polymer LINKS

News from the UK's #1 academic/industrial polymer research network

Issue 10 December 2007

CHAINING THEORY ILLUMINATES PRACTICAL PROBLEM

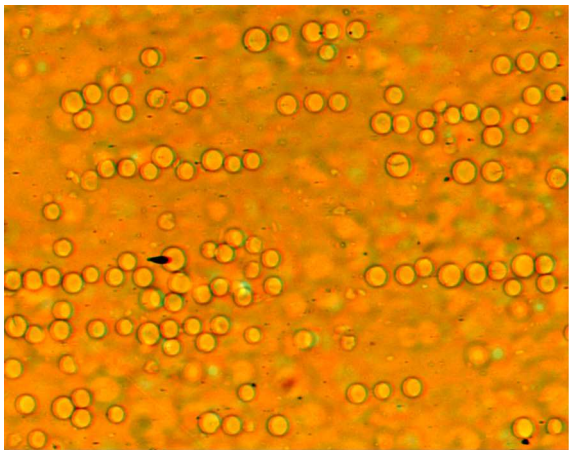
New insights into structure formation in "2Phase" materials

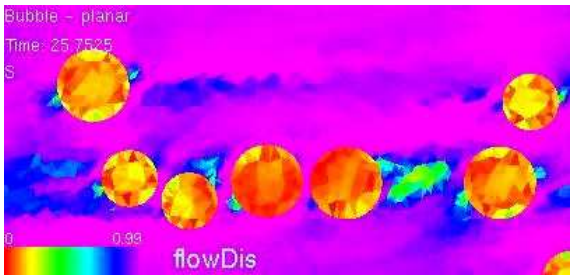
Recent work within the Microscale Polymer Processing project, MuPP2, has shown the advantage of combining experimental studies and computer simulation for understanding meso-scale structuring of polymer blends, in particular the phenomenon of chaining of spherical particles in polymer melts.

Chaining was first observed experimentally in a glass bead reinforced polystyrene sample, manufactured using the micromoulding facilities at Bradford, with the help of Ben Whiteside and Tim Gough. Post process image analysis showed chains of glass beads in the high shear regions of the sample, when injected at a high speed of 900m/s.

Further rheo-optical studies were carried out on a visit by Manlio Tassieri (Leeds) and Tim Lord (Cambridge) to Eindhoven, who are also part of MuPP2. For this experiment, a special blend was prepared by Manlio, incorporating cross-linked polystyrene beads in the same shear thinning polystyrene matrix as used in the injection moulded studies reported above. Visualisation was achieved using a Linkam shear cell at 190°C. The first picture shows the chaining of cross-linked PS particles occurring after ~ 20 min of continuous shear deformation at shear rate of 2 s^{-1}.

Computer simulation has subsequently been used to shed some insight into the mechanisms behind chaining. Malidi Ahamadi, in Applied Mathematics at Leeds, has developed a meso-scale version of the flowSolve programme developed in the first stage of the MuPP programme. Malidi has found that the occurrence of chaining depends very much on the constitutive behaviour of the polymer matrix, but also the shear rate. If the matrix is Newtonian, then chains do not form but rather the particles rotate around each other. However, if the matrix is shear thinning (its viscosity decreases with increasing shear rate), then the particles can form chains at a critical shear rate. The second image shows a typical computational solution of a structure formed in a shear thinning matrix, after continuous shear deformation of a few seconds. Once the particles form a chain they remain in this configuration.





This dependence of chaining on the matrix constitutive behaviour reflects some recently published experimental studies by Scirocco et al. Future work will aim to establish the critical conditions (temperature, shear rate, particle volume fraction etc) for chaining utilising this mixture of experiments and simulation.

For further information on these studies, or for other aspects of the 2Phase stream of MuPP2, please visit the programme website at www.mupp2.co.uk or contact Peter Hine (p.j.hine@leeds.ac.uk).

IRC POLYMER SCIENCE & TECHNOLOGY COURSE SET TO EXPAND

Capacity attendances at Autumn modules

This year's IRC Polymer Science & Technology modular course, which ran from 29 October to 8 November, really did excel all expectations. In all, 87 delegates attended, 48 from industry and the remainder from academic groups in the Polymer IRC and certain modules were oversubscribed.

IRC Club members continued to support the course. People attended from Infineum, Cytec and ICI, and Huntsman sent two delegates from their operation in Basel, Switzerland. Other overseas visitors came from Belgium and Ireland, and an Iranian professor came especially for the Polymer Nanotechnology day.

The feedback as always gave many helpful suggestions and the overall opinion from the delegates was excellent.

"Very good venue and hospitality - very good notes and CD format"

"Thank you very much for your organization of the training courses, they are very useful and informative, I will recommend it to my other colleagues if they need the similar kind of training."

Because of the enormous demand, we are considering running the first five modules again in the Spring of next year. Dates will be announced on our web site, www.polymercentre.org.uk/courses. The next full 9 day course is pencilled in for 27 October to 6 November 2008.

Finally, the organisers would like to extend an enormous "thank you" to all of our presenters on the course this year.

More information is available from Shelagh Cowley (s.h.cowley@sheffield.ac.uk), the course co-ordinator.

FOCUS : Science Highlights

PLATINUM PROPULSION FOR MICROSPHERES

Experimental demo of key nanotech theory

A Sheffield-led team of researchers have demonstrated the ability to propel tiny polystyrene spheres in a hydrogen-peroxide solution by coating them on one side with platinum. The micrometre-sized balls move because the platinum converts hydrogen peroxide into water and oxygen causing a pressure differential between the coated and uncoated sides of the sphere. The researchers believe that these "artificial swimmers", which move nearly as fast as swimming bacteria, could someday be adapted to deliver drugs within the body.

Making micrometre-sized objects swim is no easy task because over very short distances, water behaves like a very viscous fluid such as honey. Mechanical propulsion systems such as bacterial flagella have proven very difficult to mimic in the construction of nano- and micromachines.

In 2005, Prof Ramin Golestanian, a theoretical physicist at the University of Sheffield and colleagues proposed the chemically-fuelled mechanism described above, which uses no moving parts. Now a team including Sheffield physicists Prof Richard Jones and Dr Jon Howse has created such a propulsion system for making particles swim in a solution of water and hydrogen peroxide.

By looking at the system with an optical microscope, the researchers measured particle speeds of up to 5μm/s, not far off the 10μm/s observed in similarly-sized bacteria. However, like bacteria, the swimmers also have to contend with another consequence of being very small. Periods of a few seconds of motion in a specific direction were punctuated by the swimmers following random paths thanks to the battering of Brownian motion.

Ramin says the propulsion technique could be adapted to work in other liquids including blood, which could someday allow micromachines to swim within the body to deliver drugs to specific locations. However, it is impossible to design a tiny object that would be able to avoid Brownian motion on its own and travel in a straight line. A more likely solution would involve external guidance. For example, if the particle could be magnetised, it could be steered using a magnetic field.

[J.R. Howse, R.A.L. Jones, A.J. Ryan, T. Gough, R. Vafabakhsh, and R. Golestanian, "Self-motile colloidal particles: from directed propulsion to random walk", *Phys. Rev. Lett.* (2007) 99, 048102]

More info: r.golestanian@sheffield.ac.uk

FLYING FISH?

Sheffield MSc project takes off

The prototype of an unmanned aerial vehicle (UAV), debuted by Prof Costas Soutis and a group of Sheffield MSc students at the 46th Paris International Airshow in 2005, was displayed again in June 2007. Aelius, a metamorphic UAV that can fly, become a boat and even operate as a submarine, is entirely built out of polymer composite materials—specifically, carbon fibre-epoxy systems.

The former students, participants in Sheffield's range of aerospace-related MSc courses, have now set up a company, www.aeroart.eu, raising €500k to build and fly Aelius.

A video of the gliding flights of Aelius is available on YouTube:

www.youtube.com/watch?v=9iXmxH5EAyw

For more information, please contact Prof Costas Soutis (c.soutis@sheffield.ac.uk).

Link: www.sheffield.ac.uk/aerospace

BRANCHING OUT

International collaboration elucidates flow behaviour of branched PE

Rheological and film-casting properties of well-characterised polyethylenes (PE) with different branching structures are under investigation through interdisciplinary MuPP2 collaboration. The group of Prof Tom McLeish is working with those of Prof Donald Baird of the Department of Chemical Engineering at Virginia Tech University and Prof Jimmy Mays at the Chemistry Department, University of Tennessee.

The aim of this interdisciplinary study is to investigate the samples' complex flow properties—and their consequences for structure—in relevant processing operations of thermoplastic resins such as film-casting, examining, for example, the neck-in profile.

For this study, a lab extruder has been employed at Virginia Tech with the materials and flow conditions specifically chosen due to the small sample quantities available. Non-linear visco-elastic properties in shear and uniaxial elongation have been determined from constant strain-rate tests and fitted with a multi-mode Pom-Pom model [Inkson et al. *J. Rheol.* (1999) 43, 873]. The model parameters are compared to the molecular analysis of the branching structure determined by size-exclusion chromatography with coupled light-scattering provided at Tennessee.

The experimental results for the film flow behaviour are compared to model predictions of the group at the Polymer IRC in Leeds for different branching structures and draw ratios by using the approach of Ito and Doi [Ito et al. *J. Soc. Rheol. Jap.* (2003) 31, 157] together with the Pom-Pom constitutive equation.

Comparing experimental results to the model continues to inform the development of predictive tools. Thanks to key interactions such as this with overseas collaborators, the MuPP2 partners are developing knowledge-based approaches to process development, to lead to higher quality, lower cost plastics of the future.

Please contact Dr Dietmar Auhl (d.auhl@leeds.ac.uk) for more information.

Link: www.mupp2.co.uk

SHOWCASING DESIGN AND SCIENCE

The product design community is constantly seeking new materials that will fulfil the increasing expectations of their consumers. September's UK Polymer Showcase 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 in which they could combine stylish design and cutting edge science to produce desirable products for the market place.

The meeting featured collaborations that have been built upon exchanges of ideas between the sciences and design communities, 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 für Metallforschung, Stuttgart, showed us how biology could inspire the development of 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.

Presentations from the meeting are available for review on the Polymer IRC website at www.polymerirc.org/pages/PolymerShowcase.

Details of the free-registration 2008 UK Polymer Showcase will be available in the New Year.

FOCUS : Analysis Resources

STATE-OF-THE-ART SOLID STATE NMR AT LEEDS

New investment in dedicated polymer analysis facilities

The School of Physics and Astronomy at the University of Leeds has recently bought a Bruker Ultra-Shield-Plus 400 MHz NMR machine. This is a vertical wide bore (89mm) triple resonance solid state spectrometer with magic angle spinning, 3D-imaging, diffusion and rheology probes.

We can carry out multi dimensional NMR experiments on a wide range of NMR active nuclei to determine chemical structure, inter nuclear distances, orientation, dynamics and morphology. The field gradients that the equipment has enable 3D imaging with resolutions down to 10 mm. We also have high powered field gradients with which it is possible to measure diffusion coefficients down to 10^{-12} m^2s^{-1}. The rheology probe can measure flow velocities in cone and plate and couette cell geometries to an accuracy of 0.2 mm/s.

You are warmly invited to make use of this equipment. We will supply support and guidance in carrying out the measurements and even in deciding which techniques will provide useful information for your systems. For more information about this please don't hesitate to contact Mike Ries (m.e.ries@leeds.ac.uk).

Link: www.pcf.leeds.ac.uk/facilities/nmr

BUSINESS-FOCUSED ANALYSIS SERVICES AT BRADFORD

The major analytical equipment at the University of Bradford is housed within The Analytical Centre (AC). This facility provides access to a broad range of quantitative analysis and structural science capabilities.

Instruments are housed in dedicated laboratories, mostly within Bradford's recently-built Innovative Pharmaceuticals Institute but also in satellite amenities such as the Advanced Materials Characterisation Laboratory within the Polymer Engineering IRC.

Specialist wet laboratory facilities include a clean room, full extraction facilities and sample preparation areas with HF capabilities.

The Analytical Centre is serviced by academic and technical specialists to provide bespoke solutions for sample-by-sample analysis, batch analysis, method development and training programmes.

External users can take advantage of the facilities in both serviced and hands-on modes. Interested readers are warmly invited to contact the AC's Director, Dr Ian Scowen (i.scowen@bradford.ac.uk).

Link: www.brad.ac.uk/gateway/facilities/analytical-centre.php

IBA AT DURHAM IRC

Durham University's Chemistry Department is one of only three UK institutions able to offer ion beam analysis in its arsenal of analytical services.

The family of ion beam analysis techniques available (Rutherford back-scattering, forward recoil spectroscopy, particle-induced X-ray emission etc.) measures elemental composition versus depth in almost any material. Applications include analysis of polymer films, coatings, metals, composites and aerosols to name but a few.

As well as underpinning a vast array of basic research, ion beam experiments are making a growing contribution to biomedical, environmental and industrial materials science. For informal enquires about using the Durham ion beam analysis facility, please contact the service manager, Dr Richard Thompson (r.l.thompson@dur.ac.uk, 0191 334 2139).

FIRST CLASS SEM AT SORBY

The Sorby Nano Investigation Centre, Sheffield's centre of excellence for materials characterisation by microscopy, has just announced the commissioning of a new FEI *Inspect F* Field Emission Gun Scanning Electron Microscope (FEG-SEM). This high-specification instrument is to be dedicated to the analysis of polymer materials.

SORBY NANO
INVESTIGATION CENTRE

The advanced features of the new FEG-SEM include a high brightness, high current Schottky Field Emission source providing clear, sharp and noise free imaging in high resolution, secondary and back-scattering modes, as well as options for compositional mapping of samples.

Prospective users of the new instrument are invited to contact Sorby Nano's Manager, Dr Martin Highett, for more details (martin.highett@sorbynano.org).

More information, including an invitation to the Sorby Nano Drop In Session on 30 January 2008, is available at the link below.

Link: www.sorbynano.org

FOCUS : IRC News

POLYMER FORESIGHT PROGRAMME FUNDED

The Polymer IRC has been awarded a contract to provide technical foresight activities aimed at connecting UK polymer industrialists with leading science and technology on behalf of the Polymer Innovations Network. The programme will create a series of projects whose outputs can generate new wealth-creating products, opportunities and processes.

Over an initial 12 month period, a series of workshops will be held on topics that have been identified as promising for knowledge creation and transfer. A dedicated Industry Fellow, based at the IRC's Leeds Office will organise the programme of workshops and develop the best ideas that emerge from the day into funded projects.

The programme will kick-off in early 2008 with a workshop on new science and technology for Polymer Waste. Details of the workshop will be posted on www.polymerirc.org as soon as they become available.

NEW FACES AT THE POLYMER CENTRE

Richard France has joined the Polymer Centre to plan and run the Molecular Engineering Translational Research Centre. Bringing together the N8 universities of the Northern Way, itself a coalition of Yorkshire Forward, 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 at the University of Manchester and CMD at the University of Liverpool, facilitating joint 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.

For further information, please contact Richard:

r.m.france@sheffield.ac.uk

The Polymer Centre's new secretary is Deborah Coupe, who joins us from Sheffield Teaching Hospitals Trust. Deborah will be responsible for dealing with any administrative requirements readers may have of the Polymer Centre—if your contact details need updating, for example, she will be happy to help. Deborah can be contacted at:

d.coupe@sheffield.ac.uk

NEW FACE *FOR* THE POLYMER CENTRE

The Polymer Centre is having a facelift. Market research carried out by the University of Sheffield over the summer showed the need for a fresh, recognisable new look for the Centre's promotional materials and website.

We therefore engaged local agency, Eleven Design, to create a new logo and templates for marketing literature. The results will be seen in all future leaflets and presentations and our web-site, www.polymercentre.org.uk, is currently being rebuilt, with the new version due to go live at the end of January.

New leaflets will be made available on the website in pdf format. We welcome any comments you may have. Please contact Polymer Centre manager, Malcolm Butler:

m.a.butler@sheffield.ac.uk

RSC MACRO GROUP MEDAL

Congratulations to Professor Steve Armes, who has been awarded the Royal Society of Chemistry's Macro Group Medal for 2007. The medal has been awarded in recognition of his contributions to polymer chemistry, in particular controlled radical polymerisation for synthesis of water-soluble block copolymers; branched copolymers; surface-grafted polymer brushes; and stimulus-responsive biocompatible block copolymers that can self-assemble into micelles, vesicles or gels.

Steve Armes has been a member of the Polymer Centre at the University of Sheffield since 2004, when he joined us from the University of Sussex.

s.p.armes@sheffield.ac.uk

UK POLYMER SHOWCASE 2007

Enthralled delegates at September's Polymer Showcase. Please see page 2 for a report and links.

CHEMICAL CONUNDRUM

Rearrange the nine letters below to find a polymer-related word.

C	A	T	S	L	A	Y	E	R

Send your answer to polymers@sheffield.ac.uk to win a mystery prize!

[Last time: AUNTIEDEB = BUTADIENE]

CONTACT US

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bringing UK polymer researchers together