08
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 2007/08

I have the impression of a year shot through with smiles in the Polymer IRC community since the last review. It's all good hard work, and not everything we try works out first time – but it's also fun with a purpose, and there are always new ideas and new people to turn up the corners of our mouths. Before we plunge into the reports, projects, outreach and international stuff in the pages that follow, I'd like first to thank the people whose continuous effort and attention to detail make the wheels of the IRC turn. Helen Clancy and Glenys Bowles in Leeds, Shelagh Cowley, Liam Sutton and Malcolm Butler in Sheffield and the other members of our growing support team work very very hard to create the events, projects and channels of communication that turn ideas into reality. Without them the following pages would contain little more than multiple imprints of Kandinsky's "White on White".

Where did we see the smiles? The year began with our first Showcase meeting in the South – guests of the London College of Fashion. Slowly the looks of bemusement on the faces of scientists listening to fashion designers, and of the designers listening to polymer chemistry and physics, slowly surrendered to expressions of expectation as we realised that after all, everyone was talking about the same "stuff". Again the idea of linking "design" at the macroscopic level to "design" within the molecular world showed how much rich opportunity there is when we cross disciplinary boundaries. I hope as many people as possible saw Helen Storey and Tony Ryan's Disappearing Dresses exhibit. They showed us how many unconventional ways there might be to engage people in science after they have come to believe that there is nothing in it for them. Mindful of our mandate to communicate science, and to assist those who do so, this year's Showcase is to be hosted by the National Science Learning Centre in York. I'm looking forward immensely to welcoming inspiring communicators of science like Quentin Cooper of Radio 4's Material World to help us reflect on how we portray science when "plastics" do not always carry positive connotations!

The Spring Club Meeting was huge fun as well. Everyone enjoyed celebrating Ian Ward's special birthday with an excuse to hear about wonderful science. Rather than listening to others for a whole day more, we gave ourselves some real work to do. Planning projects and workshops in small groups proved very productive. Patrick Fairclough and Richard France both put enormous and expert efforts into translating those ideas into real proposals to the EU. The disappointment that neither was funded at the first attempt is one of those challenges that we will always face – and the way to do it is to brush off the dust and keep going. We owe them both our thanks for getting us to this point with a wonderful project idea on molecular design of phase separated polymeric materials and with an imaginative concept of industrial-academic exchange networks. May I invite any interested reader to contact them as we look at different ways of realising those two hopes?

Of course there are ups as well as downs. Richard France also cajoled us and drafted the “Molecular Engineering” theme bid to the N8 consortium of universities under Tony Ryan’s chairmanship. From a trailing position, the contribution of the IRC together with partners in Newcastle and our partner institutions west of the Pennines created a business case of such weight that it became the only shortlisted theme within N8 to win the £2M initial funding. Another happy success has already resulted from Barry Maunders’ appointment as the IRC Networks Development Director announced last year. The Polymer Innovation Network, a wing of the Materials KTN, has contracted to the IRC its “Foresight” programme of workshops generating new science and technology projects in the sector. As this is one of our core functions and if you will permit me to say so, we also know how to do it, it was a strong case. We welcome heartily Stephen Morris to the Leeds IRC team as manager of the Foresight programme – so be prepared for a doubly rich series of “fun with a purpose” workshop days in the year to come.

The workshop that comes foremost to my mind from the last season is that on “Advanced Polymer Waste Management” held at the National Railway Museum in York. This is not only for the moment when half the participants stood up to gaze at a steam locomotive chugging past the window of our room, but also for the quality of the presentations and the immediacy of the connections that were taking place. At one point a participant bemoaned his inability to find anyone in the country who would accept agricultural plastic waste for recycling – then “We will!”, came a call from the other side of the room! I think that probably justified the day on its own – but two exciting project teams were nucleated during the afternoon: a “Plastics Refinery” and a project for using large amounts of plastic waste in the building industry. Easan Sivaniah and Barry Maunders are chairing the two proposals; you can read more about them later in the review.

Training is increasingly dear to the heart of the IRC, and the annual fortnight of courses for academic and industrial polymer researchers in the autumn, managed by the ever-capable Sheffield IRC team, becomes increasingly popular. This year we will be increasing our European connections by offering a limited number of places at the courses to students from the EU “SoftComp” Network of Excellence, co-ordinated on behalf of the IRC by Peter Olmsted at Leeds. We have also been awarded a “Marie-Curie” Initial Training Network blessed with the acronym (so beloved of the EU) of DYNACOP (sorry - we could not quite squeeze ROBOCOP out of the subject headings). This project takes the results of the MuPP project into new programmes on molecular rheology and processing with our European partners, as well as explicitly linking our training programme right into the research that it is intended to succour.

Beyond Europe, the IRC community continues to partner creatively across the globe. Our "Virtual Processing Institute" funded by EPSRC and run by Prof. Phil Coates in Bradford to foster polymer processing collaborations with China and Japan, has supported several lengthy visits by IRC scientists to top groups in those countries, and is currently supporting a 6-month student residence with the leading polymer dynamics group of Hiroshi Watanabe in Kyoto. The Marie Curie network also gives us salary funds to welcome substantial visits from international leaders already collaborating with members of the IRC such as Watanabe, Paul Callaghan from Wellington, New Zealand and Taihyun Chang from Pohang, Korea, who has developed unique polymer characterisation techniques.

I have counted the five years I have been lucky enough to have the IRC Director's job a very great privilege indeed. Working with people in industry and university of the calibre represented by the IRC team has also been a joy. My successor will be able to take us in more new directions, and I look forward immensely to being able to support him or her from my new role at Durham. But it will continue to be true that the most important people in the IRC community are the readers of this review, anyone who contributes their own skills and experience to a research project, and anyone who comes up with a new idea saying, "why don't we try …"

Tom McLeish
Director
Pro-Vice-Chancellor for Research
University of Durham

Introduction to New Site Directors

Dr Nigel Clarke

Dr Nigel Clarke, Associate Director, Durham

Nigel Clarke joined the Department of Chemistry at Durham University in 2000, after completing his undergraduate and postgraduate degrees in Physics at the University of Sheffield . He gained postdoctoral experience at the Universities of Southampton and Leeds, prior to taking up his first Lectureship at the Materials Science Centre at the former University of Manchester Institute for Science and Technology in 1998. He has been an active member of the Polymer IRC since joining Durham University.

Nigel has a research programme in both theoretical and experimental polymer science, and in particular, the phase behaviour, morphology evolution and properties of multicomponent polymer materials. His work on modelling the consequences of shear flow on phase separation in polymer solutions and blends[1] has shown how blend miscibility can be influenced by flow. He has explored the effects of polydispersity on phase equilibrium in colloidal systems and phase separation dynamics and, in collaboration with Tony Ryan, has shown that models accounting for polydispersity can be used to quantitatively predict vitrification in two-phase curing systems. More recently he has undertaken numerical studies of pattern formation processes, such as phase separation from inhomogeneous mixtures[2] and the properties of disordered networks[3], which despite being formed from small molecules interacting non-covalently, display behaviours analogous to that of polymer gels[4]. His work on structure – property relations in polymeric photovoltaics has resulted in the recent award of a Nanotechnology Grand Challenge grant from the EPSRC, as part of a consortium including the Universities of Sheffield and Manchester and Imperial College. He has also developed the first theoretical framework with which to address simultaneous dewetting and phase separation in thin films, work that is now being developed alongside an experimental program at Sheffield University with Mark Geoghegan.

He has recently, in collaboration with Russell Composto and Karen Winey at the University of Pennsylvania, developed a model that is able to explain experimental results in which anomalous concentration dependence of diffusion within carbon nanotube filled polymers was observed. He is now collaborating with Russell Composto and So-Jung Park, also at the University of Pennsylvania, on the phase behaviour of nanoparticles in multicomponent mixtures[5].

As a member of the microscale polymer processing consortium, Nigel leads the neutron scattering studies probing molecular organisation in complex flows. A recent highlight from this project is the experimental observation, confirming recent developments of the tube model, that macromolecules within polymer melts are able to avoid stress singularities and extreme stretching at re-entrant corners within a contraction-expansion flow.

Alongside Lian Hutchings at Durham, he is currently working with Lucite on the synthesis, rheology and phase behaviour of nanocomposites. Previously he has worked with both Cytec Engineered Materials and Akzo Nobel International Coatings on the phase behaviour and morphology of industrially relevant polymer blends. He has also consulted for ICI and Proctor and Gamble.

Visiting posts include the Universidad Carlos III de Madrid and the University of Pennsylvania. He is currently a Visiting Professor at the CNRS/Rhodia Centre de Recherche et Technologie, Lyon, where he is developing a program, in collaboration with Didier Long, on the behaviour of nanoparticles within multicomponent polymer mixtures. He is a member of the Scientific Advisory Committee for Target Station II, the upgrade to the neutron scattering facility at the Rutherford Appleton Laboratory, leading the proposal for a neutron spin echo instrument, which will hopefully be installed on TS II, the first of its kind in the UK. He was recently elected as a Fellow of the American Physical Society, and is Secretary and Treasurer of the Polymer Physics Group of the Institute of Physics.

Selected recent publications

1. Clarke, N., Effect of shear flow on polymer blends. In Phase Behavior of Polymer Blends, 2005; pp 127-173.
2. Buxton, G. A.; Clarke, N., Creating structures in polymer blends via a dissolution and phase-separation process. Physical Review E 2005, 72, (1), 011807.
3. Buxton, G. A.; Clarke, N., Drug diffusion from polymer core-shell nanoparticles. Soft Matter 2007, 3, (12), 1513-1517.
4. Anderson, K. M.; Day, G. M.; Paterson, M. J.; Byrne, P.; Clarke, N.; Steed, J. W., Structure Calculation of an Elastic Hydrogel from Sonication of Rigid Small Molecule Components. Angewandte Chemie International Edition 2008, 47, (6), 1058-1062.
5. Deshmukh, R. D.; Buxton, G. A.; Clarke, N.; Composto, R. J., Nanoscale block copolymer templates decorated by nanoparticle arrays. Macromolecules 2007, 40, (17), 6316-6324.

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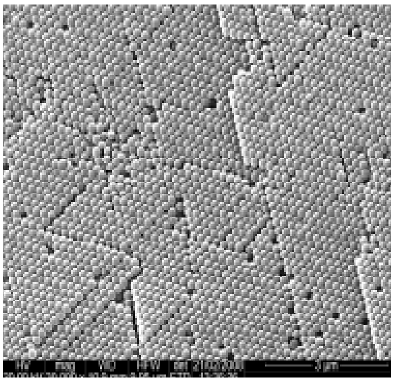
Professor Steve Armes



Cationic PEGMA-PS latex of 250 nm diameter prepared by emulsion polymerisation

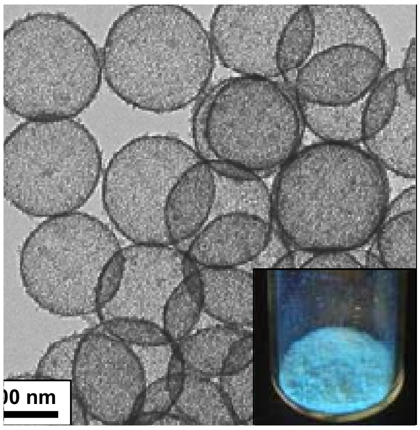
Professor Steve Armes, Associate Director, Sheffield

Prof. Steve Armes took over as Director of the Sheffield Polymer Centre and Associate Director of the IRC in June 2008. He has published more than 310 papers (H index = 54; over 10,000 citations) in polymer/colloid science and is a named inventor on 13 patents. Steve has served on the editorial boards for Macromolecules, J. Colloid Interface Sci., Progress Polym. Sci., Eur. Polym. J., J. Mater. Chem. and Macromolecular Rapid Commun. and has been awarded more than thirty EPSRC and BBSRC research grants. He received the RSC 2007 Macro Group Medal for his contribution to UK polymer science and is currently the recipient of a five-year Royal Society/Wolfson Research Merit Award. Steve has worked on living radical polymerisation for more than a decade. He has exploited this chemistry for the design of stimulus-responsive water-soluble block copolymers, biocompatible gelators, block copolymer vesicles, model branched copolymers etc. His discovery of aqueous ATRP led to the rapid adoption of aqueous formulations for surface ATRP by many research groups worldwide. In addition, his group prepare a wide range of novel polymer colloids, including shell cross-linked micelles, pH-responsive microgels, vinyl polymer-silica colloidal nanocomposite particles, conducting polymer colloids, sterically-stabilised latexes and 'smart' Pickering emulsifiers. Recent industrial sponsors include ICI, AkzoNobel, Unilever, Biocompatibles, Lubrizol, BASF, Syngenta, Rohm & Haas, DeBonding and Cognis Chemicals. He has published joint papers with more than one hundred scientists worldwide including many industrial co-authors.

Steve's current research interests include: colloidal nanocomposite particles, surface polymerisation via ATRP, Janus particles, latex-stabilised foams, stimulus-responsive sterically-stabilised latexes, development of aqueous dispersion polymerisation, design of novel shell cross-linked micelles and block copolymer vesicles, synthesis of branched copolymers via living radical polymerisation, biocompatible block copolymers for biomedical applications, well-defined primary amine-based block copolymers, block copolymer-mediated biomineralisation of calcium carbonate and silica, and the design of model organic projectiles for aerogel capture at hypervelocities.

Recent publications include:

1. Long-range structural order, moiré patterns and iridescence in latex-stabilized foams S. Fujii, A. J. Ryan and S. P. Armes, J. Am. Chem. Soc., 128, 7882-7886 (2006).
2.Cross-linking of cationic block copolymer micelles by silica deposition, J.-J. Yuan, S. P. Armes, O. Mykhaylyk and A. J. Ryan, J. Am. Chem. Soc. 129, 1717-1725 (2007).
3. Continuous structural evolution of calcium carbonate particles: a unifying model of copolymer-mediated crystallization, A. N. Kulak, F. C. Meldrum, R. M. Wilson, P. D. Iddon, Y. T. Li, S. P. Armes, H. Cölfen and O. Paris, J. Am. Chem. Soc., 129, 3729-3736 (2007).
4. Recent advances in shell cross-linked micelles, E. S. Read and S. P. Armes, Chem. Commun., 3021-3035 (2007).
5.How does the nature of the steric stabilizer affect the Pickering emulsifier performance of lightly cross-linked, acid-swellable poly(2-vinylpyridine) latexes? D. Dupin, S. P. Armes, C. Connan, P. Reeve and S. M. Baxter, Langmuir, 23, 6903-6910 (2007).
6. Synthesis of controlled-structure primary amine-based methacrylic polymers by living radical polymerization, L. He, E. S. Read, S. P. Armes and D. J. Adams, Macromolecules, 40, 4429-4438 (2007).
7. Is latex surface charge an important parameter in foam stabilization? S. Kettlewell, A. Schmid, S. Fujii, D. Dupin and S. P. Armes, Langmuir, 23, 11381-11386 (2007).
8. Biomimetic pH-sensitive polymersomes for DNA delivery, H. Lomas, I. Canton, N. Green, S. MacNeil, J. Bury, J. Du, S. P. Armes, A. J. Ryan, A. L. Lewis and G. Battaglia, Adv. Mater., 19, 4238-4243 (2008).
9.Surface ATRP of hydrophilic methacrylic monomers from planar surfaces using polyelectrolytic macro-initiators, S. Edmondson, C. D. Vo, S. P. Armes and G.-F. Unali, Macromolecules, 40, 5271-5278 (2007).
10. A new highly efficient route to polymer-silica colloidal nanocomposite particles, A. Schmid, J. Tonnar and S. P. Armes, Advanced Materials, in the press (2008).



TEM image of hollow silica capsules obtained by calcination. The inset is a digital photograph illustrating the striking blue colour observed for these particles due to light scattering effects.

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IRC Interactions

This section gives you a flavour of the activities taking place around the IRC network that involve more than one IRC member , encompassing academic-academic collaborations and academic-industrial member projects. As ever we are especially grateful to industrial partners who have allowed their projects to be featured.

Featured collaborations include the IRC + project, MuPP2, which is producing some outstanding results as we approach the end of the current phase of the project; updates on our TSB funded programmes and our work with the DTI. We also feature our activities on the VIPps programme, designed to link the IRC more closely with colleagues located in Pacific Rim countries, which have been extensive.

The Polymer IRC: Integrated Knowledge Transfer from a Global Player – Evolving the Network

Barry Maunders, Network Development Director

Dr Barry Maunders

The last year has seen a number of activities aimed at increasing the visibility of the Polymer IRC.

The Polymer IRC, already a member of the Polymer Innovation Network (PIN) Board of the Materials Knowledge Transfer Network, has been contracted to co-ordinate and deliver technology foresight activities for the PIN. Whilst waiting for the formalities of the contract to be finalised the Polymer IRC organised the first workshop, “New Frontiers in Polymer Waste Management”, in York at the end of February. The workshop produced two projects which are being actively progressed for funding with a wide range of partners:

1. The Plastics Refinery;
2. Advanced Construction Composites from Engineered Plastics Recycle.

Each project has led to further networking as the project plans progress; the first with WRAP (Waste Resources & Action Programme) and their work on assessing the feasibility of recycling domestic mixed plastics packaging and the second with BRE (Building Research Establishment) who are managing the Technology Strategy Board’s BeAware project to reduce waste and improve efficiency in the construction industry.

With the contract now finalised Dr Steve Morris has been appointed to manage technology foresight activities. More information on the foresight programme is in our Workshops Section.

Discussions to raise the awareness of the Polymer IRC have been held with the UK Displays & Lighting and Chemistry Innovation Knowledge Transfer Networks. The UK Displays & Lighting KTN has subsequently invited the Polymer IRC to present at the UK-Korea Display Forum at the Korea-UK Science, Technology & Innovation Forum hosted by the UK Trade & Investment group.

IRC delegates attended the Modern Built Environment Knowledge Transfer Network annual meeting and a follow up meeting will be held to discuss areas of common interest with the Polymer IRC.

As well as making contacts with the Technology Strategy Board’s KTNs, ideas have been exchanged with members of the TSB’s Advanced Materials programme, with the IRC gaining an opportunity to input our views into their strategy development. Several of the topics we discussed have emerged in ensuing strategy presentations.

The importance of building on established links with the science-led organisations, particularly the EPSRC, should not be forgotten. Presentations and discussions were held with the Chemistry Programme and with the Materials Programme and Sector Groups. With the subsequent re-organisation of the EPSRC it will be necessary to meet again with the appropriate new groups and people.

Several meetings and discussions have been held with the local Regional Development Agencies. Yorkshire Forward continue with strong support for the Polymer IRC; they are a valued sponsor for the UK Polymer Showcase and are employing a consultant to scope out details for a project to translate knowledge learnt from “MuPP” (Microscale Polymer Processing) to provide useful tools to support the SME converters in the region.

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Track and Trace Profiling for Packaging Applications

Laurence Hogg, Faraday Packaging Partnership and the University of Leeds

Funding: Technology Strategy Board

The project enters its final year well ahead of schedule with the production of a prototype time/temperature label by the end of 2008. The label is aimed at the cold food supply chain and will be applied to the palette or case, enabling the supply chain to monitor product-specific abuse levels of time and temperature. Many foodstuffs from minced meat to bananas are very sensitive to the temperature conditions of the supply chain in which they are transported and most are subject to strict regulations in this regard. The label, which will cost around 40 pence, will display the total time for which it has been active in the form of a clock, and also indicate several levels of temperature abuse which can be selected depending on the product to be monitored. For example the label will be able to show either single or multiple critical abuse levels (over 20C, over 40C etc) and, most importantly, for how long the label experienced that temperature. Once deactivated the label can be stored and integrated into current due diligence processes. Negotiations are currently under way with a well known retailer and it is hoped to complete trials with this new partner well before the end of the project.

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Next-Generation Inkjet Technology

Universities of Leeds, Durham, with Cambridge, Manchester and Wales
Oliver Harlen, Tom McLeish, University of Leeds
Funding: EPSRC and Industrial Consortium

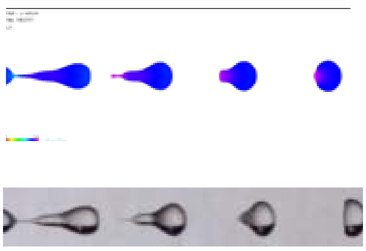

Figure 1: Top: numerical simulation of jet break-up in a forced continuous inkjet. Bottom: experimentally observed break-up shapes (courtesy of Dr J.R. Castrejon-Pita).

The Polymer IRC at the University of Leeds is a member of a research consortium together with the universities of Cambridge, Durham and Manchester 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's objectives are to improve understanding, characterisation and modelling of inkjet fluid flow and the effects of nozzle design and substrate properties. At the Leeds IRC we have developed a numerical simulation of jetting and jet break-up from both drop-on-demand and continuous inkjet. Figure 1 shows a comparison between the simulations and experiments performed at the Inkjet Research Centre at Cambridge University. Note that in this example the asymmetric break-up pattern means that no satellite drops are formed. The form of the break-up is found to depend strongly on both nozzle design and the amplitude of the driving frequency.

Using these simulation results we are able to predict the critical concentration at which a high molecular weight additive prevents or significantly delays jet-break-up. For high molecular weight polymers this concentration is much lower than c* and so cannot be detected from viscometry. However, existing constitutive models are not able to capture the extensional rheology of dilute polymer solutions at very high strain-rates as the molecules are stretched out from their randomly coiled equilibrium conformation. Dr Michael Knott is developing new constitutive models for dilute polymer solutions that take account of intermediate conformation states between coiled and stretched polymers.

Postdocs: Dr Michael Knott, Dr Neil Morrison

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Towards a Natural Nanotechnology for Targeted Delivery in the Foods and Personal Care Sectors

Unilever, ICI, Sheffield, Leeds and Hull

Funding: Technology Strategy Board

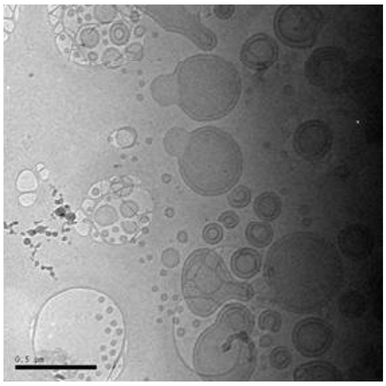

Figure 1. Cryo-TEM image of unusual morphologies obtained in a mixed poly(ethylene oxide)-b-poly(caprolactone) system.

Since 2006, this project has worked towards developing self-assembling polymer vesicles (polymersomes) as a vehicle for the encapsulation of active ingredients, with particular emphasis on peptide-containing block copolymers. Polymeric amphiphiles – block copolymers combining hydrophobic and hydrophilic blocks – have several potential advantages over conventional naturally occurring phospholipids for the creation of vesicles for the encapsulation of systems of small molecules; the control of the molecular weight and the chemical character of the blocks allows the wall thickness and permeability to be systematically varied. A variety of synthetic routes to vesicle forming polymers have been pursued in combination with a theoretical approach using self-consistent field theory (SCFT) to predict vesicle-forming conditions, culminating in the characterisation of the morphologies. (See figure 1 for an unusual example in a system containing a mixture of different poly(ethylene oxide)-b-poly(caprolactone) polymers) and their assessment as effective capsules.

We have evaluated various mechanisms for encapsulation, including solvent switch, rehydration, dehydration/rehydration and reverse phase evaporation, determining their encapsulation efficiency for both hydrophilic and hydrophobic molecules. Unfortunately, results have consistently shown that many of these routes lead to encapsulation efficiencies that are much too low to be of practical value, the reason being that the mechanism of vesicle formation is not the simple wrap-up one operative in lipid vesicle formation. Instead, polymer vesicle-forming pathways proceed by a mechanism that precludes encapsulation; a pathway of spherical and worm-like micelles is followed instead. Whilst SCFT calculations, which have promisingly shown good agreement between calculated and experimental sizes of self-assembled block copolymer micelle structures (see figure 2), may yet shine light on the region where polymersomes can form via the wrap-up mechanism and hence become effective capsules, this region remains elusive.

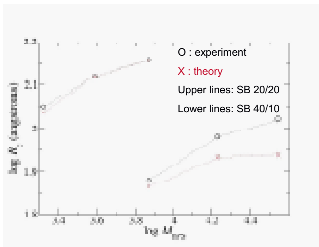

Figure 2. SCFT prediction and measured micelle core radii for different poly(styrene) block lengths in self-assembled poly(styrene)-b-poly(butadiene) systems.

Despite the negative encapsulation application results, the project has led to notable advances in the field of polymersome research, assisted by the applications of new techniques such as real-time cryo-TEM. The mechanistic information thus gained will be hugely valuable in determining which directions future research should (and should not) take, and is practically important for dispelling the view that polymersomes are a versatile and straightforward option for encapsulation. Advances in the development of SCFT modelling using these systems as an example will be far more broadly applicable to a range of solution self-assembled structures, and developments in synthetic protocols pave the way for the synthesis of novel polymers with interest beyond polymersome formation and encapsulation.

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Virtual Institute – Polymer Process Structuring (VIPps)

Phil Coates, University of Bradford; Tom McLeish, University of Leeds

Funding: EPSRC

Prof Phil Coates is made a Visiting Professor of Sichuan University by Senior Vice President Professor Li, May 2008; Academician Prof Xu Xi is on the right of the picture.

This EPSRC-funded (£227k) People Collaboration programme, focuses on polymer engineering and aims to develop co-operations with academics in China, Japan, Taiwan and Korea. Led by Phil Coates, in conjunction with Tom McLeish, it has provided an excellent platform of cooperative meetings to date. These started with Phil Coates' strategy plus technical meetings with Chinese academics in Shanghai in July 2007, in association with the Polymer Processing Society conference which allowed a survey of leading polymer engineering-related groups in China to be conducted, followed by meetings in Chengdu (State Key Laboratory for Polymer Materials Engineering, SKLPME), Beijing (Institute of Chemistry, Chinese Academy of Sciences, ICCAS) and Tokyo (associated with the major Japan Society for Polymer Processing meeting) in May 2008. Phil was honoured to be appointed a Visiting Professor of Sichuan University during his visit.

In Salerno, during the PPS-24 international meeting in June 2008, there was an opportunity to meet with colleagues from all of the participating Far East countries, to share information and discuss collaboration in such areas as micromoulding, nanocomposite structuring and processing of modified polymers. This was complemented by Phil Coates' visit to Taiwan (in conjunction with IUPAC Macro2008), including a laboratory visit to the fluid-assisted moulding centre of Prof Liu. On to Beijing, July 2008, to visit four institutions, presenting science and discussing strategy. First, Beijing University of Chemical Technology (BUCT), then ICCAS where Phil was honoured to be made a Molecular Sciences Forum Professor, followed by Sinopec Beijing Research Institute, and finally Tsinghua University.

Prof Wan, Director of ICCAS Beijing, welcomes Prof Coates as Molecular Sciences Forum Professor, July 2008.

In addition, Leeds colleagues have been involved in cooperative visits to Japan - Easan Sivaniah, Frederico Roschzttardtz (on a 6 month placement with Prof H Watanabe, Kyoto University), and China - Peter Olmsted and Xiaosong Wang. A range of other 'one to one' meetings, particularly by Bradford staff, are being planned.

The VIPps UK meeting will be held during the week of 15th September 2008, including participation in the UK Polymer Showcase, with some 30 Chinese academics being brought to the UK under the VIPps programme, from Sichuan University, ICCAS, and Zhejiang University. VIPps technical meetings, with presentations by invited Chinese and IRC academics, together with posters from each participant, are in Bradford on Monday and Friday, and the posters will be at the UK Polymer Showcase, which will also include a lecture from Prof Qi Wang, Director of SKLPME Chengdu on polyolefin developments. This meeting will be mirrored by one in China in Spring 2009. At least two of the Chinese visitors will stay in Bradford for some weeks for cooperative research studies in the laboratory, with a view to building more substantial programmes.

Academic activity in China is developing rapidly, so it is a privilege, timely and strategic to be involved in this cooperative venture. It is also a significant time in relation to the development of R&D in the industry there. In general the polymer industry has a limited experience of R&D, although the trend in Sinopec, to establish a new processing laboratory to complement its excellent characterisation facilities in Beijing, reflects that of Sabic and other major developing polymer manufacturers (against the trend to diminish R&D centres in the West). The Japanese polymer groups in particular are strong, with an established industry base, so the nature of our interaction is different – more ‘one to one’. In all cases, the VIPps programme has received an extremely warm welcome, and has generated many new opportunities to be built upon.

Meeting with Chinese academics from SKLPME and ICCAS at PPS-24, Salerno, June 2008

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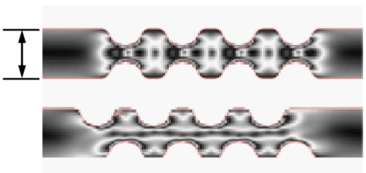

Figure 1: Simulation of the flow birefringence of a linear PS melt flowing through the Bradford wavy wall channel through a 4:1 contraction.

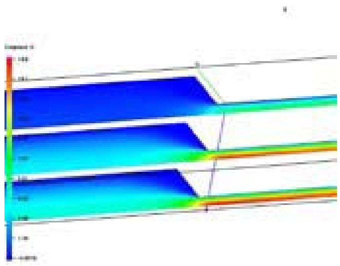

Figure 2: Three dimensional finite element calculations of the flow of an LDPE through a 4:1 contraction.

Microscale Polymer Processing (μPP)

Universities of Leeds, Bradford, Durham, Sheffield, Cambridge, TUE Eindhoven, Oxford, Reading, UCL.
BASF, Dow, DSM, ICI, Ineos,Lucite International, LyondellBasell and Mitsubishi
Funding EPSRC and Industrial Consortium

Toolbox (Macro)

This stream of the project is concerned with developing experimental and numerical tools for studying the flow behaviour of polymer melts with different molecular architectures in complex flow domains. These tools are being used to study single phase polymer melts within the toolbox stream as well as the rheology of multiphase materials and flow induced crystallisation in the two phase and crystal streams respectively.

The Bradford IRC have developed sophisticated optical measurement techniques that provide fully 3 dimensional fluid velocity measurements as well as stress measurements from flow induced birefringence. In addition to contraction flow experiments, new geometries including a wavy wall channel (see figure 1) and co-extrusion flow are being used to study the onset of flow instabilities in collaboration with University College London.

Another advanced experimental technique being pioneered jointly by the Bradford and Durham IRCs is the measurement of small angle neutron scattering of melts under flow. A new recirculating X-slot flow cell has been developed to study scattering by polymer melts at point of high molecular strain.

The Leeds IRC in collaboration with the School of Computing have developed a fully three-dimensional flow solver capable of solving time-dependent viscoelastic flows using molecularly aware constitutive equations from the micro toolbox stream, (see figure 2). These simulations give accurate predictions of the velocities measured in the Bradford flow rig. The 3d solver is now being used in the 2phase stream to provide mesoscale simulations of suspensions of spherical fillers.
The original two dimensional flowsolve continues to be developed and now includes the latest models for binary blends and a new model for predicting the onset of flow induced crystallisation from the crystal stream.

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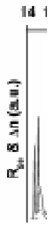
ToolBox (Micro)

The Toolbox Micro stream for the Microscale Polymer Processing 2 (µPP2) project covers a broad range of research, all aimed at the prediction of flow and processing properties of polymeric materials from their microscopic and chemical structure. In the theoretical world, this involves "coarse-graining": building bridges from detailed atomistic simulations of polymer motion, through to simplified constitutive models suitable for use within flow-solving applications in the other µPP2 streams. This is all grounded by detailed experimental investigation.



Separation of a polystyrene comb using TGIC.

Highlights include the atomistic simulation of the linear rheology of a set of entangled linear polymers of varying degrees of polymerisation, by Alexei Likhtman and co-workers[1]. Simulation of the longest polymers took a year of computer time! The results inform the latest tube models. All this is complemented by the most extensive data-set ever measured on the linear and non-linear rheology of linear polymer melts: the polyisoprene molecules were made in Sheffield and their rheology measured in Leeds[2].

A set of polystyrene comb polymers, again made in Sheffield, were analysed by Taihyun Chang (South Korea) using temperature gradient interaction chromatography (TGIC). This revealed the exact distribution of the number of arms on the polymers (see figure) allowing the prediction of their linear rheology using our in-house Branch-on Branch ("BoB") code[3]. A new "Dendrimac" (or Cayley tree) made in Durham is set for a similar analysis, though present rheological investigations suggest it is extremely monodisperse. Finally, efforts are under way to extend the BoB code towards predictions on non-linear rheology of industrial resins, starting from their reaction chemistry. An initial analysis on a set of tubular LDPEs is very encouraging. The chemistry part of this work is being incorporated into a new "React" application within our growing "Reptate" software.

1. Likhtman, AE, Sukumaran, SK, Ramirez, J Linear viscoelasticity from molecular dynamics simulation of entangled polymers Macromolecules 40, 6748 (2007).
2. Auhl, D, Ramirez, J, Likhtman, AE, Chambon, P, Fernyhough, C Linear and nonlinear shear flow behavior of monodisperse polyisoprene melts with a large range of molecular weights J. Rheol. 52, 801 (2008)
3. Chambon, P, Fernyhough, CM, Im, K, Chang, T, Das, C, Embery, J, McLeish, TCB, Read DJ Synthesis, Temperature Gradient Interaction Chromatography, and Rheology of Entangled Styrene Comb Polymers Macromolecules 41, 5869 (2008)

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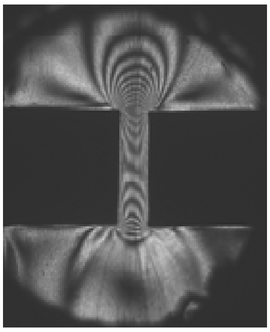
2Phase



Birefringence measured during flow for a crosslinked PS particles/PS matrix in the Cambridge multi-pass rheometer

Research in the 2Phase stream continues to investigate the effect of fillers on the molecular dynamics and processability of polymers. The work on rigid spherical particles (glass or crosslinked polystyrene) in polystyrene is almost complete, with a full characterisation of their rheology and measurements of processability, the latter assessed via die swell measurements at Leeds and the Multi-pass rheometer at Cambridge. The use of matched refractive index polystyrene particles has enabled stress-optical analysis to be carried out on the PS/PS system in the MPR, thereby allowing the first comparison between experiment and simulation (using the in-house developed Lagrangian FE package flowSolve) to be carried out for a filled polymer. FlowSolve has also been used to predict die exit profiles for comparison with online measurements using a newly developed video system.

The important effects of particle shape, distribution and elastic properties continue to be explored using a mesoscopic version of flowSolve, in both 2D (Lagrangian) and 3D forms (fixed grid). Particular interest has centered on the effects of particle stiffness and shape. Rubber particles have been seen to deform and roll (track treading) during deformation and elongated particles (fibres) are aligned during deformation. Experimental systems, incorporating soft particles, are currently being developed to compare with these mesoflowSolve simulations. MesoflowSolve is also providing insight into the structuring of particles (chaining) seen in processing this material using the microinjection moulding facilities at Bradford.

The Sheffield group, who have recently joined the 2Phase team, have developed a micellar based system, which allows the incorporation of soft particles, whose shape can be either circular or cylindrical, allowing the effects of both shape and stiffness to be evaluated against the simulations. There are currently three embedded Knowledge Transfer projects with industrial collaborators, on various aspects of the above, running in collaboration with industrial members of the consortium.

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Flow-Induced Polymer Crystallization

The crystal stream of the MUPP project has been studying the origins of oriented growth during flow induced crystallization. The ability to control the morphology of semicrystalline polymers is important for numerous industrial applications and processes, including injection-moulding and film blowing. Scientifically, this problem is old but remains unexplained and at the forefront of scientific interest in polymers. The IRC-led team, including groups from Leeds, Sheffield, Cambridge, and Eindhoven (Netherlands), has made significant advances in the past year, including:

(1) the identification of a robust criterion for the development of oriented growth;

(2) the discovery of an instability similar to turbulence or elastic instability, if melts are subjected to flow long enough for sufficient crystallization to occur;

(3) the development of a kinetic Monte Carlo scheme for calculating the effect of flow on nucleation of polymer crystals, based on detailed knowledge of molecular orientation and stretch in flow;

(4) visualization of crystallization in complex flow geometries, together with qualitative calculations based on the "critical work" criterion for oriented growth;

(5) development of a new optical in situ method for characterizing morphology development in flow.

PD Olmsted, P Chokshi, J Embery (Leeds); O Mykhyahlyk, AJ Ryan, P Fairclough (Sheffield); RS Graham (Nottingham); G Peters, R Steenbakkers, L Bolzano (Eindhoven); L Scelsi, M Mackley (Cambridge).

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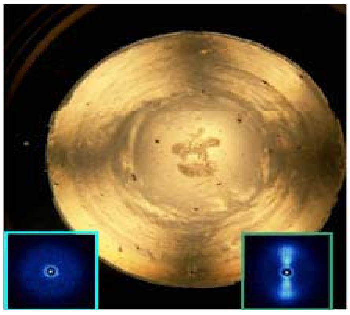


Figure 1 Disc of polymer blend after shearing, showing unoriented (center) and oriented (outside, showing Maltese Cross) regions. The insets show X-ray scattering in the disordered and oriented regimes. This demonstrates how optical measurements can be used to efficiently study the criteria for obtaining oriented morphology upon crystallizing in flow

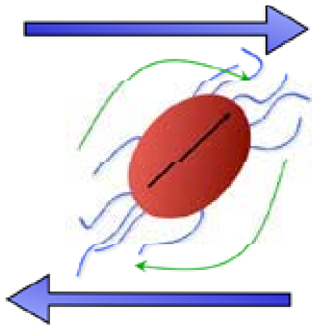
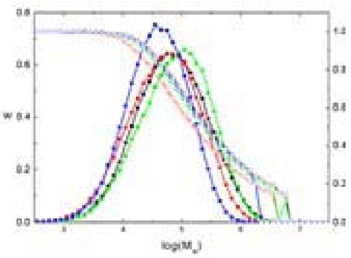


Figure 2 Monte Carlo simulations take into account the stretch in the molecules according to current molecular theory, and account for the orientation of nuclei in shear flow. The subsequent enhancement in nucleation rates is primarily kinetic.

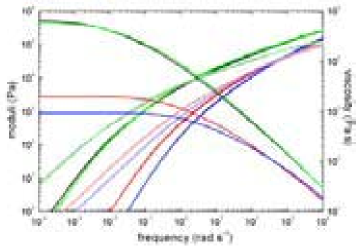
MuPP Knowledge Transfer Update



Shrinkage in sheet extrusion (with Lucite International)

Lucite recently introduced a branched acrylic polymer that had increased chemical resistance over its linear counterpart. However the branched polymer showed excessive shrinkage compared to the linear polymer. In order to balance chemical resistance and processing, the branched and linear polymers were blended in different compositions. From shear and extensional rheology and a finite difference modelling of residual stresses, it was possible to suggest an optimum blend composition.

Reaction kinetics to rheology (Branch on Branch Model, with DOW and LyondellBasell)



Four reaction models with four different reaction parameter sets were used to calculate (a) molecular weight and branching distributions and (b) linear rheology (from the BoB code). Note that green and black runs produce very different distributions yet near-identical linear rheology, while red and black runs, differing in branching but not MWD, show rheological differences of two orders of magnitude.

In recent years the association between molecular structure and linear rheology has been established and well-understood through the tube concept and its extensions for well-characterized materials. However, for industrial branched polymeric material at processing conditions this piece of information is missing. In addition to that, there is no physical model capable of capturing the nonlinear response of LDPE's which is more relevant to polymer processing.

The approach being used combines reaction kinetics models with information from analytical methods (such as chromatography) in order to predict the linear and nonlinear rheology of industrial LDPE's.

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Molecular Engineering and Multi-Scale Modelling of Self-Assembling Peptides

Prof. T.C.B. McLeish, Dr A. Aggeli, Dr S.A. Harris and Dr. Binbin Liu,
University of Leeds PCF Group and SOMS Centre; Wageningen Research Centre, TU Eindhoven
Funding : Dutch Polymer Institute

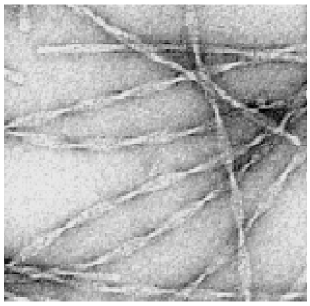

Figure 1

New nanostructured multifunctional materials based on biological-like self-assembly are promising candidates for medical, personal care, nanotechnological and chemical applications eg as scaffolds for regenerative medicine and drug delivery and functional nanocoatings . Proteins have the intrinsic ability for precise self-assembly; However the natural complexity of biological proteins poses hurdles.

Simple, rationally-designed peptides offer attractive model systems and a route to the quantitative and thorough understanding of protein-like self-assembly. The Dutch Polymer Institute, a sister organisation to the Polymer IRC in the Netherlands, has funded a project to achieve exactly that, comprising three highly interconnected elements: i) experimental studies of systematically-varied de novo designed peptides carried out by Dr Shane Scanlon and Phil Davies with Dr. Amalia Aggeli, in Chemistry and the SOMS Centre ; ii) theoretical analysis, carried out by Prof. Tom McLeish, in Physics in collaboration with Dr. Sara Jabbarifarouji and Prof. Paul van der Schoot in the Technical University of Eindhoven; iii) computer molecular modelling to simulate the experimentally-observed behaviour, carried out by Dr Binbin Liu with Dr. Sarah Harris, in Physics. Particular focus of the project is given to well-defined fibrous or porous nano and microstructures. An example is shown in the figures: measured helicity of self-assembled “beta-sheet” tapes within fibrils (figure 1) can be compared with computer simulations (figure 2).

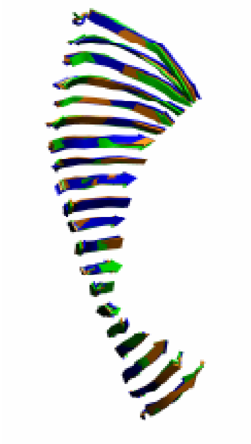

Figure 2

The aim of the modelling work is to design and construct multi-scale atomistic models of amyloid-like peptide aggregates (see figure 3). Molecular dynamics simulations of single (tape) and double (ribbon) -sheets have been run and it has been found that the formation of ribbons from tapes is energetically favourable, but entropically unfavourable.

The project benefits not only from interactions with the industrial members of the DPI, but also from a close connection with another DPI-funded project on mimicking nanostructured natural materials following a modular approach, carried out at the TU Eindhoven and Wageningen Research Center.

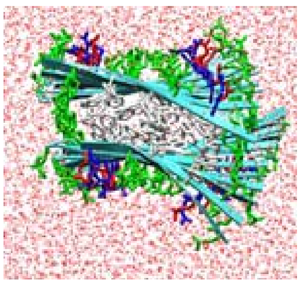

Figure 3

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Yorkshire Forward Micro- and Nano-Technology Project “Overcoming Barriers to Commercialisation”

The aim of this project was the identification of barriers to commercialisation of new Micro- and Nano-technologies (MNT), recommendations as to how to overcome these barriers, and practical promotion and marketing of the region’s capabilities in MNT to industrial companies.

During the course of the project there were two distinct phases of work:

Phase 1: Overcoming barriers to commercialisation (July 2005 to September 2006)

Phase 2: Selecting and Marketing Planning for Key Activities (October 2006 to March 2008)
Key regional MNT activities were identified and specific marketing effort targeted at these to promote any areas that might benefit the region in the short- or long-term. The activities relating to this utilised many approaches (e.g. articles, presentations, brochures, stands at conferences, identifying and discussing with target companies, etc.).

Some of the key achievements from this project were:

- Specific strategic recommendations were made to R&D centres within Yorkshire and Humberside on the best practice.
- Direct discussion with 343 contacts on technology needs,
- A ‘target companies’ list.
- Publicity material. This material and associated presentations were presented at key conferences around the world including NanoForum (UK), NSTI conference 2007 Santa Clara, USA, and NanoTech (Japan) 2006 & 2008.
- 13 events were organised within the region for promotional purposes, and others were advertised or sponsored.
- Funding was raised for a £48,000 ‘NanoFactory Stakeholders Fund, leading to three patents applied for or granted and two spin-out companies which are under discussion.
- £2.9m outline business plan (OBP) was prepared by the MNT Manager and submitted to Yorkshire Forward for ERDF on “Utilising synergies in nanomanufacturing to accelerate innovation“.

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Centres and Spin Outs

The success of polymer science across the network has resulted in a significant number of spin-out companies, centres of excellence and knowledge transfer mechanisms being created. This means there is an extensive range of facilities and services available to both existing and new members of the IRC community.

Working as a network makes members of the IRC aware of the wide-ranging facilities and expertise available. This allows the formation of cross-disciplinary teams that can exploit the comprehensive services to the benefit of their sponsor, whether this is a research council or industrial investor and either for basic science or product development.

The Polymer Centre at The University of Sheffield 2007/08.

The Polymer Centre represents approximately 40 academic members and their research groups active in seven departments across the University of Sheffield. Managed since its inception by Dr Malcolm Butler, the Polymer Centre staff co-ordinate a range of training and technology opportunities for industry and other external partners, with a particular focus on the shorter term interactions key to building the strong relationships necessary for successful, longer term collaboration.

Key developments in 07/08 were the award of £2.3m from The Northern Way, a joint initiative of three Regional Development Agencies in the North of England, to found and manage the N8 Molecular Engineering Translational Research Centre (METRC) and the appointment of Dr Richard France as its Manager. Early 2008 also saw the conclusion of a 3 year, Yorkshire Forward-funded project to address the barriers to commercial exploitation of developments in micro- and nanotechnology.

The Polymer Centre's success is underpinned by a number of distinctive features:

- An extensive contacts database: 2000 contacts, representing some 800 companies, alongside universities and other organisations.
- Customer First accreditation of customer relations management systems.
- Highly knowledgeable technical staff members with the generalist's approach to mapping problems and possible solutions onto the range of expertise at Sheffield, complementing the expert's focused, in-depth approach typical of the academic staff.
- Talented staff dedicated to marketing, event management and training course organisation.
- Project management experience in R&D, testing and analysis and event organisation. The Polymer Centre manages the £3m, multi-university SNOMIPEDE project, for example, as well as one-to-one, Sheffield-to-industry programmes such as Knowledge Transfer Partnerships.
- Familiarity with the array of external funding sources that support knowledge transfer.
- Increasing integration with the Polymer Interdisciplinary Research Centre, a body bringing together polymer expertise at the universities of Leeds, Bradford, Durham and Sheffield.
- A close relationship with FaraPack Polymers Ltd, the spin-out contract R&D company with the ability to carry out short research, testing and analysis jobs drawing on the academic expertise and facilities of the University of Sheffield on a sub-contracted basis.

Significant changes to the structure of the Polymer Centre took effect from 1 September 2008. METRC and the Polymer Centre are to be managed by Dr Richard France and Dr Liam Sutton, respectively, under the direction of Prof Steve Armes. Prof Tony Ryan is to become Pro-Vice-Chancellor for the Faculty of Pure Science at Sheffield, whilst Dr Malcolm Butler becomes Director of Operations for the Faculty of Engineering.

The Polymer Centre continues to provide single-point-of-contact access to all aspects of polymer science and technology at the University of Sheffield, managing relationships and projects with a focus on clients and, hence, commercial expectations. For more information, potential clients are welcome to visit www.polymercentre.org.uk or to email polymers@sheffield.ac.uk.

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FaraPack Polymers: Providing industry with technical expertise and problem solving capabilities in all areas of polymer science.

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 world-class Polymer IRC. It was set up as a joint venture between Polymer Centre and Faraday Packaging partnership (www.faradaypackaging.com).

It specialises in short to medium term-projects of a few days through to several months. It can arrange longer term work through association with the Polymer IRC.

It can meet the polymer research needs of both industry and academia by:

- Utilising FaraPack Polymers' in-house polymer scientists
- Hiring academic and post doctoral research staff from within the Polymer IRC
- Utilising the state of the art facilities available at the four universities

The last year has seen continued growth with two new full-time members of staff added to the team. Chris Saywell (Technical Sales) and Dr Claire Hurley (Polymer Scientist) have joined Dr Andy Pryke (Principal Polymer Scientist), Dr Malcolm Butler (Managing Director) and Dr Liam Sutton (Technical Consultant).

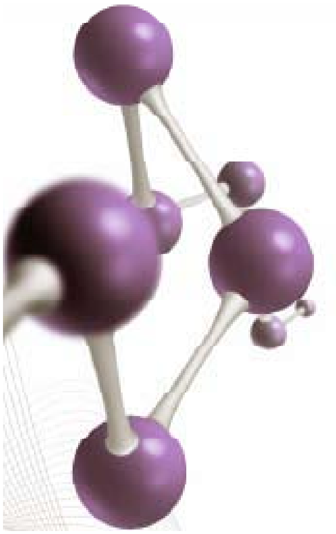
Turnover was again of the order of £200k with a profit being made. During this year we had 46 orders from 30 different companies mostly from the UK and European countries, but also from Canada and the USA.

The focus for 2008/2009 will be in three areas:

Research:	Feasibility studies Technical problem solving (materials, processes & manufacturing) Detailed literature searches Consultancies with academics
Synthesis:	Custom polymer synthesis Functionalisation Reactive groups Fluorescence Proteins Surface Modification Smart Materials i.e. controlled release
Analysis:	Chemical analysis, mechanical testing, thermal testing Degradation testing Surface analysis Quality control tests

Further details are available on the website at: www.farapackpolymers.com

Scale-up facilities: Lara CLR from Radleys



Key to our synthesis will be the recent investment in a larger scale lab reactor (see below)

FaraPack's in house scale-up equipment is available to both industry and academia, facilitating rapid access to process optimisation, intermediate scale syntheses and technology transfer.

The Lara CLR system from Radleys is a reaction station which securely holds glass reaction vessels from 100ml to 10 litres. It was developed specifically to facilitate scale up and process R&D chemistry, by reducing set up time to only a few minutes, as opposed to hours, and offering a huge variety of potential accessories and peripheral device integration.

The automation of Lara allows accurate control of reaction temperatures from -30ºC to +165ºC, during exothermic additions, reflux and complex multi step syntheses. It also enables investigations of variable and exponential monomer addition rates and allows reaction profiles to be imported from other processes e.g. industrial or academic.

The Lara CLR is able to reliably reproduce reactions by being able to store and re-use pre-programmed methods to control reactor variables and peripheral equipment such as additions pumps. The pre-programmed methods (recipes) can be operated with a high degree of reproducibility, irrespective of reactor volume or the time elapsed between experiments. All these factors can clearly lead to improved productivity and safety, particularly when large scale reactions are being run.

The Radleys Lara CLR enables FaraPack Polymers Ltd. to expand its custom and specialty polymer synthesis facilities, enabling them to offer a wide variety of rapid and reproducible scale up and process optimisation services to contract customers.

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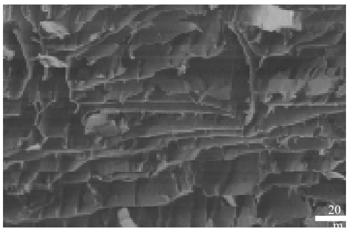
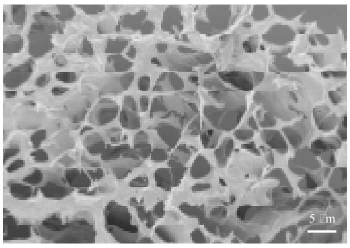
Centre for Self-Organising Molecular Systems (SOMS)

SOMS is an interdisciplinary centre within the University of Leeds specialising in molecular nanoscience research, with particular interests in molecular self-assembly and self-organisation. SOMS is active in various research areas as described below.

Supported and suspended lipid membranes

This research involves the development and study of model membrane systems to act as platforms for biosensing and biointerrogation including bilayers suspended above lithographically defined apertures. Recent work has involved increasing the complexity of the membrane system by selective population with membrane proteins, and by tethering actin networks on the membrane surface. Suspended membranes have also been used to create biologically functionalised surfaces: hydrophobic/hydrophilic surface contrasts have been created using lithography and photocleaving, as part of a RCUK Basic Technology research programme.





Freeze Dried Gels

Self-assembling peptides

Self-assembling peptides exhibit a hierarchy assembly process, forming tapes, fibres, fibrils and ultimately extended gel matrices. Application areas include molecular ‘scaffolds’ for both hard and soft tissue engineering. Significant remineralisation of teeth has been demonstrated following the application of a peptide gel. Freeze drying has been used to create highly porous peptide ‘aerogels’ for catalysis and filtration applications. Peptide assembly on solid surfaces offers a route to surface functionalisation as well as having potential application as an antibacterial coating.

Discotic Liquid Crystals

SOMS is one of the worldwide pioneers in the field of conducting discotic liquid crystals. Liquid crystals of the type first developed in SOMS are now used globally to improve the viewing angle of flat panel displays, and more recently, in high pressure, high temperature lubricants. Recent work has focussed on obtaining increased charge carrier mobilities

Directed Assembly

The ability to exercise control over self-assembly and self-organisation processes is an essential aspect in the exploitation of any of the above research areas. New research in controlled assembly of all three is under way.

Nanoparticle toxicity

Phospholipid monolayers supported on mercury have already been used to screen for membrane disruption caused by both organic nanoparticles (peptides) and metal oxides. A new spin-out company, Organisense, was set up within the SOMS Centre in 2008 to commercialise this technology.

SOMS research is complemented by our European-leading education portfolio, including our four interrelated Nanofolio Masters degrees – delivered in partnership with Sheffield University - and a 3 year Nanotechnology undergraduate degree.
For further details see www.soms.leeds.ac.uk

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Leeds Lithium Power

Flexible Rechargeable Lithium Batteries with Polymer Gel Electrolytes

Alison Voice and Ian Ward; University of Leeds

The research and development on polymer gel electrolytes has developed in several respects during the present year. The production of prototype rechargeable lithium batteries is proceeding with the cooperation of Fife Batteries at Culham, and has led to an extensive test programme. Another application for the polymer gel electrolytes is SMART cards and this is progressing well with an international collaboration. These developments are supported by the spin out company Leeds Lithium Power which is under the auspices of the IP Group.

Recent scientific research in this area has been directed at successfully extending the range of polymer gel electrolytes with particular emphasis on excellent high temperature performance, and the use of new electrolyte systems.

Interested parties can view further information and contact details through the website www.LeedsLithiumPower.com

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Rigicom Ltd
Self-Reinforced Composites
Technology and Licencing

A New Era for Self-Reinforced Composites

A new company, Rigicom Ltd, has been formed to extend the Hot Compaction technology for the manufacture of self-reinforced composites, developed at the University of Leeds. The company has now secured an option to the rights to the extensive portfolio of patents and is now seeking new licensees for the technology in addition to helping create new markets and applications.

Self-reinforced composites are produced from highly drawn polymer tapes compacted to create lightweight, highly impact resistant thermoformable sheets. Being single polymer materials they are totally recyclable.

Hot Compaction is the technology behind Curv® self-reinforced polypropylene, currently manufactured by Propex Fabrics GmbH in Germany. Curv® is already recognised as being the world leading self-reinforced polypropylene, seen in a wide range of cutting edge products from blue chip companies including light weight luggage from Samsonite and high performance sports protection from Nike. Other applications range from automotive parts to panelling and anti-ballistics.

Professor Ian Ward, lead inventor of the Hot Compaction technology in the 1990's and a Director of Rigicom commented, "In the time since we signed our first licence (with BP, now Propex Fabrics) we have developed ways to extend the technology to a wide range of polymers. Some of these offer remarkable levels of stiffness, strength and impact resistance and we are looking forward to working with Propex and new licensees in the development of new products and materials."

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Wildfire Snowsports Ltd

The Snowsports Technology is gaining momentum both literally and academically. The work on self-waxing skis, originally funded as a Demonstrator Project by Sheffield Polymer Centre, has now achieved full patent status and has become world renowned. Wildfire Snowsports are currently seeking manufacturers to develop the new technology for production and race skis. The research has developed to look at new surface modifications to increase speed and novel engineering solutions to the design of new skis and training processes. The company has also worked with Sheffield Steelers Ice Hockey Team in developing new resilient ice hockey sticks.

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The Dyecat™ Process

Sustainable Production of Coloured Polymers

Richard Blackburn, Patrick McGowan,
Chris Pask and Chris Rayner, University of Leeds

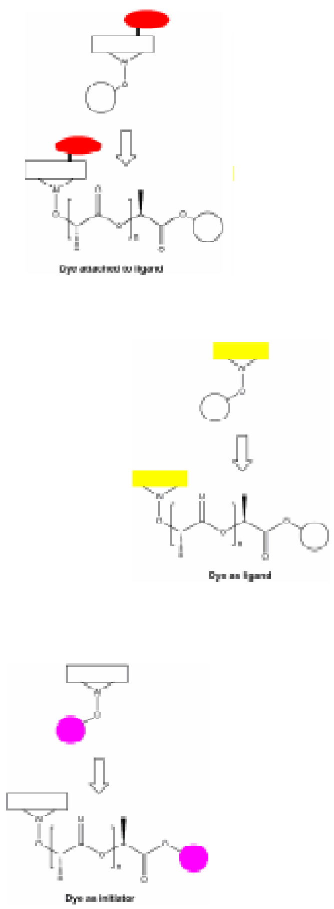
With the depletion of petrochemical feedstocks, it is necessary to produce new, useful and environmentally friendly polymers for a sustainable future. Poly(lactic acid) (PLA) is a linear aliphatic thermoplastic polyester derived from 100% renewable sources such as corn and sugar beet, and the polymer is biodegradable. NatureWorks LLC (USA) has developed large-scale operations for the economic production of PLA polymer used for packaging and fibre applications. PLA fibre is derived from annually renewable crops, it is 100% biodegradable and its life cycle potentially reduces the earth's carbon dioxide level.

PLA is formed by ring opening polymerisation of the cyclic dimer of lactic acid (lactide). As the range of potential applications continues to grow, coloration becomes a significant problem as it is required for most large-scale (tonnage) applications.

Proprietary polymerisation technology referred to as the DyeCat™ Process has been developed which allows coloration of PLA to be carried out at the polymerisation stage by incorporating appropriate chromophores into the catalyst structure, which remain in the polymer at the end of the process (see Scheme 1). This totally eliminates any subsequent dyeing step and also allows access to colours which are otherwise difficult to achieve on PLA (e.g. black) due to the high dye loadings usually required.

Examples of DyeCat PLA can be seen in Figure 1. A range of colours can be achieved (including UV absorbing), best demonstrated by the solvent cast films in Figure 1a-c. Figure 1d shows DyeCat PLA containing a fluorescent dye photographed under UV light, whereas Figure 1e shows a reel of melt-spun DyeCat PLA fibre.

DyeCat Ltd. was established as a spin out from the University of Leeds in late 2006. The DyeCat approach is patented, and has also been applied to a range of different polymers in addition to PLA. Dyecat is now working with major manufacturers to commercialise the technology. The focus of the company is on giving superior polymer properties while reducing the environmental impact of textiles and plastics, as well as giving significant cost reduction compared to conventional technology.



Scheme 1. The DyeCat Approaches to Coloured Polymers

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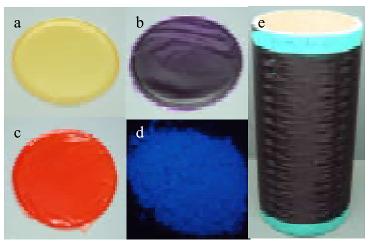


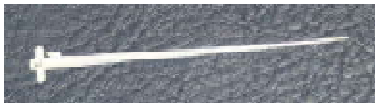
Figure 1. Examples of DyeCat PLA

Micro and Nano Moulding at Bradford

The Centre for Micro & Nano Moulding is a £2.2 million development funded by the Higher Education Funding Council for England and regional development agency Yorkshire Forward, the Department for Trade and Industry, the Engineering and Physical Sciences Research Council and industry, including Battenfeld, Motan and Fanuc for open access to industry.

Precision micromoulding meets root canals!

DRFP (Dental Root Filling Products)/ University of Bradford
Dr Ben Whiteside, Prof Phil Coates, Keith Norris, Majid Akhtar, Andrew Czenkusc

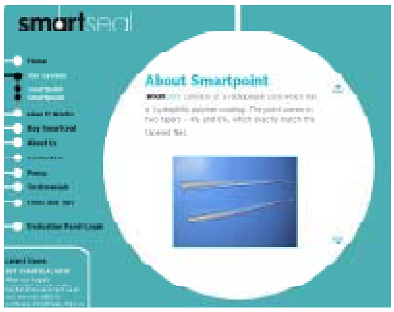


DRFP required a high aspect ratio, ceramic filled polymer component for a novel dental root filling treatment – the radio-opaque product, made from a hydroscopic polymer compound with a hydrophilic coating offers a very high level of success in the tortuous process of root canal filling. The programme has combined underpinning science and technology skills, through to commercial development, in a strong industry-university collaboration. Conventional injection moulders could not undertake the work due to: (a) very high repeatability requirements, (b) high aspect ratio flow paths, and (c) required high filler content (~70%wt) for radio-opacity.

Smart Point production on one of the Battenfeld high precision micromoulding machines at Bradford.

The Centre for Micro and Nano Moulding (Manager, Dr Ben Whiteside) performed a short research programme to investigate moulding feasibility, including compounding optimisation, high shear rate rheometry experiments to assess processability. Moulding trials used prototype tooling supplied by one of our industry collaborators, Microsystems UK Ltd. Significant challenges included: material compounding, with a very fine ceramic filler; a very narrow processing window, with ultra-high injection speeds (around 0.95m/s); critical control of mould temperature; careful moisture control, tool design for processing and ejection of components – all to deliver the highly accurate 3-d profile required.

Solutions in the laboratory included batch mixing of polymer/filler material prior to compounding, titanium nitriding of the cavity surface to promote release, and extensive computer-monitored experiments to establish ideal processing conditions. The product was launched in October 2007 at UK NEC, causing considerable interest and uptake. DRFP has been trialling the SmartPoint – which is used as part of an obturation system with a specially developed curable hydrophilic sealing compound. These trials, within more than 100 dental surgeries, have shown that the system provides easier insertion, improved sealing and a more than 90% success rate. Currently >140,000 products have been manufactured at the Micro & Nano Moulding Centre in the laboratories, in a fully automated process. In due course, production will be transferred to industry – but the very successful R&D programme continues at Bradford, on new generation products.



website


Demonstration in an endo block

The product won the UK Plastics Industry Awards Best Technology Application in July 2008. The judges felt the SmartPoint project was a great example of innovation and technical collaboration. “The combination of material formulation, sophisticated tooling and micromoulding shows all the benefits of a collaborative approach. This uses innovative polymers in an application where the materials have never been used before.”

For further information see www.smart-seal.co.uk/ for the SmartPoint product and www.polyeng.com or www.microandnanomoulding.co.uk/ for the MNM Centre

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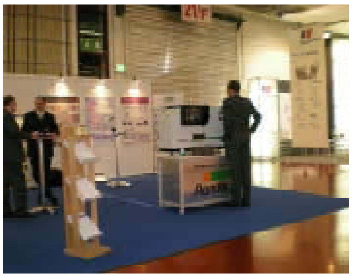
The Polymer Centre for Industrial Collaboration

During the past year, the Polymer Centre for Industrial Collaboration has achieved all of its major objectives within the original Yorkshire Forward 5-year plan for the CIC Programme and continues to stay ahead of target both in terms of industrial collaborations and income generation (regional, national and international). The YF CIC Programme was the winner (out of 71 Applicants) of the prestigious EU "RegioStars Award" and the Polymer CIC, together with one of it's industrial collaborators, Briton Engineering Development Ltd., were used by YF as examples of good practice in the award assessment phase.

The Polymer CIC is the key contact point for industry, mapping directly on to the Polymer IRC activities in Bradford, thereby enabling a clear route for industry to access the combination of high academic skills and world-class facilities. The Director, Phil Coates and Commercial Manager, John McGrath (ex industry) are assisted by Industry Associates and Area Managers in specialist areas (injection moulding, extrusion, micro & nano technology, solid-phase processing and materials re-cycling) and over 50 researchers.



With UK SME, Rondol Ltd – laboratory demonstration of lab-on-a-chip product to industry , using Rondol 5 tonne bench top injection moulding machine, and technical posters on the Rondol stand at Plastics Design and Moulding 08 exhibition.

New growth in inter-CIC/School/University collaborations include:- (a) participation in the White Rose Health Innovation Partnership (both direct and in partnership with PI-CIC etc.), (b) large programmes of work with industry (direct and via Technology Strategy Board) being carried out in the strong development area of solid-phase deformation and feature automotive and marine application activities and (c) projects in medical application-related areas (some with Dept. of Health, Health Technology Device Core).

Industry-related awards include:- (i) for the second year running the winning poster in the Materials KTN annual awards category "Best Industrial Collaboration", with "Polymers and Medical Applications" by B. Whiteside, P. Caton-Rose, M.T. Martyn, K. Norris, M. Woodhead, A. Watts, P.D. Coates (ii) "Best KTP for NE England" (also shortlisted for the National Event), John Sweeney and Briton Engineering Development, which company was also (iii) winner at the YF "Innovators 08 Event" in the category "Global Innovation Award". The Polymer CIC has won 4 SPARK awards from the Materials KTN and run 4 Knowledge Transfer Partnerships, 4 DTI/TSB/HDTC programmes, 2 RDA programmes in addition to EU and direct industry contracts.

The PolyLAB concept offers companies open access to technology for exploratory studies, including 16 injection moulding facilities, 16 extrusion lines (one specialised line for processing of pharmaceutical materials), two solid-phase orientation laboratories, a rheo-optical laboratory and reactive processing and process spectroscopy laboratory, an advanced materials characterisation suite, a coating laboratory and a computer modelling laboratory – all with strong industrial in-kind support in technology (process technology, sensors, characterisation technology) and software (Moldflow, Polyflow, Compuplast, Abaqus, Ansys, Mattlab, Labview, etc.). The Polymer CIC is very active in a range of workshops and open days and joint meetings with sponsoring companies.

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Molecular Engineering Translational Research Centre (METRC)

METRC is a new virtual research centre funded by The Northern Way and N8 Research Partnerships. The Northern Way is an initiative between the three Northern Regional Development Agencies (Yorkshire Forward, One North East and North West Development Agency) which has been formed to facilitate cross regional collaboration on strategic issues such as infrastructure, investment and innovation. The ultimate aim is to reduce the gap that exists in GDP between the Northern and Southern regions. N8 Research Partnerships Ltd is a collaboration between eight research intensive universities in the North of England: Durham, Lancaster, Leeds, Liverpool, Manchester, Newcastle, Sheffield and York.

The Northern Way has funded the formation of five virtual research centres in specific areas of collective strength across the N8 group. The five themes are: Regenerative Medicine, Energy, Sustainable Water Use, Ageing and Related Health, and Molecular Engineering. The Molecular Engineering theme (METRC) is being led by Tony Ryan OBE.

The fundamental objective of METRC is to help stimulate economic growth. This will involve new collaborations across the N8 group to address societal issues that could not be achieved by a single institution or centre alone. The scientific focus of METRC is soft nanotechnology. Research will be goal oriented, focussed on translation to industry, targeting identified markets where there is economic impact and societal benefit. Initial market sectors include Home and Personal Care, Medicine and Healthcare, and Energy. Acting as a virtual corporate laboratory, METRC will develop distributed shared translational laboratories across the North. Here, researchers seconded from industry will work together with centre researchers to move new technology past the proof of concept phase. As projects move towards commercialisation, relocation of both academic and industrial researchers back into industry laboratories will facilitate projects through final development to market realisation.

METRC will build on the expertise and augment a number of established centres within the Northern Region, including: the Polymer IRC; the Organic Materials Innovation Centre at Manchester; the Centre for Materials Discovery at Liverpool; the NanoManufacturing Institute at Leeds; the Liquid Crystal Group at York; and the nascent Knowledge Centre for Materials Chemistry in the North West. This background affords the new centre key strengths and credibility in the area of molecular engineering: globally significant research centres; a demonstrable track record of delivering for and working in partnership with industry; complementary backgrounds across key academic disciplines; a culture of innovation and enterprise. A workshop at the National Railway Museum in York earlier in the summer brought together over 50 senior academics to identify areas of synergy across initial market sectors.

The funding will be used to pump-prime new industry sponsored research projects across the N8 partners and leverage further funds from other funding sources. The goal is to produce a sustainable virtual research centre within five years.

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METRC

N8 Research Partnership

Moving Forward: The Northern Way

one North East · Yorkshire Forward · Northwest Regional Development Agency

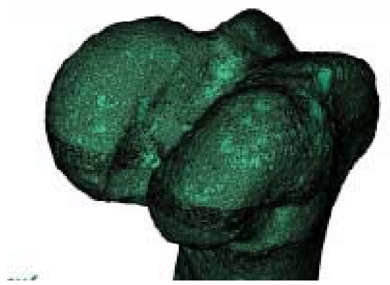
Research Highlights

Work in Progress Around the Network

Throughout the year we ask academic staff across the IRC to keep us up to date with interesting developments in their research work so that we can distribute the news through newsletters and web sites. With such a large bank of expertise it is impossible to represent all the research being carried out at any one time. This section features developments that members themselves think will interest you.

Exciting New Trends at Bradford

Following the opening of the new Micro & Nano Moulding Centre at Bradford in mid 2007, a range of subsequent meetings have emphasised the contribution that the Centre and the Polymer IRC/ Polymer CIC laboratory are making to the regeneration of Bradford, through the raising of the science profile in the City and Region. The Polymer IRC/ CIC has a local and regional impact with SMEs through to international companies in the region, and is a strong contributor to the Nanofactory concept.



Finite element model, constructed from laser scanning, of a sheep's knee, for optimisation of articulating surface implant geometry.

Major new trends in the Bradford laboratories are in solid phase orientation, biomedical, pharmaceutical and nanomaterials applications.

Solid phase orientation

The major small and large scale batch and continuous die drawing and compaction processing facilities are now housed in the Polymer IRC Laboratories in Bradford, where Ian Ward is a Visiting Professor and Fin Caton-Rose is the Solid Phase and Modelling Manager. Substantial contracts continue with Dow in the USA for large scale oriented polymer products, plus a new one with a large US automotive product manufacturer.

Biomedical applications:

The first example combines solid phase orientation and orthopaedics. Following the success of a Yorkshire Forward large company grant with Smith & Nephew and Leeds University, a new TSB grant for orthopaedic applications of oriented polymers has been won (Mike Martyn, Phil Coates, Ian Ward). This exploits unique properties of oriented bioresorbable polymers and involves experimental and finite element modelling studies.

A White Rose Health Innovation Partnership proof of concept programme between Bradford (Fin Caton-Rose, Phil Coates) and Smith & Nephew biologists aims at minimally invasive articulating surface repair for knees. This has led to the award of a £1.2m Health Technology Devices (Department of Health) programme for a fuller study to develop precision moulded optimised components.

Pharmaceutical applications – Pharmaceutical Engineering Science

Our links with Life Sciences have developed over the years, including surface structuring studies. Very recently a new collaboration has been established with the Institute for Pharmaceutical Innovation in Bradford, in what is described as Pharmaceutical Engineering Science - the combination of pharmaceutical chemistry and polymer engineering, for solvent-free drug manufacture and product structuring. Adrian Kelly and Tim Gough, with Phil Coates and Peter York lead the area. This has led to the establishment of a new

Chair (to be taken up in September by Anant Paradkar), a current patent application, a Yorkshire Concept award for drug manufacture using polymer extrusion technology, and the delivery in July 2008 of a Thermo Fisher 'Pharmalab'. This entirely stainless steel twin screw extruder (the model will be 16mm diameter screws, 40:1 L/D) is made to pharmaceutical industry standards, and will incorporate Bradford's extensive computer monitoring capabilities, including at-process spectroscopy.

Nanomaterials

An extensive EPSRC research project on modelling of polymer nanocomposites (John Sweeney, Paul Spencer and Phil Coates) with Queens Belfast and Oxford has covered atomistic to finite element modelling, developing understanding of issues concerned with optimisation of properties. A similar EPSRC competitive call led to Bradford winning a related programme on controlled processing of polymer nanocomposites (Phil Coates, Hadj Benkreira, Raj Patel), in collaboration with Queens and six companies with particular product property interests. A coherent study on the effects of key processing variables (using the novel minimixer at Bradford) on exfoliation number and interparticle distance is a vital requirement in understanding how to control these parameters, and hence product properties.

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Stimulus responsive branched polymers: a new contribution to bionanotechnology

Stephen Rimmer, University of Sheffield

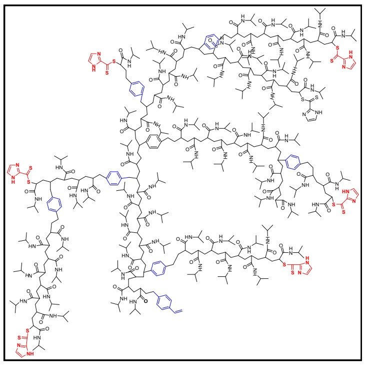
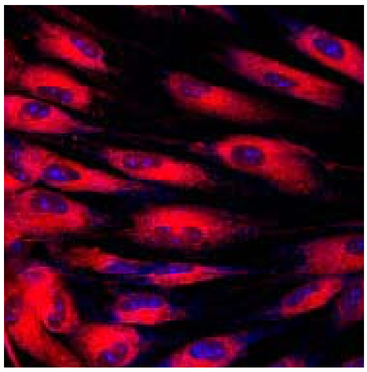


Figure 1 A highly branched PNIPAM

Synthetic polymers in aqueous solution respond to changes in the environment by passing from a solvated open chain coil conformation to a more compact non-solvated globular conformation at a lower critical solution temperature. All aqueous polymer solutions display this behaviour but it is only observed at atmospheric pressure if the LCST lies between 0 and 100 ºC. This "smart" behaviour is the fundamental phenomenon on which most bionanotechnology rests because as the polymers pass through the coil-globule transition several important properties are influenced: eg the adsorption of proteins; adhesion of cells or diffusion of drugs etc. One of the major issues with this technology is that increasing the swelling of the PNIPAM can be desirable to allow nutrient flow to the cells but if this is done by copolymerisation with hydrophilic monomers the LCST increases to impractical values.

This issue has recently been overcome by preparing PNIPAM-based hydrogel-brushes.[1] These polymer networks are composed of an underlying network of crosslinked poly(glycerol methacrylate) from which PNIPAM "arms" extend into the aqueous phase. The LCST of these systems remains constant regardless of the swelling of the underlying hydrogel but below the LCST the networks release cells that have been cultured at the interface above the LCST. In another programme we have developed a method preparing highly branched PNIPAM (see figure 1) and in our recent work we have shown that the LCSTs of these polymers are dependant on both degree of branching and end group structure.[2] Increasing branching makes the solvated polymer more compact and thus decreases the LCST whereas the effect of the end groups depends on chemical structure: increased polarity and charge favours an increase in LCST. These features are currently being used to design new systems that respond to bind events such as binding to proteins or cell and the results of these endeavours will be reported in the literature very soon.



Branched PNIPAM (Blue) globules inside fibroblasts (cytpsketon in red)

1) Poly(N-isopropyl acrylamde) thermally responsive hydrogel-brushes
J. Collett, A. Crawford, P.V. Hatton, M. Geoghegan, S. Rimmer, J. Roy. Soc.-Interface 4 117 (2007)
2) Highly branched Poly-(N-isopropylacrylamide)s with Arginine-Glycine-Aspartic acid (RGD) or COOH chain ends that form sub-micron stimulus responsive particles above the critical solution temperature, S. Rimmer, S. Carter, R. Rutkaite, J. W.Haycock, L. Swanson Soft Matter, 3 971 (2007)

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Research Highlights in Advanced Composite Materials

A. Hodzic, and C. Soutis, Department of Mechanical Engineering, Sheffield

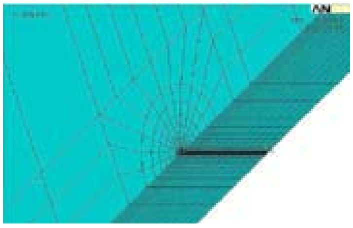

Fig. 1. (a) FEA model of the crack tip in Glare hybrid material used to make the panels for the fuselage of (b) A380, Airbus S.A.S. 2007 - photographer C. Brinkmann ©.

The Composites Group at the University of Sheffield involves academics and researchers from several departments, working together under the hub of the Composite Systems Innovation Centre, situated in the Kroto Research Institute. The team from the Department of Mechanical Engineering conduct innovative research, mechanical testing and characterisation of a range of polymer based composites, from advanced aerospace-grade carbon fibre composites, to biodegradable nanomodified polymers for the packaging industry. One of the current projects is a large EU funded programme, VULCAN, involving advanced numerical modelling of Airbus 380 hybrid composites and structures subjected to blast loading. (See fig 1). The project is particularly challenging due to the presence of crack to simulate opening in the solid structure, and thus requires accurate calculation of stresses in novel hybrid Al-GFRP structures using an in parallel fracture mechanics approach under a high-strain rate dynamic loading. The aim is to establish the critical amount of substance able to perforate the structure and use that information to provide advice on security measures.

Cytec Engineered Materials sponsors and supplies materials for the project on testing and characterisation of nanomodifed carbon fibre composites; here the influence of nanoclay in epoxy matrix is evaluated by conducting a whole-scale test protocol. The benefits of this new composite design are expected to be revealed in a better resistance to impact and blast, and compression.

A more recent and a very exciting project funded by Omega T2 programme is set to analyse the impact of composite materials on the environment. Dr. Alison Beck conducts cradle-to-grave life cycle analysis to develop a model which can guide the industrial community in better selection of suitable materials for advanced aircraft structures. Emissions released during the production and disposal of composite materials are compared to the emissions saved during their operation and use, and a critical 'neutral emissions' period established based on a composite part volume.

The team works closely with the Departments of Engineering Materials and Chemistry, in particular Professor Frank Jones, Dr. Simon Hayes and Dr. Patrick Fairclough. Joint projects involve DTI KTP and Lynwood Products sponsored design of railway sleepers from recycled plastic stream to replace standard concrete and hardwood products, and CPD Plc sponsored development of thermally and chemically stable biodegradable products for the food packaging market. The challenges in these two projects consist of finding suitable additives and advanced processing of thermoplastic and biodegradable polymers to replace standard engineering materials.

Between 15th-17th April 2009, the Kroto Research Institute will host DFC10, an International Conference on Deformation and Fracture of Composites. Over a hundred delegates will present their most recent research findings to the industrial and academic community. The keynote speakers will be Professor Frank Jones, Professor Paul Curtis (DSTL) and Dr. Alex Baidak (Cytec Engineered Materials).For more information, please visit http://www.sheffield.ac.uk/materials/conferences/dfc10/index.html

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Composites Research Group in the Department of Engineering Materials

Professor Frank R Jones and Dr Simon Hayes, University of Sheffield

The research group is part of the Ceramics and Composites laboratory, which is an EPSRC funded portfolio project. Extensive collaboration with colleagues in the Polymer Centre and The Composites System Innovation Centre (CSIC) embraces the research effort mainly in the engineering faculty, based in The Kroto Research Institute.

Hierarchical Modelling of Composite Properties

In this project Group Interaction Modelling of the thermomechanical properties of a matrix resin forms the chemical structure of the resin and hardeners. This technique computes the interaction energy and degrees of freedom of the six coordinate arrangement of the molecular model and from the total energy of the system the relevant properties of a cured resin; thermal expansion coefficient, modulus, yield strength (see figure 1).

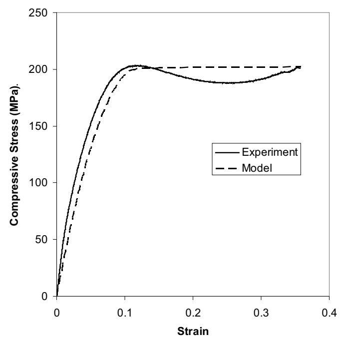

Fig 1 Comparison of predicted and measured compressive stress-strain curves for TGDDM epoxy resin

Research was funded by QinetiQ and EPSRC and is continuing with funding by DSTL which is extending the research to the prediction of properties and their degradation of phenolic composites.

Smart Self –Healing, Self Sensing Composites

In collaboration with Airbus and EADS the patented self healing resin system is being exploited. Furthermore we have demonstrated self sensing of impact damage in carbon fibre composites using the electrical resistance of the fibres. The sensor can detect the microcrack damage in the resin matrix without fibre fracture after low impact energy damage as well as fibre fracture after high impact energies. At low impact energies where only resin cracks form, resin can be healed to a sufficient extent to show a significant recovery of compression-after-impact strength. Research continues on optimizing the healing agent and sensor efficiency.

F. R. Jones, W. Zhang, S. A. Hayes Thermally Induced Self Healing of Thermosetting Resins and Matrices in Smart Composites in Self Healing Materials Ed. S. Van der Zwaag, Springer pp, 69-93

Supertough Composites with Smart Functionality

In collaboration with Colleagues in Leeds University, CamTec and CSIC the benefits of spread tow technology for improving composite first failure are being examined and hence provide improved impact resistance. The project is funded by QinetiQ.

Interfaces and Interphases in Composites Materials

Understanding how to optimize the properties of a fibre composite is essential to provide the interface with the correct interphase properties and chemistry. Plasma polymerisation is a means of providing the fibre with a functional protective conformal polymer coating. Recent research has demonstrated that the fracture energy of a composite can be increased using glass fibres coated with a plasma polymer. Future collaborations are planned with Owens and Corning plc and Sabic plc.

T.Swait, C.Soutis, F.R. Jones Comp Sci Tech) Z.Liu, F.M. Zhao, F.R. Jones, Comp Sci Tech in press.

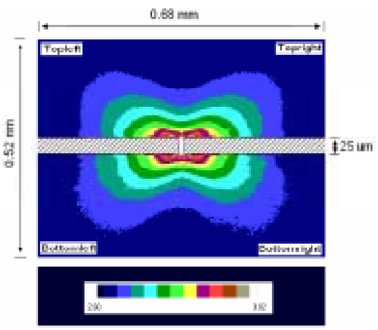

Fig 2 Fringe order map around a Fractured Glass Fibre under load

Development of Phase Stepped Photoelasticity for Studying Stress Distributions at Interfaces in Composite Materials

The study of interfaces relies on a number of indirect techniques which can only be applied to certain systems. Photoelasticity can be used to quantify directly the shear stress in the interphasal polymer. After applying the 4-phase stepping technique to a number of polymer-fibre combinations it was found that a 6-phase stepped instrument was necessary to achieve the required resolution. Figure 2 shows the stress distribution around a glass fibre break. This latter technique is now being applied to carbon composites in collaboration with Cytec Engineered Materials and to thermoplastic matrix composites in collaboration with Owens Corning Plc.

Glass Fibre Rubber Composites with Optimised Durability

By applying micromechanical understanding of composites failure, it has proved possible in collaboration with NGF (Europe) to design a technique for constructing composites with significantly enhanced durability.

Future Research

Two KTP projects have been funded: 1) Application of silane chemistry to the protection of metallic paint particles. 2) The application of composites interfacial understanding to the development of adhesives for bespoke wigs and hair pieces. Two other KTP projects are in collaboration with colleagues in the Department of Mechanical Engineering.

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Porous Polymer Scaffold for Three Dimensional Cell Culture

Neil Cameron, University of Durham

Growing mammalian cells in the laboratory enables researchers to investigate the activity of cells, test drugs and allows the development of new therapeutic approaches. Currently, cells are cultured in Petri dishes or cell culture plates and flasks that consist of flat, two-dimensional (2-D) plastic substrates, which are highly synthetic compared to the three-dimensional (3-D) environment in the body. As a consequence, cells grown in the laboratory do not always function in a realistic fashion and cell culture assays can provide inaccurate data that may be misleading. Consequently, various enabling technologies have been developed to create more favourable environments for cell growth in vitro, including systems that enable 3-D cell culture [1]

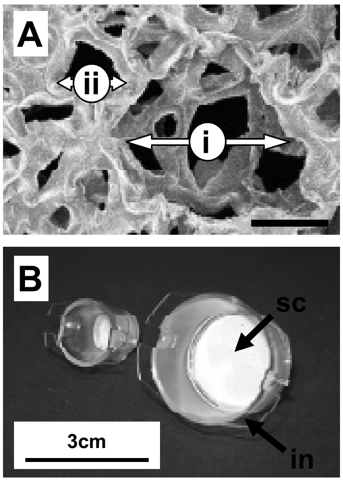

Figure (1): Development of a novel device for 3-D cell growth in vitro. (A) SEM image of scaffold showing (i) voids and (ii) interconnects. Scale bar, 20µm. (B) Examples of inserts (in) for 6- and 12-well cell culture plates incorporating a thin layer of scaffold (sc) (120 µm thick). Scale bar, 3 cm.

Recently, we have developed novel technology that enables the routine culture of cells in 3-D[2]. Using a process known as emulsion templating, highly porous scaffolds that are based on crosslinked polystyrene have been produced to create a material suitable for cell culture applications. The material can subsequently be adapted to existing cell culture products including multi-welled culture plates and well inserts (Figure 1). The scaffold is inert and can be supplied pre-fabricated, sterile and ready to use. The porosity of the scaffold is customized to within narrow tolerances during its manufacture .[3]

Validation of this in vitro technology has been performed on a broad range of different cell types. The polystyrene scaffold provides sufficient vertical space to enable cells to grow, differentiate and function in 3-D (Figure 2). Under optimal conditions, cells form layers and develop complex 3-D interactions with their neighbours, ultimately occupying all the space within the scaffold. Experiments show that cell viability is maintained at high levels during 3-D culture, in a manner resembling the activity of tissues in vivo. Furthermore, cells grown within these materials show enhanced ability to differentiate and respond to biochemical agents in a manner resembling the activity of their native counterparts in vivo[4].

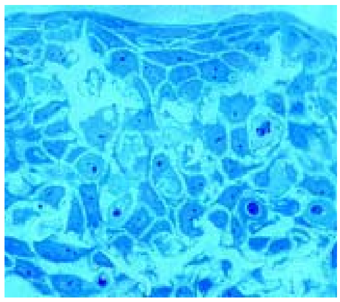

Figure (2): Section through the porous polystyrene scaffold containing the growth of mammalian skin cells (blue) throughout the material (white). Specimen embedded in resin, sectioned and stained with Toluidine Blue.

1. N. Blow, Nature, 2008, 451, 855.
2. M. Bokhari, R.J. Carnachan, N.R. Cameron, S.A. Przyborski, Biochem. Biophys. Res. Commun., 2007, 354, 1095.
3. M. Bokhari, R.J. Carnachan, S.A. Przyborski, N.R. Cameron, J. Mater. Chem., 2007, 17, 4088.
4. M. Bokhari, R.J. Carnachan, N.R. Cameron, S.A. Przyborski, J. Anatomy, 2007, 211, 567.

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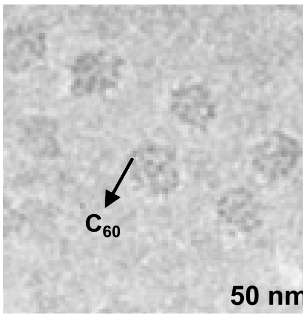
Structure-Defined C60/Polymer Colloid Supramolecular Nanocomposites in Water

Department of Colour Science, School of Chemistry, University of Leeds



To prepare structure-defined water-soluble C60 aggregates was impossible until we recently reported a supramolecular chemistry to address this challenge. To a polymer colloid (micelles or emulsion particles) solution in water or alcohol, we introduced C60 solution in a solvent that is miscible with water or alcohol. After the two solutions were mixed, C60 spontaneously assembled with the colloids. Following a dialysis process, colloidal stable nanocomposites dispersed in pure water were obtained. In an example shown in the image on the right, it was found that C60 were aggregated on the surface of the colloids. The resulting nanocomposites have many potential applications including biomedicals and photovoltaics.

Xiao-Song Wang, Tanapak Metanawin, Xian-Yu Zheng, Pei-Yi Wang, Mannan Ali and David Vernon Langmuir, 2008, ASAP

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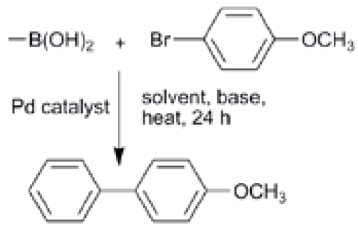
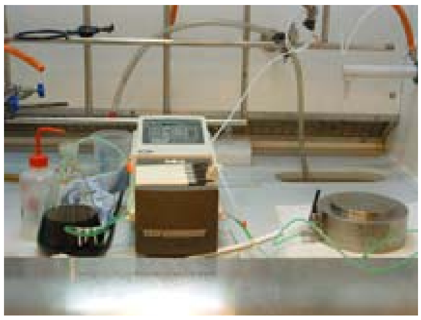
Functional Materials for Engineering and Chemical Sciences

Department of Chemical and Process Engineering, University of Sheffield



Principal interests lie in the fabrication of functional materials for a wide range of applications in engineering and the chemical sciences. Work continues on the creation of electroactive polymers for use as sensors, actuators and pumps in a wide range of applications from micro reactors through to bio-medical devices. This involves studying changes at the nano-scale as well as macroscopic deformations.

The work on polymer supported molecular catalysts is now at the forefront of research into stable and re-usable catalysts that combine the benefits of both the homogeneous and heterogeneous forms. These tethered and swellable catalysts have been termed 'androgynous' or 'androgyneous' because of their unique dual nature. A supported cross-coupling catalyst has recently been developed which is as "green" as possible, using over 99% water over the whole process, including work-up, purification and isolation. Catalysts have been developed that allow movement from discovery (μg) to production (multi-kg) of pharmaceutical materials over a 24 hour time frame.



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Public Awareness and Engagement with Science

Scientists across the IRC work hard to connect the public with developments in science, technology and innovation and to encourage them to see how these advances relate to their lives. This is achieved through a variety of means including the mass media, internet, radio and television; exhibits at science museums; science fairs and festivals and presentations to schools, groups and societies.

Wonderland: A powerful project of shared ideas. Art. Science. Discovery. More details on this project are given below.

Tony Ryan (Sheffield) in collaboration with Helen Storey (London College of Fashion) have exhibited their concept of “dissolving dresses” to the public in both London and Sheffield. The final display will take place at the Ormeau Baths, Belfast in November 2008.

During February the Royal College of Fashion London hosted a “working studio” where visitors could walk in and see first hand the skills of the design team creating the spectacular dresses, suits and jeans made from innovative dissolving textiles. In the ground floor window of the college one dress was hung over a large spherical bowl and lowered gradually over the period of the exhibition until it disappeared (see http://www.showstudio.com/wonderland).

On the 13th June, the exhibition arrived in Meadowhall, Sheffield where six large bowls sat under tall scaffolding which held the polymer dresses. Over the period of the exhibition the dresses disappeared on a timed lowering system which allowed spectators to watch in wonder as the beautiful fabric gently slipped into the water in mesmerizing formations, filling the bowl with colour and movement.

In a designated area within the Botanical Gardens, specially produced plastic washing up bottles were exhibited and the science behind how they will disappear after they are no longer useful was displayed. The polymer gel left behind once the bottles have dissolved could be used to grow plants. The BBC Newsround team filmed a number of school children enjoying the demonstration .

Three Sheffield schools sent a class from their year group 10 to an educational day at the University and they had a great time making “goo” and building polymer chains with model kits. Eighty five happy children!

To learn more about Wonderland and its conception, why the project has become such an important issue to all who have been working on it and where it wishes to be in the future, see the Wonderland website at http://www.wonderland-sheffield.co.uk

The Wonderland Exhibition

Contact: Tony Ryan
Tony.Ryan@sheffield.ac.uk

The Tom McLeish Roadshows of “The soft science of slimy stuff” and “science and ethics” have continued to enthrall science teachers and school children across the North of England. The South was represented when thirty students from Orpington studying A Level physics joined local students in a Physics Masterclass in the IRC at Leeds University in June 2008. Lectures, lab tours and an overnight stay at a university hall of residence introduced them to physics in a university environment. Their own knowledge was tested in a science quiz designed by Mike Reis, an old hand at introducing polymers to the unsuspecting through his involvement in summer programmes for the National Academy for Gifted and Talented Youth and numerous lectures to schools.

“How do you make polymers exciting to school children? Mention the p word to a young audience and they immediately think of plastic and shopping bags. You can almost see the despair on their faces when they realise they’re going to listen to an hour long talk on the physics of carrier bags! As someone who regularly gives lectures and workshops for the Royal Institution it’s my task to open their eyes to the wonders of giant long chain molecules. Fortunately there’s more to polymers than plastic bags so my job’s quite easy!

Dr Mike Ries

In June I gave my “Primeval Slime” talk to a packed audience of eager pre-GCSE students at the Cheltenham Science Festival. I started by showing them my favourite example of a naturally occurring polymer. I don’t think many of us get excited by a wrinkly old synthetic shopping bag. Claudia Schiffer on the other hand is far more appealing. She is a supermodel example of naturally occurring macromolecules: the proteins keratin for her gorgeous hair and nails, collagen for the smooth elastic skin and myosin and actin for that lovely muscle tone. This may reveal a simple male bias on my part, but I think her DNA is an excellent example of a giant polymeric molecule, a long chain of nucleotides!

There are many wonderful examples in nature of life making use of the properties of polymers. For example fleas that accelerate at thousands of metres per second squared. They catapult themselves at these tremendous rates using resilin, an elastic polymeric material.

I bring the “Primeval” in by mentioning dinosaurs and prehistoric life, which I link to fossil fuels and synthetic polymers. Then the easy part; “Slime”; everyone loves making slime. Some PVA, water and sodium borate are all you need to make my viscoelastic demo. It flows, bounces and shatters. This breaks the school taught simple classification of materials. How it responds depends on what timescale you ask it to!

Some new physics, lovely examples, fun demos and just perhaps I’ve made polymers a little more interesting! (And just in case I’ve hurt your feelings. Yes I know. Plastic bags are interesting too!)”

Contact: Mike Ries
M.E.Ries@leeds.ac.uk

Professor Ian Ward, FRS

Awards and a Notable Event!

The past year has seen Nigel Clarke (Durham) and Tom McLeish (Leeds) made Fellows of the American Physical Society. Steve Armes (Sheffield) was awarded the Royal Society of Chemistry's macro group medal for 2007 in recognition of his contributions to polymer chemistry.

The IOM3/Polymer Society has conferred the 2008 Swinburne Award on Phil Coates in recognition of his contributions to polymer science and technology. The award will be presented at the 2008 Swinburne Lecture, which will take place at the UK Polymer Showcase in September at the National Science Learning Centre in York.

The Polymer IRC's Industrial Club meeting in March 2008 opened with a tribute to Professor Ian Ward to mark his 80th birthday. Ian was instrumental in the formation of the Polymer IRC, becoming its first Director in October 1989 and is still an active member of the research network at both Leeds and Bradford Universities. Ian is also a director of two spin out companies, Leeds Lithium Power and Rigicom Ltd, (details of the work of both these companies can be found in our Centres and Spin outs section). The event brought together three long-term collaborators from different aspects of Ian's career: Professor Michael Jaffe, Professor Alan Windle and Mr Tony Dolan, who reflected on their own work and their long friendship.

For the second year running the Bradford IRC produced the winning poster in the Materials KTN annual awards category "Best Industrial Collaboration", entitled "Polymers and Medical Applications". Bradford have also been awarded best Knowledge Transfer Partnership for North East England and were winners at the Yorkshire Forward "Innovators 08 Event" in the category "Global Innovation Award".

International Collaborations

The Polymer IRC continually builds on its international reputation to develop collaborative relationships with research groups around the world. Members travel globally to meet with fellow scientists at international conferences and to talk to those overseas with related interests about the work and facilities that the IRC can supply.

L-R: John Embery with two of Don's students, Chris Seay and Chris McGrady

The Microscale Polymer Processing 2 (µPP2) programme NSF-EPSRC grant has funded visits to Don Baird's laboratories at Virginia Tech by Dietmar Auhl and John Embery. A return visit to the UK in September 2008 will bring Don Baird and Jimmy Mays to Leeds to continue the collaboration.

The visits to Virginia have generated a wealth of data to be fed in turn to the molecular modelling treatment back in Leeds. Appropriately, all this work was done on an extruder manufactured inYorkshire!

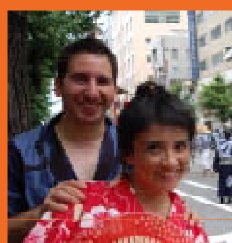
The VIPps grant has greatly enhanced relationships between the IRC and researchers in Pacific Rim countries. Phil Coates has made extensive visits to China, Japan and Taiwan , using the opportunity to discuss research collaborations in micromoulding, nanocomposite structuring and the processing of modified polymers.

Easan Sivaniah made a three-month visit to Japan, which included a very popular presentation to Japanese industrialists at the embassy in Tokyo on the capabilities of the Polymer IRC. Peter Olmsted and Xiao-Song Wang from Leeds have both used the funding to make visits to China.

The grant has made it possible for PhD student Frederico Roschzttardtz to undertake a six-month placement with Professor Watanabe at Kyoto University. He says:

"Nihon de kinku shimasu? (Doing science in Japan?)

Research in Japan at first glance could be described as an interplay between the simplicity of action and the complexity between interpersonal relations. Everything is perfectly done at the smallest level by the group; every detail is taken into account to achieve a task. Nothing is left to entropy!"



Fred and his wife enjoying their stay in Japan

The VIPps programme continues in September 2008, with a visit by 30 Chinese academics for meetings and to attend the UK Polymer Showcase meeting in York.

Visiting French Summer Student

Nigel Clarke, the new IRC site director at Durham is a Visiting Professor at the CNRS/Rhodia Centre de Recherche et Technologie, Lyon, where he is developing a programme, in collaboration with Didier Long, on the behaviour of nanoparticles within multicomponent polymer mixtures.

Visits to the IRC include Professor Ron Larson, from the University of Michigan who visited Leeds for three weeks to collaborate with Tom McLeish.

The IRC remains a popular destination for visiting post-docs and students from abroad to undertake internships; Recent visitors include students from the Indian Institute of Technology, Bombay and the Universities of Rennes, Marseilles and I.S.I.T.V in France.

European collaborations continue through interactions with the Dutch Polymer Institute and through the "Soft-Comp" network. A new International training Network programme "Dynacop", bringing together European industrialists and academics has been awarded by the EU and will commence in 2009. This programme is designed to obtain a fundamental understanding of the flow behaviour and dynamics of blends of topologically complex macromolecuar fluids and their role in the processing and properties of nano-structured polymer blends

The Polymer IRC Club

Linking excellence in science to industrial innovation.

The IRC's Industrial Club has developed a variable fee structure designed to allow companies of all shapes and sizes to interact with leading research scientists. This strategy has led to rapid growth in membership in the last three years.

The industrial club is a means for universities and industries to interact, and also for companies to meet in a forum where common research challenges can be aired. Such dialogue is vital for universities to focus their own research goals and increases industries' awareness of opportunities arising from current academic research.

Recent club meetings have been re-structured to encourage industrialists to make direct input into the planning of future activities and funding proposals. This ensures that industrial perspectives are accurately reflected in the IRC's future plans.

Spring 2008 Club Meeting

The Club continues to meet twice a year at the Spring Club Meeting and the UK Polymer Showcase event. Throughout the remainder of the year, club members are offered the opportunity to:

- Attend workshops on hot topics;
- Participate in strategic meetings such as the EPSRC International Review of Materials that took place in January 2008;
- Join consortia for funding applications;
- Attend the IRC Modular Training Courses at preferential rates.

The IRC's role as an umbrella organization for polymer scientists in the four core universities remains the key attraction to industrialists, with the large pool of expertise available giving:

Discussions at the UK Polymer Showcase

- Access to key academic working in areas of interest to them;
- New ways of approaching existing technical issues;
- Awareness of new applications for materials;
- Contact with a large cross-section of the polymers community;
- Interaction with scientists engaged in polymer research;
- Networking and identification of potential collaborators.

Current members of the Club include: Arizona Chemical, Artenius; Bayer Materials Technology; Cytec Engineered Materials; DSM; Goodfellow;Huntsman Core Technology Group; Kumho Petrochemical; ICI; Infineum; Invista performance Technologies; Mitsubishi; Mitsui Chemical; SABMiller; Scott Bader; Smith and Nephew; Unilever Corporate research; Unilever Port Sunlight; Vertellus Specialities (UK) Ltd and Victrex.

If you think your company could benefit from closer interactions with the IRC, contact Helen Clancy (h.e.clancy@leeds.ac.uk) for information about benefits and fees.

Training Courses for Industry

Delegates at the 2008 Nanotechnology Course

Polymer IRC Modular Course Autumn 2007/Spring 2008

Each year the success of this event is commented on, but this year really did exceed all expectations. 87 delegates attended, 48 of whom were from industry, the remainder being students from the Polymer IRC. For the first time applicants had to be turned away. Due to popular demand Basic Polymer Science Parts I & II were held again in Spring 2008 with 16 registered delegates, 7 from industry and 9 students. These two core subjects fill an important gap in information needed in the polymer industry. Every year we have new companies wishing to register delegates on these courses, along with regular customers.

The continued support of club members is very much appreciated with delegates attending from Infineum, Cytec, ICI, and Huntsman. In addition there were delegates from Belgium and Ireland and an academic delegate from Iran who attended especially for the Polymer Nanotechnology day. Thanks are also due to the academics from across the network who come together to present the programme each year.

The feedback as always gave many helpful suggestions but the overall opinion of the delegates was excellent.

Dates for your diary:

IRC 9 Day Science And Technology Modular Course
27th October – 6th November 2008
See www.polymercentre.org.uk/courses for the course programme and further information.

Contact: Shelagh Cowley to register your interest
s.h.cowley@sheffield.ac.uk

MSc Courses:
Formal courses leading to a Master's level qualification are available in:

- Polymers for Advanced Technologies
- Nanoscale Science and Technology
- Mechanical Engineering for Aerospace Materials
- Nanomaterials for Nanoengineering
- Polymers and Polymer Composite Science and Engineering
- MSc Route through the Doctoral training centre for Bio-Molecules and Cells.

More information on the courses available through the IRC network can be requested from Shelagh Cowley (s.h.cowley@sheffield.ac.uk)

Nanofolio – A Portfolio of Nano-training:
Nanofolio is a portfolio of courses on Nanotechnology led by Dr Mark Geoghegan (University of Sheffield) and Dr Rob Kelsall (University of Leeds). Details of events and courses can be found on the web at http://www.nanofolio.org/.

Polymer Innovation Network Foresight Workshops Programme

The Polymer IRC has been contracted by the Polymer Innovation Network to provide technical foresight activities aimed at connecting UK polymer industrialists with leading science and technology. The programme creates a series of projects whose outcomes can generate new wealth-creating products, opportunities and processes.

The programme began in February 2008 by taking a look at new science and technology for the management of polymer waste. The day was a great success and has led to two working groups which are now looking at developing projects on recycling mixed polymer waste and creating materials for the construction industry from recycled plastics.

Following the appointment of Dr Steve Morris as a dedicated industry fellow to manage the project, workshops are planned in the following subjects:

- Polymers for Transport, September 2008;
- Medical Polymers, October 2008;
- Polymers for Climate Change Mitigation, November 2008
- Predictive Modelling for Polymer Process Properties, January 2009
- Functional Coatings and Polymers, February 2009
- Polymer Electronics, March 2009

Contact: Steve Morris
physmo@leeds.ac.uk

The UK Polymer Showcase

Tony Ryan and Helen Storey

Sharon Baurley

The Latest Fashion in Polymer Science

September 2007 brought together designers and scientists at the London College of Fashion to take a look at recent developments made by the two communities and uncover ways to combine stylish design and cutting edge science. The meeting featured collaborations built on exchanges of ideas between science and design, such as Tony Ryan and Helen Storey's "Wonderland" project and "The Emotional Wardrobe", presented by Sharon Baurley.

Other speakers at the meeting gave an excellent selection of presentations: Stanislav Gorb of the Max Planck Institut fur Metallforschung, Stuttgart, who showed how biology could be used to develop new adhesives. Simon Edmonds of BERR and Robert Quarshie from the Polymer Innovation Network both examined the future for UK materials science and Christina de Matteis from the University of Nottingham gave the audience food for thought on innovative ways of engaging the public's interest in science.

For 2008, the UK Polymer Showcase moves to the National Science Learning Centre in York and will look at how polymers benefit society in general and at interactions between science and the media.

The Showcase is the largest free meeting for the polymer community in the UK, attracting around 200 delegates from industry, government and academia each year. It's no fee policy has been maintained through sponsorship by the IRC's Industrial Club, Yorkshire Forward and co-organizers, the Polymer Innovation Network. The meeting's objective is to open the latest developments in polymer science and soft-nanotechnology to as many people as possible, creating a fantastic forum to network with colleagues from all sectors of the community.

Information on UK Polymer Showcase meetings, both past and present is available on the web at www.polymerirc.org/pages/PolymerShowcase

New Faces

Dr Richard France

Richard France joined the Polymer Centre at Sheffield in September 2007 to plan and run the Molecular Engineering Translational Research centre (METRC). Bringing together the N8 universities of the Northern Way, One North East and the North West RDA, METRC will provide opportunities for companies to share the risks and rewards of polymer and chemical technology innovations with centres like the Polymer IRC, OMIC (Manchester) and CMD (Liverpool), facilitating projects with several universities where appropriate.

Richard, formerly a lecturer in Sheffield's Department of Engineering Materials, returns to the university after five years with Nottingham spin-out, Regentec Ltd.

Contact: r.m.france@sheffield.ac.uk

Dr Richard France

Dr Steve Morris

Steve Morris joined the Polymer IRC in Leeds in July 2008 to manage the Polymer Innovation Network Foresight Programme, which has been contracted to the IRC. Steve will organize a series of workshops and news bulletins on hot topics in polymers that are perceived to have the potential to create new products, opportunities and processes for UK industry.

Steve has a background in Biochemistry and worked for many years in the chemicals sector developing new business and markets for technical products. Steve has also worked in the public sector in business investment at Yorkshire Forward.

Contact: physmo@leeds.ac.uk

Dr Steve Morris

IRC Board - 2008

The IRC Board meets twice each year to oversee development and strategy of the IRC for the benefit of its members and the wider community.

Key Contacts

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Dr Liam Sutton Sheffield Polymer Centre University of Sheffield	l.r.sutton@sheffield.ac.uk	+44 (0) 114 222 9383

IRC Directory 2008

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.	+44 (0)113 34 33812 d.b.adolf@leeds.ac.uk
Dr Amalia Aggeli	SOMS Centre, School of Chemistry University of Leeds	Molecular self-assembly Biopolymers Biomaterials Peptides Fibrils	+44 (0) 113 3436407 a.aggeli@chem.leeds.ac.uk
Prof. Steven 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 radical polymerisation.	+44 (0)114 22 29342 S.P.Armes@sheffield.ac.uk
Prof. Colin Bain	Department of Chemistry University of Durham	Surfaces and Interfaces Wet surface chemistry Thin films Lubrication, Food Processing, Printing, Coating, Process Engineering,	+44 (0) 191 33 42138 c.d.bain@durham.ac.uk
Prof. David Barton	Mechanical Engineering University of Leeds	High strain properties and applications of polymers and composites Biomediacal applications of polymers Finite element analysis of solid state deformation Processing and properties of solid phase polymers.	+44 (0) 113 34 32137 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.	+44 (0)114 222 5962 g.battaglia@sheffield.ac.uk
Prof. Hadj Benkreira	Department of School of Engineering, Design & Technology University of Bradford	Rheology of polymers, films and coating flows, polymer processing, especially extrusion processing; biaxially oriented films; novel processes.	+44 (0)1274 233721 h.benkreira@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.	+44 (0)1274 233845 j.c.boot@bradford.ac.uk
Dr. Elaine Brown	School of Engineering , Design and Technology University of Bradford	Ultrasound melt flows; Enhanced Polymer Processing.	+44(0)1274 234531 e.brown@bradford.ac.uk
Dr Ashley Cadby	Physics & Astronomy University of Sheffield	Scanning near field optical microscopy for exploring the optical properties of materials at 50nm length scales Optical spectroscopy of optically active materials such as conjugated polymers. Study of radiative relaxation in optically active systems.	+44 (0) 114 222 3509 a.cadby@sheffield.ac.uk
Prof. Neil Cameron	Department of Chemistry University of Durham	Polymers for tissue engineering and 3D cell culture Glycopolymers Biologically active polymers Living radical polymerisation Porous polymers Production of functional nanostructures by polymeric self-assembly.	+44 (0)191 334 2008 n.r.cameron@durham.ac.uk
Dr. Phil Caton-Rose	School of Engineering, Design and Technology University of Bradford.	FEA of solid polymer deformation	+44(0)1274 234551 p.caton-rose@bradford.ac.uk
Dr Nigel Clarke	Department of Chemistry University of Durham	Theory Modelling Scattering Rheology Thin films Blends.	+44 (0) 191 3342069 nigel.clarke@durham.ac.uk
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, visualisation, ultrasound, image analysis, UV spectroscopy. Process modelling using finite element analysis in conjunction with process measurement techniques.	+44 (0)1274 234540 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.	+44 (0)191 334 4638 sharon.cooper@durham.ac.uk
Prof. Andrew Day	School of Engineering Design & Technology University of Bradford.	Engineering applications of elastomers and friction materials, especially in automotive applications. Quality engineering and Automotive engineering - brakes and belts.	+44 (0)1274 234522 a.j.day@bradford.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.	+44 (0) 114 222 7736 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.	+44 (0)1274 233787 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.	+44 (0) 113 3432981 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.	+44 (0) 113 34 33807 r.m.l.evans@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.	+44 (0) 114 222 9411 p.fairclough@sheffield.ac.uk
Dr Christine 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.	+44 (0)114 22 29415 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.	+44 (0) 114 222 3544 mark.geoghegan@sheffield.ac.uk

Dr Ramin Golestanian	Department of Physics University of Sheffield	Theoretical Studies of: Soft condensed matter Casimir effect and dispersion forces Elasticity of biopolymers Polyelectrolytes Wetting Molecular machines	+44 (0)114 2224273 r.golestanian@sheffield.ac.uk
Dr. Tim Gough	School of Engineering, Design and Technology University of Bradford	Flow visualisation, rheo-optics, spectroscopy, x-ray and neutron scattering for improved understanding of materials processing.	+44(0)1274 234536 t.gough@bradford.ac.uk
Dr Martin Grell	Department of Physics & Astronomy University of Sheffield.	Light Emitting Organic Materials.	+44 (0) 114 222 3589 m.grell@sheffield.ac.uk
Prof. Jim Guthrie	Department of Colour & Polymer Chemistry University of Leeds	Polymers in personal cosmetic systems. Studies of interactions in composite polymer systems, copolymers and blends via solution properties. 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. Polymers in flame retardant coatings and fillers-glass lamination systems. Fibre reinforced polymer composites. Influence of polymers on the "delivery" of pharmaceutical preparations	+44 (0) 113 343 2934 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.	+44 (0)113 34 35189 o.g.harlen@leeds.ac.uk
Dr Sarah Harris	School of Physics & Astronomy University of Leeds	Pka prediction Peptide self-assembly DNA structure and dynamics Biophysics Molecular dynamics	+44 (0) 113 3433816 s.a.harris@leeds.ac.uk
Prof. Paul Hatton	Centre for Biomaterials & Tissue Engineering University of Sheffield	Tissue Engineering and Polymer Biocompatability. Tissue engineering, the ability to grow new cartilage & bone on polymer supports offers the potential for reconstructive surgery at the time of injury & avoidance of later surgery to replace joints. Facilities for assessing biocompatability of polymers & other materials used in the healthcare industry.	+44 (0) 114 222 7983 p.hatton@sheffield.ac.uk

Dr John Haycock	Department of Engineering Materials University of Sheffield	Bioactive surfaces for tissue engineering.	+44 (0) 114 222 5972 j.w.haycock@sheffield.ac.uk
Dr Simon Hayes	Department of Engineering Materials University of Sheffield	Self-sensing and self-healing smart materials. Damage detection systems, cure monitoring systems and through-life monitoring of environmental and mechanical degradation. Nanomechanical testing, including nanoindentation for testing bulk polymers, thin polymer coatings on a variety of substrates and biological materials that are intractable to conventional testing techniques. Viscoelastic properties of very low modulus polymers (< 100 MPa) at a range of temperatures and frequencies.	+44 (0) 114 222 5516 s.a.hayes@sheffield.ac.uk
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 Micromechanical Models & the links between processing & properties (MOLDFLOW or other structure/property relationships in novel polymers including functionalised novel norbornenes synthesised at Durham University.	+44 (0)113 34 33827 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.	+44 (0)114 2229316 jamie.hobbs@sheffield.ac.uk
Dr Alma Hodzic	Department of Mechanical Engineering (Aerospace) 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 packaging . 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.	+44 (0)114 222 7720 A.Hodzic@sheffield.ac.uk
Dr Robert Howell	Department of Mechanical Engineering University of Sheffield	New instrumentation for measuring particle flows and high temperature gas flows feeds into the design of UMAVs, micro rocket engines and micro wind turbines. Aerodynamics of turbines for use in aircraft propulsion and electricity generation	+44 (0) 114 2227725 r.howell@sheffield.ac.uk
Dr John Howse	Department of Chemical and Processing Engineering University of Sheffield	Polymer Vesicles (formation, processing and encapsulation). Molecular motors and machines. Methods include: scattering techniques (x-ray, light) x-ray & neutron reflectivity, Ellipsometry, optical microscopy (inc. confocal fluoresence microscopy), atomic force mcroscopy (AFM), particle tracking, UV-VIS-NIR spectroscopy. Soft Codensed Matter, Smart Materials, Soft Matter at Interfaces	+44 (0) 114 22 7596 j.r.howse@sheffield.ac.uk

Dr Barry Hunt	Department of Chemistry University of Sheffield	Polymer analysis, including MALDI-TOF-MS. TGA, DSC & DMTA. Coulter particle size analysis on emulsions and suspensions of polymeric and other materials. Pyrolysis-GC-MS for the identification of fragmentation products and volatiles. Size exclusion chromatography.	+44 (0) 114 222 9563 b.hunt@sheffield.ac.uk
Dr Lian Hutchings	Department of Chemistry University of Durham	Living polymerisation techniques principally anionic polymerisation but also ring opening metathesis polymerisation (ROMP), atom transfer radical polymerisation (ATRP) and reversible addition fragmentation chain transfer polymerisation (RAFT). Synthesis and application of novel well defined, long-chain, branched polymer architectures - DendriMacs and HyperMacs. Multifunctional polymer additives for the control and modification of surface properties - where a surface constitutes an air-polymer, polymer-polymer, polymer-liquid or polymer-solid interface, including nanoparticles. Polymer Nanocomposites.	+44 (0) 191 334 2133 l.r.hutchings@durham.ac.uk
Dr Ahmed Iraqi	Department of Chemistry University of Sheffield	Electro- and Photo- Active Polymers including Polythiophenes, conjugated main-chain carbazole polymers and poly-acenes.	+44 (0) 114 222 9521 a.iraqi@sheffield.ac.uk
Dr Lars Jeuken	School of Physics and Astronomy University of Leeds	Redox-active membrane enzymes Novel electrode surfaces Protein-Film Voltammetry	+44 (0) 113 3433829 l.j.c.jeuken@leeds.ac.uk
Dr Leigh Mulvaney-Johnson	School of Engineering, Design and Technology University of Bradford	Injection moulding Gas assisted injection moulding Water assisted injection moulding	+44(0)1274 236267 l.johnson@bradford.ac.uk
Prof. Richard Jones	Department of Physics & Astronomy University of Sheffield	Kinetics of crystallisation and degree of crysystallinity when compared to the bulk phase - control of ahesion, interfacial electronic properties of semi-conducting polymers. Monitoring of phase separation kinetics in mixed polymers, polymer blends and bio-polymer mixtures. Polymers at Surfaces & Interfaces: Monitoring of nano-metre scale structure of interfaces between amorphous polymers by neutron reflectivity. Nanotechnology	+44 (0) 114 222 4530 r.a.l.jones@sheffield.ac.uk
Prof. Frank Jones	Department of Engineering Materials University of Sheffield	Fibre Composites: Mechanics, Chemistry & Performance. Fibre-reinforced polymer matrix composites - fibre breakage and new ways of improving fibre-reinforced composites.	+44 (0) 114 222 5477 f.r.jones@sheffield.ac.uk
Dr. Adrian Kelly	School of Engineering, Design and Technology University of Bradford	Extrusion, injection moulding, compounding, in-process monitoring, thermal optimisation, process energy consumption. Materials include commodity polymers, engineering polymers, pharmaceutical polymers, nanocomposites, recycled polymers, novel additives and fillers.	44(0)1274 234532 a.l.kelly@bradford.ac.uk
Dr Robert Kelsall	Centre for Self Organising Molecular Systems and School of Electronic & Electrical Engineering University of Leeds	Theory and simulation of semiconductor and molecular nanostructures and nanodevices.	+44 (0) 113 3432068 r.w.kelsall@leeds.ac.uk

Dr Ezat Khosravi	Department of Chemistry University of Durham	Expertise: Polymerisation Chemistry, Polymerisation Reactions particularly ring opening metathesis polymerisation (ROMP); Polymeric Materials; Biopolymers; Self Healing Polymer Systems.	+44 (0)191 334 2014 ezat.khosravi@durham.ac.uk
Prof. Graham Leggett	Department of Chemistry University of Sheffield	Surface Analysis Scanning probe microscopy & atomic force microscopy for characterisation of surface morphology and development of methods for quantitative characterisation of surface properties with nm spatial resolution. Friction force microscopy, chemical force microscopy to probe surface properties. X-ray photoelectron spectroscopy, secondary ion mass spectrometry Nanotribology Self-assembled monolayers, organic monolayers, polymer surfaces, polymer films Nanofabrication.	+44 (0) 114 222 9556 graham.leggett@sheffield.ac.uk
Dr Roger Lewis	Deapartment of Mechanical Engineering University of Sheffield	Sustainability and management of waste. Skin/finger friction in relation to grip of packaging (for opening) sports equipment etc. Testing and design of latex and nitrile examination/surgical gloves for improved friction/grip and tactile discrimination and reduced hand fatigue. Friction, wear and contact mechanics of ferrous and non-ferrous materials for a range of applications inc. railway, automotive and aerospace.	+44 (0) 114 222 7838 roger.lewis@sheffield.ac.uk
Prof. David Lidzey	Department of Physics & Astronomy University of Sheffield	Fabrication and evaluation of solution-processed organic (polymeric) electronic devices, including thin-film photovoltaics (solar cells) and light emitting diodes (OLEDs). Spectroscopy and microscopy of conjugated polymers and related device-applicable materials via a range of techniques including scanning near-field optical microscopy. Applications of photonic devices based on organic materials, including optical microcavity and nanocavity structures.	+44 (0) 114 222 3501 d.g.lidzey@sheffield.ac.uk
Dr Long Lin	Department of Colour & Polymer Chemistry University of Leeds	Synthesis of dyes, pigments and polymers, synthesis of thermochromic and photochromic colorants, printed electronics, micro/nano-encapsulation, security printing and anti-counterfeit solutions, digital printing and conventional printing technologies - particularly for high-value added applications, ink/coating formulations	+44 (0) 113 343 6735 l.lin@leeds.ac.uk
Prof. Sheila MacNeil	Department of Engineering Materials University of Sheffield	Tissue Engineering. How polymers can serve as matrices for generating replacement human tissue. Current work is focused on generating a totally synthetic matrix for skin cells, to replace matrices derived from skin banks & animal sources.	+44 (0) 114 222 5995 s.macneil@sheffield.ac.uk
Dr Mike Martyn	School of Engineering, Design and Technology University of Bradford	Coextrusion Processing Biomaterials Processing Polymer Property Enhancement	+44 (0) 1274 235929 m.t.martyn@bradford.ac.uk
Prof. Tom McLeish	School of Physics & Astronomy University of Durham	Molecular Polymer Rheology. Dynamics of Phase Separation in Polymeric Fields. Self-Assembled Complex Fluids and Biopolymers.	+44 (0)191 334 6051 t.c.b.mcleish@durham.ac.uk

Prof 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	+44 (0) 113 3432962 b.s.murray@food.leeds.ac.uk
Dr Peter Olley	School of Engineering, Design & Technology University of Bradford	Computer modelling of polymer processing; constitutive development and 3D modelling of viscoelastic polymer melt and plastic/viscoelastic solid phase polymer ;development of methods for 3D finite element application.	+44 (0)1274 234437 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.	+44 (0)113 34 33830 p.d.olmsted@leeds.ac.uk
Dr Emanuele Paci	School of Physics and Astronomy University of Leeds	Computational studies of protein folding Simulation of the mechanisms of forced unfolding and unbinding.	+44 (0) 113 3433806 e.paci@leeds.ac.uk
Dr Sophoclis Patsias	Department of Mechnanical Engineering University of Sheffield	Polymer enhanced ceramic damping coatings. Development and testing of new damping materials created by the combined use of polymeric materials and ceramic coatings.	+44 (0) 114 222 7845 s.patsias@sheffield.ac.uk
Dr Andy Pryke	Fara Pack Polymers University of Sheffield	Polymer Synthesis New materials Packaging Feasibility studies Polymer testing and analysis Short-term research and development	+44 (0)114 222 09499 andy.pryke@farapackpolymers.com
Prof. Chris Rayner	School of Chemistry University of Leeds	Preparation of coloured and functionalised polymers Renewable biopolymers (e.g. PLA). Coloration and natural dyes Photochemistry Natural product synthesis Continuous reactions Reactivity of CO2 Supercritical CO2 Stereocontrol (enantioselectivity and diastereoselectivity).	+44 (0) 113 3436579 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.	+44 (0)113 34 35124 d.j.read@leeds.ac.uk

Dr Tim Richardson	Department of Physics & Astronomy University of Sheffield	Nanomaterials Engineering Group Building organised molecular multilayered architectures using a wide range of materials including monomeric & oligomeric porphyrins, calixarenes, polyethylene oxide & other polymers. Applications include toxic inorganic gas sensing, organic vapour detection, production of thiol-coated gold nanoparticles, growth of II-VI semiconductor nanoparticles (CdS, PbS etc), nanolithography based on gold nanoparticle films, monolayer expansion and contraction dynamics.	+44 (0) 114 222 4280 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. NMR micro imaging, diffusion tensor imaging, self-diffusion constants and rheo-nmr. Solid state NMR to measure dynamics in polymeric systems	+44 (0) 113 34 33859 m.e.ries@leeds.ac.uk
Dr Steve Rimmer	Department of Chemistry University of Sheffield	Synthesis and biological properties of functional hydrogels and conetworks. Studies of protein adsorption and cell adhesion behaviour. Synthesis of telechelic oligomers using novel 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. Currently, working on polymers that respond to biological stimuli. Synthesis and properties of peptide functional polymers. Biodegradation of polymers Polymer analysis using mass spectrometry - MALDI-TOF and electrospray mass spectrometry of polymer and oligomer systems.	+44 (0) 114 222 9565 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.	+44 (0) 114 222 7845 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.	+44 (0)1274 234521 g.f.rosala@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.	+44 (0)114 222 9409 Tony.Ryan@sheffield.ac.uk
Dr Ian Scowen	Department of Chemical Technology University of Bradford.	Organo-metallic catalysis.	+44 (0)1274 233764 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.	+44 (0) 114 222 5475 r.short@sheffield.ac.uk
Prof. Costas Soutis	Department of Mechnical 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.	+44 (0) 114 222 7811 c.soutis@sheffield.ac.uk
Dr Peter Styring	Department of Chemical & Process Engineering University of Sheffield	Snowsports Engineering Polymers & Soft Actuators in Chemical Engineering - Micro Reactors. Design & synthesis of soft acuators for use as artificial muscle, micro pumps & valves. Immobilisation of catalysts onto polymers to facilitate heterogeneous catalysts in Flow Reactors. Fabrication of Micro Reactors from polymeric materials.	+44 (0) 114 222 7571 p.styring@sheffield.ac.uk
Dr Liam Sutton	The Polymer Centre University of Sheffield	Polymer Technology Transfer. Serving innovators in industry by matching their needs to the most appropriate expert(s) within the 40 polymer science and engineering research groups at the University of Sheffield, determining the most appropriate format for interaction and assisting in project management where necessary.	+44 (0) 114 2229383 l.r.sutton@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.	+44 (0) 114 222 9564 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.	+44 (0)1274 235456 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	+44 (0) 113 3436529 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 interdiffusion 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.	+44 (0) 191 334 2051 r.l.thompson@durham.ac.uk
Dr Harvey Thompson	School of Mechanical Engineering University of Leeds	Experimental flow visualisation Process flow simulation and optimisation	+44 (0) 113 3432136 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.	+44 (0)114 22 27705 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 insoluable materials to be carried in aqueous solution for application of such drug delivery.	+44 (0) 114 222 9560 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.	+44 (0) 114 222 5457 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.	+44 (0) 114 271 7932 r.vannoort@sheffield.ac.uk
Dr Alison Voice	School of Physics & Astronomy University of Leeds	IR and Raman spectroscopy/microscopy, DSC, Rheology Polymer Gel Electrolytes. Lithium Batteries. PVDF, PEN, PEEK.	+44 (0)113 34 36647 a.m.voice@leeds.ac.uk
Dr Xiao-song Wang	Department of Colour and Polymer Chemistry University of Leeds	Functional nanomaterials: to create nanomaterials through supramolecular chemistry and explore nano-size induced properties for application in modern technologies. Synthesis of well designed polymers that have controlled designed attributes. Supramolecular Chemistry: to understand macromolecular self-assembly behaviour. Synthesis, macromolecules, Supramolecular chemistry, Functional Nanomaterials, Biomedical applications.	+44 (0) 113 3432809 x.s.wang@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.	+44(0)113 34 33808 i.m.ward@leeds.ac.uk
Mr. Ben Whiteside	School of Engineering, Design and Technology University of Bradford	Modelling; Glass filled polymer injection; Micromoulding	+44(0)1274 236266 b.r.whiteside@bradford.ac.uk
Dr Andrew Wilson	School of Chemistry University of Leeds	Organic synthesis Supramolecular chemistry Molecular recognition Self-assembly	+44 (0) 113 3431409 a.j.wilson@leeds.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	+44 (0) 113 3432177 m.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.	+44 (0)191 334 4634 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, Energy modelling and Optimisation.	+44 (0)1274 234281 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.	+44 (0) 114 222 5499 p.v.wright@sheffield.ac.uk
Dr Junjie Wu	School of Engineering University of Durham	Tissue Engineering Bioactive Chemistry Biomedical engineering and Energy Conversion.	+44 (0) 191 33 42440 junjie.wu@durham.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.	+44 (0) 114 222 9418 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).	+44 (0) 114 222 5967 x.zeng@sheffield.ac.uk