gifted came along to take part in a series of interactive teaching sessions to discover polymer science.

The course aims to intellectually challenge the children and excite them about the latest breakthroughs. Lectures from the Polymer IRC provided 3 days of hands-on interactive challenges, lecture sessions, demonstrations and laboratory based activities introducing the children to a variety of topics including biological polymers, random walks, Brownian motion, viscoelasticity an inevitably, slime. The sessions culminated in a quiz to test the students on all that they had discovered. Summer 2006 will see the process repeated with renewed enthusiasm!

March saw Robots take over the stage at the Crucible theatre in Sheffield for a special one-off public lecture on future nanorobotics hosted by Prof Noel Sharkey and Prof Tony Ryan. The audience was asked to imagine a ‘science fiction’ future in which tiny robots could be put inside people’s bodies to heal them at cellular level, and then shown how fiction could become fact, but with a few unexpected twists. The event inspired great enthusiasm amongst the audience with great interaction and children eager with questions about what they had heard.

The first week of July 2006 saw μPP2 take “Puzzling Plastics” to the Royal Society’s Summer Exhibition. With the help of a model extruder capable of showing how crucial flow data is collected, glow sticks and silly putty the team demonstrated different polymer properties to an enthusiastic audience. Explaining the research that goes into producing simple daily objects, from very small scale molecular physics right up to the large scale of industrial processes to a constantly changing crowd over a week is no mean feat, but the μPP2 team went away satisfied that a good number of the next generation of scientist had glimpsed something of the complexity of making an typical plastic object like a drinks bottle. The team has been asked to take the exhibit on to the National Sixth Form Science Conference at Oundle School in the spring of next year.

This year has seen a number of academics involved in the IRC rewarded for their work. The plastics industry recognized the work of Prof Phil Coates at the Plastics Industry awards held in June 2006. Phil was given the award for “Personal Contribution to the Plastics Industry”. Phil, who is Associate Director of the Polymer IRC at Bradford and Director of the Polymer Centre for Industrial Collaboration, was delighted to receive the award, commenting that it reflected the excellence of the whole Bradford team. Phil specializes in the study of manufacturing processes and their control, developing in-process measurements techniques.

May 2006 saw Prof Richard Jones, Sheffield, elected as a Fellow of the Royal Society. Richard’s work area is the physics of soft matter, particularly the theory and properties of polymer interfaces, and evaluating how properties of polymers change at their surfaces.

Prof Tony Ryan, Sheffield, received an OBE in the 2005/6 New Years Honours list for services to science. Tony’s research interests lie in the structure development during polymer processing. He has applied the understanding he has developed to a number of applications, including nano-scale devices and the development of synthetic skin.

Twelve co-authors from the μPP team have won the *Journal of Rheology* Publication Award for 2006. The paper “Constriction flows of monodisperse linear entangled polymers: Multiscale modeling and flow visualization” *Journal of Rheology* 49 (2), 2005, 501-522. The coauthors are M.W. Collis, A.K. Lele, M.R. Mackley, R.S. Graham, D.J. Groves, A.E Likhtman, T.M. Nicholson, O.G. Harlen, T.C.B. McLeish, L.R. Hutchings, C.M. Fernyhough, and R.N. Young. The paper represents a major triumph in working towards a common goal of predicting polymer flow patterns from knowledge of molecular structure. The *JOR* Publication Award is an annual recognition for an outstanding paper published in the Journal of Rheology in the two proceeding years. Oliver Harlen will travel to the USA in October 2006 to collect the prize.

The Polymer IRC Club:
Linking Industry to Research

2006 has been a bumper year for the development of the Polymer IRC's industrial Club. The strategy of encouraging companies across the sector to become involved through an increasing range of activities and services, and a variable fee structure has led to rapid growth in memberships. In addition to new industrial members of the Club, the four host universities of Leeds, Bradford, Durham and Sheffield have continued their support of the IRC through joining the Club and participating on the same level as the businesses involved:

In the last twelve months Club members have participated in the UK Polymer Showcase, the Spring Club Meeting at Durham University, the Polymer IRC Training Programme and in Core Science Projects. The introduction of a workshop programme where academics and club members can meet to discuss hot topics has proved popular with members. These can take two forms:

- Focus workshops that look at a specific subject that is of particular interest to one of the participants. The workshop provides a forum for discussion of the theme by interested parties seeking common ground for research proposals;
- Scoping workshops are a technology road-mapping exercise, taking a forward look at a general area under discussion, allowing the parties involved to express their aspirations for the future. As the day progresses common themes emerge and focus groups breakout to consider how common themes might be developed to form future projects.

The current Club membership incudes DSM, ICI, Invista Performance Technologies, DuPont Teijin Films, Infinium, Mitsubishi, Unilever Port Sunlight and Unilever Corporate Research, Victrex, Cytec Engineered Materials, Arizona Chemical, Advansa, Bayer Materials Technology, Proctor and Gamble, Bite CIC, Zeeland Chemicals, Universities of Leeds, Bradford, Durham and Sheffield.

Details of membership benefits and rates can be obtained from Helen Clancy.

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IRC Workshops:
Generating New Ideas

Over the last twelve months the Polymer IRC has been building a programme of workshops with the objective of creating opportunities to bring together members of the polymer community from industry and university. The workshops are designed to act as a catalyst to create innovative research and development involving industrial and academic partners. These may be drawn from existing members of the Polymer IRC network or include other parties who are active in the sector under discussion.

Focus workshops build upon the IRC's ability to respond quickly to new challenges, drawing on the wide ranging expertise across the four universities and within the Industrial Club members. Stakeholders meet for one day to take part in a road mapping session that allows participants to outline the developments that they would like to see in a chosen area. By the afternoon those involved will have identified key opportunities and those with related interests break out to discuss how to develop their ideas into an R&D project.

So far, successful workshops have been held in Polymers for Electronic Devices and on Self Assembly in Polymers. The second has led to two new projects within the IRC, one linking to DPI groups in the Netherlands on peptide self-assembly, the other to an exploration of a possible project on molecular process control for photovoltaics.

Future plans include:

- A forward look at science management;
- Energy efficiency;
- Safety and personal security (to include fire);
- Sustainability and bio-degradable polymers;
- Tissue engineering;
- Microfluids.

September 2006 will see a variant on the workshop theme, when members of the Industrial Club turn the tables and advise young researchers on the IRC on the skills they require to interact effectively with industry. In early 2007 a joint workshop with Faraday Packaging members on "Packaging and the Future for polymers in consumer goods", will be presented.

Scoping workshops bring together a cross-section of IRC expertise to discuss an area that a particular company would like help to progress. Again, the wide ranging expertise and technology within the consortium enables the Polymer IRC to respond to industries needs and deliver solutions to the challenges they face.

We are always open to suggestions for new workshops – please send ideas to Helen Clancy.

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The UK Polymer Showcase:

Bringing UK Polymer Scientists and Industry Together

The UK Polymer Showcase was introduced by the Polymer IRC in 2004 to provide a forum where industrialists and academics could mix to discuss the state of the industry and new developments. There are other such events across the UK, the real difference here being that registration for the two-day event is free, lowering the access barrier and giving more people the chance to come along and interact, and the goal to hold current applications and radical new science together in the same forum. The IRC has been able to develop this through the support of its industrial club members who have sponsored the event through their subscriptions, sponsorship by Yorkshire Forward and the support of Faraday Plastics and Faraday Packaging. This year the Showcase welcomes partners from the British Plastics Federation and the DTI's Knowledge Transfer Network (KTN) in Materials.

The 2005 Showcase attracted over 200 delegates split almost equally between businesses and universities with representatives from home and abroad. The meeting included representatives from more than 50 different industrial organisations, large and small who enjoyed presentations blending science and technology management.

In 2006 the theme of combining presentations on new technology in polymers and soft-nanotechnology continues with a strong international flavour. Speakers have been recruited from the University of California, Santa Barbara and the National Institute for Science and Technology in the USA along with a trans-Atlantic double act from Club member's Victrex examining the relationship between marketing and technology.

The Showcase continues its exploration of the relationship between science and arts that began in 2004, with Sebastian Conran's look at designing with plastics. The IRC has invited writer, broadcaster and NESTA Dream Time fellow, Sue Nelson to speak on her creative approach to communicating science.

The IRC and partners have been extremely successful in creating a forum that allows representatives from all sectors of the polymer community to mingle and exchange ideas. We hope that this is a format that can continue to serve the polymer and soft-matter industry, the Materials KTN and the wider community productively for many years to come.

www.polymerirc.org/pages/polymershowcase

Training and Courses for Industry:
Sharing Knowledge

The 5 day **modular programme** of introductory level courses was run for the first time in Autumn 2005 and proved an outstanding hit. The event brought together academics from across the IRC's skills base to present courses to personnel aiming to increase their basic knowledge in different aspects of polymer science and engineering.

Attendance was excellent with 71 delegates attending in total, 30 coming from Industry and 41 students attending from around the four Universities. Each course had between 28 and 33 delegates registered. An optional programme in the following week allowed delegates the option of combining activities such as one-to-one sessions with academics, private study time with tours of equipment and demonstrations. The one-day introduction to polymer rheology day, run during the second week, proved a popular choice.

Building on the success of the 2005 courses, a full two-week programme will be offered this year, beginning on Monday 30th October 2006. These courses are all designed to appeal to those working in a science area wishing to expand their knowledge and horizons. We will be offering:

- 30th October - Basic Polymer Science
- 31st October - Characterisation & Analysis
- 1st November - Polymer Chemistry
- 2nd November - Polymer Engineering (at the University of Bradford)
- 3rd November - Polymer Physics
- 6th November - Multiphase Polymer Materials and Composites (Revised Syllabus)
- 7th November - Polymer Dynamics and Macromolecular Rheology
- 8th November - Polymeric Bio Materials
- 9th November - Introduction to Polymer Nanotechnology

Outlines of the content of the training days offered can be found at:
www.polymercentre.org.uk/courses/shorts.php

All these courses remain available as individual **short courses for industry** and will be offered during the year according to demand. **Tailor made courses** can be created for companies from any area of IRC expertise. Former customers include ICI, Laing O'Rourke, Kuwait Institute for Scientific Research, Unilever and Astra Zeneca. In June 2006 a successful course on Nanotechnology for Chemists was presented in collaboration with the RSC, attracting 15 delegates.

July 2006 saw 30 members of μPP2 come together to take part in a three-day training event to master the *flowSolve* (viscoelastic flowsolving predictor) and REPTATE (molecular rheology) software that has arisen from the project.

MSc Courses

Formal courses leading to masters level qualifications are available in:

- Polymers for Advanced Technologies
- Nanoscale Science and Technology
- Mechanical Engineering for Aerospace Materials
- Nanomaterials for Nanoengineering (new for 2006)
- Polymers and Polymer Composite Science & Engineering
- MSc Route through the Doctoral Training Centre for Bio-Molecules and Cells.

Further information on training is available from Shelagh Cowley.

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IRC Directory 2006

Dr David Adolf	School of Physics & Astronomy UNIVERSITY OF LEEDS	Experimental: Time resolved optical spectroscopy to monitor local polymer dynamics (solution to blended and unblended melt) at pressures up to 3000 atmospheres. Computational: Molecular and brownian dynamics simulations of linear and dendritic polymers from the solution to the melt state. Applications include rheology, gas diffusion in melts, chain folding/unfolding & controlled delivery.	**t.** +44 (0)113 343 3812 **e.** d.b.adolf@leeds.ac.uk
Dr Amalia Aggeli	School of Chemistry UNIVERSITY OF LEEDS	Molecular Self-Assembly. Biopolymers. Biomaterials. Peptides. Fibrils.	**t.** +44 (0)113 343 6407 **e.** a.aggeli@chem.leeds.ac.uk
Prof Steve P Armes	Department of Chemistry UNIVERSITY OF SHEFFIELD	Synthesis of vinyl polymer-silica colloidal nanocomposites, microgels, stimulus-responsive gelators and conducting polymer particles. Synthesis of controlled-structure water-soluble polymers, biocompatible block copolymers, block copolymer micelles, shell cross-linked micelles and latex-based particulate emulsifiers. Synthetic polymer chemistry, with a strong emphasis on colloidal forms of polymers. Development of synthetic methodology in the area of living nradical polymerisation.	**t.** +44 (0)114 222 9342 **e.** s.p.armes@sheffield.ac.uk
Dr William Barford	Department of Physics & Astronomy UNIVERSITY OF SHEFFIELD	Electronic Properties of Conjugated Polymers. Computational methods to elucidate the nature of excited states & the opto-electronic properties of conjugated polymers. Use of density matrix renormalisation group technique to calculate the electronic states. Comparisons between spectroscopic measurements & theoretical calculations to elucidate the nature of the important electronic states.	**t.** +44 (0)114 222 4350 **e.** w.barford@sheffield.ac.uk
Prof David Barton	Mechanical Engineering UNIVERSITY OF LEEDS	High strain properties and applications of polymers and composites. Biomedical applications of polymers. Finite element analysis of solid state deformation. Processing and properties of solid phase polymers.	**t.** +44 (0)113 343 2137 **e.** d.c.barton@leeds.ac.uk

Dr Giuseppe Battaglia	Engineering Materials (Kroto Research Institute) UNIVERSITY OF SHEFFIELD	Self assembled membranes and structures for drug delivery systems and tissue engineering scaffolds. Self organisation of polymer molecules to give useful micro and nano scale structures. Phase behaviour of amphiphilic polymers in self assembled membranes. These membranes are more robust than those formed by biological phospholipids.	**t.** +44 (0)114 222 5962 **e.** g.battaglia@sheffield.ac.uk
Prof Hadj Benkreira	Department of Chemical Engineering UNIVERSITY OF BRADFORD	Rheology of polymers, films and coating flows, polymer processing, especially extrusion processing; biaxially oriented films; novel processes.	**t.** +44 (0)1274 233721 **e.** h.benkeira@bradford.ac.uk
Dr Jess Boot	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Finite element analysis of cold forming of polymers; polymer pipelines, particularly the design of structural and semi-structural pipe linings. Mechanical properties of polymers for civil engineering applications.	**t.** +44 (0)1274 233845 **e.** j.c.boot@bradford.ac.uk
Dr Elaine Brown	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Ultrasound melt flows. Enhanced Polymer Processing.	**t.** +44 (0)114 222 9342 **e.** s.p.armes@sheffield.ac.uk
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Dr. Phil Caton-Rose	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	FEA of solid polymer deformation.	**t.** +44 (0)1274 234551 **e.** p.caton-rose@bradford.ac.uk
Prof Tom Childs	School of Mechanical Engineering UNIVERSITY OF LEEDS	Mechanism of densification (sintering). Heat flow in densifying materials. Selective laser sintering (polymer, metal, ceramics powders). Mechanical and thermal properties of processed materials. Mechanical and thermal modelling and simulation. Experimental and theoretical research into manufacturing processes.	**t.** +44 (0)113 343 2165 **e.** t.h.c.childs@leeds.ac.uk
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Prof Phil Coates	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Polymer Engineering: Combination of real time measurements on polymers in the melt and solid phase during processing operations and computer modelling of processing. Research & application of process monitoring techniques:investigate molecular features, assist process design & material formulations, data for rheological CAD. Techniques used: process rheometry, in-line & on-line measurements, visualiszation, ultrasound, image analysis, UV spectroscopy. Process modelling using finite element analysis in conjunction with process measurement techniques.	**t.** +44 (0)1274 234540 **e.** p.d.coates@bradford.ac.uk
Dr Sharon Cooper	Department of Chemistry UNIVERSITY OF DURHAM	Semi-crystalline polymers, crystallisation mechanisms. Interfacial effects and crystallisation control and their implication for adhesion between semi-crystalline and amorphous polymers. The research uses the combined techniques of x-ray diffraction, FTIR, optical microscopy and computational modelling.	**t.** +44 (0)191 334 4638 **e.** sharon.cooper@durham.ac.uk

Prof Geoff Davies	School of Physics & Astronomy UNIVERSITY OF LEEDS	Solid polymer electrolytes. Electrostrictive polymers. Hyperbranched polymers. Molecular motions in solid polymers.	**t.** +44 (0)113 343 3815 **e.** g.r.davies@leeds.ac.uk
Prof Andrew Day	School of Engineering Design & Technology UNIVERSITY OF BRADFORD	Finite element analysis of elastomers and friction materials, especially in automotive applications. Quality engineering and Automotive engineering. Electrofusion welding of polymers.	**t.** +44 (0)1274 234522 **e.** a.j.day@bradford.ac.uk
Dr Alan Duckett	School of Physics & Astronomy UNIVERSITY OF LEEDS	Short fibre composites: Fibre orientation in model components; study of fibre orientation in injection moulded articles. Phase-separated morphologies: phase separation of block copolymers into hard & soft block morphologies. Molecular orientation during drawing. New matrix polymers.	**t.** +44(0)113 343 3815 **e.** r.a.duckett@leeds.ac.uk
Dr Rob Dwyer-Joyce	Department of Mechanical Engineering UNIVERSITY OF SHEFFIELD	Tribology - Wear, Friction & Lubrication. Monitoring and evaluating tribology (wear, friction and lubrication) between novel and traditional materials used in manufacturing today.	**t.** +44 (0)114 222 7736 **e.** r.dwyerjoyce@sheffield.ac.uk
Prof Howell Edwards	Department of Chemical Technology UNIVERSITY OF BRADFORD	Infra red and raman spectrosopy of polymers and a wide variety of materials. At-process spectroscopy of polymers.	**t.** +44 (0)1274 233787 **e.** h.g.m.edwards@bradford.ac.uk
Dr Rammile Ettelaie	Food Science UNIVERSITY OF LEEDS	Study of steric and electrostatic interactions in food colloids and emulsions. Simulation and modelling of competitive adsorption process in food systems. Mechanical properties and rheology of complex fluids in food. Modelling of disproportionation and stability of bubbles. Transport properties in heterogeneous food systems.	**t.** +44 (0)113 343 2981 **e.** r.ettelaie@food.leeds.ac.uk
Dr Mike Evans	School of Physics & Astronomy UNIVERSITY OF LEEDS	Theory of Complex Fluids: polymer/liquid crystal mixtures, colloids, amphiphiles. Statistical mechanics of driven steady states including continuous shear flow. Effects of molecular polydispersity on phase equilibria, structure & dynamics. Kinetics of phase ordering: nucleation, spinodal decomposition, metastable phases mesoscopic morphology.	**t.** +44 (0)113 343 3807 **e.** phyre@phys-irc.leeds.ac.uk
Dr Patrick Fairclough	Department of Chemistry UNIVERSITY OF SHEFFIELD	Physical Chemistry of Macromolecular Systems. Wide range of techniques and methodologies for the characterisation of macromolecular systems ranging across the entire structure-property scale. Wide range of IR and Raman facilities, often used in conjunction with structural methods. This use of simultaneous techniques is a strong thread running through much of the research. High throughput screening (HTS) based around acoustic wave sensors. HTS systems developed to study gas permeability via mass uptake for gas mixtures, including humidity, in polymers.	**t.** +44 (0)114 222 9411 **e.** p.fairclough@sheffield.ac.uk
Dr Christine M. Fernyhough	Department of Chemistry UNIVERSITY OF SHEFFIELD	Anionic polymerisation of polymers with controlled architectures including combs, stars, and diblock copolymers. Synthesis of near-monodisperse polymers with specific molecular mass and composition for determining structure-property relationships in a range of applications from packaging to biomaterials.	**t.** +44 (0)114 222 9415 **e.** c.m.fernyhough@sheffield.ac.uk

Dr Mark Geoghegan	Department of Physics & Astronomy UNIVERSITY OF SHEFFIELD	Smart (responsive) materials. Structural properties of all-polymer electronic devices. Polymer adhesion. Soft nanotechnology: diffusion of single molecules. Polymers at Surfaces and Interfaces. Diffusion of polymers in heterogeneous media. Polymer gels and networks. Neutron reflectometry, scanning probe microscopies, confocal microscopy, fluorescence correlation spectroscopy, ion beam analysis.	**t.** +44 (0)114 222 3544 **e.** mark.geoghegan@sheffield.ac.uk
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Prof Jim Guthrie	Department of Colour & Polymer Chemistry UNIVERSITY OF LEEDS	Anti-corrosion coatings for metal surfaces-coil coatings, an interactions standpoint. Bi-liquid foam systems as delivery vehicles. Polymers in personal cosmetic systems. Studies of interactions in composite polymer systems, copolymers and blends via solution properties and inverse gas chromatography. Immobilised cells in effluent treatments (coloured effluents-chromophore destruction), transition metal ions-reduction etc). Optimisation of image creation processes in printing packaging and graphics (the role of the polymer). Physical chemistry of formulation, application, wetting, film formation, adhesion and drying/curing in surface coatings systems. Optimisation of the performance of medical diagnostic biosensors systems - the polymeric systems contribution.	**t.** +44 (0)113 343 2934 **e.** j.t.guthrie@leeds.ac.uk
Dr Oliver Harlen	School of Applied Mathematics UNIVERSITY OF LEEDS	Dynamics of polymer melts and solutions. Development of constitutive equations for polymeric fluids. Numerical simulation of processing of viscoelastic materials using finite element methods. Dynamics of short fibres in viscoelastic and Newtonian fluids, including the effect of fibre-fibre contacts. Nematic-isotropic transitions in liquid crystals.	**t.** +44 (0)113 343 5189 **e.** o.g.harlen@leeds.ac.uk
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Dr Peter Hine	School of Physics & Astronomy UNIVERSITY OF LEEDS	The Production & Properties of Novel Polymer/Polymer Composites from Oriented Fibres & Tapes using the Hot Compaction Technique. The use of Filters to Enhance the Properties of Oriented Fibres and Tapes, with particular regard to their use in the Hot Compaction Technique. Design-performance interactions in Short Fibre reinforced Polymers, including understanding of links between Fibre orientation & Mechanical properties using Micro-mechanical Models & the links between processing & properties (MOLDFLOW or other Structure/property relationships in novel polymers including functionalised novel norbornenes synthesised at Durham University.	**t.** +44 (0)113 343 3827 **e.** p.j.hine@leeds.ac.uk
Dr Jamie Hobbs	Department of Chemistry UNIVERSITY OF SHEFFIELD	Non-destructive observations of processes in polymers in real time under a wide variety of environmental conditions. Development and application of scanning probe microscopy (SPM) techniques for the study of polymers. Studies on polymer crystallization.	**t.** +44 (0)114 222 9316 **e.** jamie.hobbs@sheffield.ac.uk
Dr Alma Hodzic	Aerospace Engineering UNIVERSITY OF SHEFFIELD	Development of link between fracture toughness and nano/micro properties of multiphase materials, composites. Development of novel nano-hardness techniques so as to be suitable for measurement of thin coatings and interface/interphase regions in composite and multiphase materials on a nano-level. Development of environmentally friendly materials, (green composites) to replace standard fossil fuel based plastics used in the packaging industry. Design and development of new generation of aerospace composites to resist high shear, compressive and bending stresses in large civil aircraft. Hybrid composites and nanocomposites.	**t.** +44 (0)114 N/A **e.** a.hodzic@sheffield.ac.uk
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Dr Robert Kelsall	School of Electronic & Electrical Engineering UNIVERSITY OF LEEDS	Monte Carlo simulations of electronic transport in semiconductor materials and devices for high-frequency/ ULSI applications. Transport in quantum well structures and ultra-short gate FETs. III-V quantum cascade lasers. Silicon germanium quantum cascade lasers. Electrothermal device simulation. Nanoscale thermal transport. Strained layer structures including pseudomorphic HEMTs, InGaAs/GaAs and Si/SiGe systems. Electronic properties of nanoscale organic structures.	**t.** +44 (0)113 343 2068 **e.** r.w.kelsall@leeds.ac.uk
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Dr David Lidzey	Department of Physics & Astronomy UNIVERSITY OF SHEFFIELD	Conjugated Polymer LED's (light -emitting diodes). Preparation of thin-films in and devices in dust-free conditions to create high quality structures and devices. Fabrication of high efficiency polymer LEDs in an inert atmosphere to prevent oxidation of their low work function metallic cathode. Spectroscopy suite allows measurements of the optical & electronic properties of conjugated polymers and organic thin films to be made. Near field scanning microscope allows material surfaces to be studied at length-scales of <100nm.	**t.** +44 (0)114 222 3501 **e.** d.g.lidzey@sheffield.ac.uk
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Dr Brent Murray	Department of Food Sciences UNIVERSITY OF LEEDS	Gelation of proteins and polysaccharides. Interfacial and bulk rheology of adsorbed biopolymers. Colloidal interaction forces. Emulsions, foams, dispersions.	**t.** +44 (0)113 343 2962 **e.** b.s.murray@food.leeds.ac.uk
Dr Peter Olley	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Computer modelling of polymer melt processing; constitutive equations for viscoelastic fluids; ultrasound studies of polymer melts; large scale computational studies.	**t.** +44 (0)1274 234437 **e.** p.olley@bradford.ac.uk
Dr Peter Olmsted	School of Physics and Astronomy UNIVERSITY OF LEEDS	Biologically motivated physics: Membrane dynamics & phase behaviour; protein dynamics. Flow induced structure and phase transitions in complex fluids; including lamellar phases, wormlike micelles, liquid crystals, polymer solutions. Polymer crystallisation; phase behaviour in polymer solutions, melts & blends. Theory (phase behaviour & dynamics) of complex fluids: polymers, colloidal suspensions, liquid crystals, surfactants & biomaterials.	**t.** +44 (0)113 343 3830 **e.** p.d.olmsted@leeds.ac.uk
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Dr Sebastien Perrier	Department of Colour & Polymer Chemistry UNIVERSITY OF LEEDS	Polymers for functional materials, biology, nanotechnology. Polymer Synthesis: Mechanism; kinetics; process. Living Radical Polymerisation. Green chemistry & polymers. Use of polymeric renewable resources; environmentally friendly polymerisation systems. Synthesis of polymeric architecture and functional polymers: graft, block co-polymers, hyperbranched, composites etc.	**t.** +44 (0)113 343 2932 **e.** s.perrier@leeds.ac.uk
Mr Andy Pryke	Fara Pack Polymers UNIVERSITY OF SHEFFIELD	Polymer Synthesis. New materials. Packaging. Feasibility studies. Polymer testing and analysis. Short-term research and development.	**t.** +44 (0)114 222 09499 **e.** andy.pryke@farapackpolymers.com
Prof Chris Rayner	School of Chemistry UNIVERSITY OF LEEDS	Natural product synthesis. Photochemistry. Continuous reactions. Reactivity of CO2. Supercritical CO2. Stereocontrol (enantioselectivity and diastereoselectivity). Polyamines and their interactions with bio-molecules. Reactive intermediates.	**t.** +44 (0)113 343 6579 **e.** c.m.rayner@leeds.ac.uk

Dr Daniel Read	School of Applied Mathematics UNIVERSITY OF LEEDS	Development of constitutive equations for linear and branched polymers. Relating mechanical properties to microstructure of semicrystalline and phase-separated polymers. Statistics of polymer architectures obtained in industrial reactions. Theoretical polymer physics: calculation of scattering patterns from stretched polymer melts & blends.	**t.** +44 (0)113 343 5124 **e.** d.j.read@leeds.ac.uk
Dr Tim Richardson	Department of Physics & Astronomy UNIVERSITY OF SHEFFIELD	Applied Molecular Engineering. Building organised molecular multilayered architectures using a wide range of materials including monomeric & oligomeric porphyrins, calixarenes, rare earth containing complexes, polyethers & other polymers. Applications include toxic inorganic gas sensing, organic vapour detection, heat sensing, production of thiol-coated gold nanoparticles, ultra-thin film deposition of unmodified polymers.	**t.** +44 (0)114 222 4280 **e.** t.richardson@sheffield.ac.uk
Dr Mike Ries	School of Physics & Astronomy UNIVERSITY OF LEEDS	Rouse & reptation parameters of linear monodisperse polymer melts; Kuhn length, Rouse times & ideal glass transition temperature. Polymer electrolytes; the effect of salt on dynamics & structure of polymer matrix. Structure & dynamics of miscible polymer melt blends; local friction coefficient & entanglement length as a function of composition. NMR experimental & theoretical studies of: Orientation & dynamics in polymer networks, network blends & interpenetrating polymer networks; crosslink densities, screening lengths & correlation times.	**t.** +44 (0)113 343 3859 **e.** phy5mer@phys-irc.leeds.ac.uk
Dr Steve Rimmer	Department of Chemistry UNIVERSITY OF SHEFFIELD	Synthesis of telechelic oligomers using techniques including living radical/ cationic polymerizations and by chain cleavage. Synthesis of new functional block and graft copolymers and highly branched polymers. Smart materials that act as drug delivery agents & protein purification phases, artificial antibodies that recognise analytes in aqueous solution & synthesis of functional polymers for tissue engineering. Much work is aimed at producing improved drug delivery and tissue engineering systems. Current work involves synthesis of polymers that can support catalysts & reagents. Synthesis and properties of functional and reactive polymers. Development of polymers with both chemical & biological functionality. The retention or addition of functionality within polymers forms the basis for many high value added materials; including those proposed in the fields of nano & biotechnonology. Polymer mass spectrometry - MALDI-TOF and electrospray mass spectrometry of polymer and oligomer systems.	**t.** +44 (0)114 222 9565 **e.** s.rimmer@sheffield.ac.uk
Dr Jem Rongong	Department of Mechanical Engineering UNIVERSITY OF SHEFFIELD	The work is heavily applied; materials passing test criteria are subsequently incorporated into engine and other test beds in industry, prior to production. Vibration damping using Polymers. Characterisation of materials in terms of their damping characteristics. Parameters derived are then applied in finite element models to estimate the characteristics of the material in service.	**t.** +44 (0)114 222 7845 **e.** j.a.rongong@sheffield.ac.uk
Dr George Rosala	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Finite element analysis of polymer solids and engineering materials.	**t.** +44 (0)1274 24521 **e.** g.rosala@bradford.ac.uk

Dr Michael Rose	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Instrumentation systems; in-process monitoring of polymer melts; extrusion processing of polymers.	**t.** +44 (0)1274 234537 **e.** r.m.rose@bradford.ac.uk
Prof Tony Ryan	Department of Chemistry UNIVERSITY OF SHEFFIELD	Methods include scattering (x-rays, light, neutrons), x-ray & neutron diffraction, rheology, calorimetry, microscopy & spectroscopy. Following structural changes in real time, as polymers are processed, synthesised, or react to changes in their environment. Polymer, Structures, Properties and Processing. Work involves building processes into analytical techniques or building new techniques to follow development of structure.	**t.** +44 (0)114 222 9409 **e.** Tony.Ryan@sheffield.ac.uk
Dr Ian Scowen	Department of Chemical Technology UNIVERSITY OF BRADFORD	Organo-metallic catalysis.	**t.** +44 (0)1274 233764 **e.** I.scowen@bradford.ac.uk
Prof Robert Short	Department of Engineering Materials UNIVERSITY OF SHEFFIELD	CellTran is a cell therapy business specialising in the treatment of difficult to heal wounds utilising the patients own cells. Plasso Technology uses a proprietary surface modification technique to impart chemical functionality onto surfaces in a controlled fashion.	**t.** +44 (0)114 222 5475 **e.** r.short@sheffield.ac.uk
Prof Costas Soutis	Department of Mechanical Engineering (Aerospace) UNIVERSITY OF SHEFFIELD	Intelligent materials & structures, non-destructive testing & evaluation, modelling & finite element analysis. Advanced Composites Structures. Mechanical properties & characterisation (static & fatigue); Failure analysis & fracture mechanics from micro to macro scale (inc. hydro-thermal effects); structural applications; low velocity impact, jointing & repair.	**t.** +44 (0)114 222 7811 **e.** c.soutis@sheffield.ac.uk
Dr Peter Styring	Department of Chemical & Process Engineering UNIVERSITY OF SHEFFIELD	Polymers & Soft Actuators in Chemical Engineering - Chemical Micro Reactors (CMRs). Design & synthesis of soft acuators for use as micro pumps & valves. Immobilisation of catalysts onto polymers to facilitate heterogeneous catalysits in Chemical Micro Reactors. Fabrication of Chemical Micro Reactors from polymeric materials.	**t.** +44 (0)114 222 7571 **e.** p.styring@sheffield.ac.uk
Dr Linda Swanson	Department of Chemistry UNIVERSITY OF SHEFFIELD	Motion of Polymers in Solid and Solution Phases. Use of labelled polymers to establish links between molecular properties & mechanical & electrical behaviour. Use of phosphorescent labels attached to polymer backbones to monitor the dynamics of individual polymer chains in polymer solids & blends.	**t.** +44 (0)114 222 9564 **e.** l.swanson@sheffield.ac.uk
Dr John Sweeney	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Solid phase deformation processing of polymers; constitutive relationships for solid polymers; finite element analysis of deformation processing.	**t.** +44 (0)1274 235456 **e.** j.sweeney@bradford.ac.uk
Dr Annette Taylor	School of Chemistry UNIVERSITY OF LEEDS	Complex systems. Excitable media. Biomimetics. Chemical and biological kinetics. Nonlinear dynamics. Oscillations, waves and patterns.	**t.** +44 (0)113 343 6529 **e.** a.f.taylor@leeds.ac.uk

Dr Richard Thompson	Department of Chemistry UNIVERSITY OF DURHAM	Ion beam accelerator laboratory. Ion beam analysis, and complementary AFM, ellipsometry, x-ray and neutron techniques applied to study polymer surfaces and interfaces. Development of ion beam analysis methodology, and the use of ion beam analysis to measure diffusion, adsorption, self-organisation and chemical reactions at polymer surfaces and interfaces. Experimental investigations into the influences of polymer thermodynamics, crystallisation and structure on inter-diffusion and surface segregation in blended films and coatings. Industrial and academic collaborations have been established to study multi-layer films and polymer LEDs, as well as solid state chemistry, archaeometry and engineering materials.	**t.** +44 (0)191 334 2051 **e.** r.l.thompson@durham.ac.uk
Dr Harvey Thompson	School of Mechanical Engineering UNIVERSITY OF LEEDS	Experimental flow visualisation. Process flow simulation and optimisation.	**t.** +44 (0)113 343 2136 **e.** h.m.thompson@efm.leeds.ac.uk
Prof Geof Tomlinson	Department of Mechanical Engineering UNIVERSITY OF SHEFFIELD	Vibration Damping using Polymers. Characterisation of materials in terms of their damping characteristics. Parameters derived are then applied in finite element models to estimate the characteristics of the material in service. The work is heavily applied; materials passing test criteria are subsequently incorporated into engine and other test beds in industry, prior to production.	**t.** +44 (0)114 222 7705 **e.** g.tomlinson@sheffield.ac.uk
Dr Lance Twyman	Department of Chemistry UNIVERSITY OF SHEFFIELD	Dendrimers and Hyperbranched Polymers. Dendrimers with hydrophillic surfaces & hydrophobic interiors, allowing water insoluble materials to be carried in aqueous solution for application such as drug delivery.	**t.** +44 (0)114 222 9560 **e.** l.j.twyman@sheffield.ac.uk
Prof Goran Ungar	Department of Engineering Materials UNIVERSITY OF SHEFFIELD	Supramolecular Structures & Polymer Crystallization. Research concerns the way that large molecules & polymers self order into supramolecular structures. By selecting molecular architectures & functionality (e.g. dendrimers) a range of shapes can be formed, including cylinders, spheres, wedges & ribbons.	**t.** +44 (0)114 222 5457 **e.** g.ungar@sheffield.ac.uk
Prof Ric Van Noort	School of Dentistry UNIVERSITY OF SHEFFIELD	Structural Integrity of the Restored Tooth. There is a wide range of material used in restorative dentistry, an extremely active area for new polymeric materials . Work relates to the performance of these new materials, how they fail, and how to produce better materials for dentistry.	**t.** +44 (0)114 271 7932 **e.** r.vannoort@sheffield.ac.uk
Dr Alison Voice	School of Physics & Astronomy UNIVERSITY OF LEEDS	Polyelectrolyte Gels: swelling, contraction, bending in an electric field. IR and Raman spectroscopy/microscopy.	**t.** +44 (0)113 343 6647 **e.** a.m.voice@leeds.ac.uk
Prof Ian Ward	School of Physics & Astronomy UNIVERSITY OF LEEDS	Highly-oriented polymers & studies of their properties & structure. Structural studies of polymer deformation processes; NMR; molecular modelling of orientation; modelling the mechanics of engineering processes; hot compaction. Ionically conducting polymers for rechargeable lithium batteries.	**t.** +44 (0)113 343 3808 **e.** I.m.ward@leeds.ac.uk
Mr Ben Whiteside	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Modelling. Glass filled polymer injection.	**t.** +44 (0)1274 236266 **e.** b.r.whiteside@bradford.ac.uk

Dr Mark Wilson	School of Mechanical Engineering UNIVERSITY OF LEEDS	Industrial coating flows. Thin film flow over topographies. Ink jet printing. Droplet dynamics. Mixing/chaotic advection. Lattice Boltzmann methods. Dynamic wetting. Vehicle ventilation for animal welfare.	**t.** +44 (0)113 343 2177 **e.** m.wilson@leeds.ac.uk
Dr Andrew Wilson	School of Chemistry UNIVERSITY OF LEEDS	Organic synthesis. Supra-molecular chemistry. Molecular recognition. Self-assembly.	**t.** +44 (0)113 343 1409 **e.** a.j.wilson@leeds.ac.uk
Dr Mark Wilson	Department of Chemistry UNIVERSITY OF DURHAM	Simulation of dendrimers. Development of new parallel simulation methods for polymers. Molecular dynamics and Monte Carlo simulation techniques - simulation of functional polymers including amphiphilic polymers at interfaces and liquid crystal polymers.	**t.** +44 (0)191 334 4634 **e.** mark.wilson@durham.ac.uk
Prof Alastair Wood	School of Engineering, Design & Technology UNIVERSITY OF BRADFORD	Numerical techniques for polymer forming. Numerical heat transfer. Phase change. Plastics fusion modelling.	**t.** +44 (0)1274 234281 **e.** a.s.wood@bradford.ac.uk
Prof Peter Wright	Department of Engineering Materials UNIVERSITY OF SHEFFIELD	Synthesis and Application of Electro-active Polymers. Radar active materials & smart microwave materials and structures. Working towards applications including tuneable antennae - without the need to physically change its shape. New battery technologies - next generation mobile power sources.	**t.** +44 (0)114 222 5499 **e.** p.v.wright@sheffield.ac.uk
Dr Ron Young	Department of Chemistry UNIVERSITY OF SHEFFIELD	Controlled Architecture Polymers. Obtaining desirable polymer properties through co-polymerisation of two or more polymer types to give a product with characteristics of both components. Ionic polymerisation techniques give best control over co-polymerisation process & allows mixing & matching of components with very different properties into products. Synthesis of both linear & star or branched copolymers which gives considerable control over molecular architecture.	**t.** +44 (0)114 222 9418 **e.** r.young@sheffield.ac.uk
Dr Xiangbing Zeng	Department of Engineering Materials UNIVERSITY OF SHEFFIELD	Scattering Methods for Nanoscale Structures. Study of 1-d, 2-d, 3-d ordered macromolecular and supra-molecular nano-structures (on the scale 1-100nm). The main methods used are small angle x-ray & neutron scattering (SAXS & SANS).	**t.** +44 (0)114 222 5967 **e.** x.zeng@sheffield.ac.uk