

UK POLYMER SHOWCASE 2006

**ABSTRACTS**  
**OF**  
**LECTURES**

**UK POLYMER SHOWCASE  
12/13 SEPTEMBER 2006  
CEDAR COURT, WAKEFIELD**

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Alison Voice University of Leeds	“Flexible Polymer Battery Technology
Peter Wright, University of Sheffield	“A Decoupled Carrier Mechanism for Conductivity in Polymer Electrolytes for Lithium Batteries”
Richard Bushby, University of Leeds	“Functional Supported Biomembranes”
John Haycock University of Sheffield	“Polymer Applications in Tissue Engineering and Drug Delivery”
Giuseppe Battaglia University of Sheffield	“Biomimetic Polymeric Membrane-enclosed Structures”
Tony Cheetham University of California, Santa Barbara	“Materials Research in the 21 <sup>st</sup> Century”
John Grasmeder and Terri Jordan Victrex PLC	“Innovating for Impact-Marketing and Technology Perspectives”
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Rick Mitchell Cranfield University	“Innovation Management: What Technologists Need to Know”
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Rob Kelsall University of Leeds	“Molecular Self Organisation and Self Assembly”
Eric Amis, N.I.S.T. Gaithersburg	“Exploiting the Innovator’s Dilemma: Making Breakthroughs Happen”
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Richard Jones University of Sheffield	Responsive Polyelectrolyte Layers as Smart Surfaces and Actuators

# **Charge transport at organic-organic heterointerfaces**

*Henning Sirringhaus*

*Cavendish Laboratory, University of Cambridge, Madingley Road,  
Cambridge CB3 0HE, UK*

## **A B S T R A C T**

Polymer transistors offer new opportunities for the controlled manufacturing of active electronic circuits by a combination of solution processing and direct printing. We will review current understanding of their device physics with a particular emphasis on understanding the electronic structure of the interface between the organic semiconductor and the gate dielectric. Recent advances towards realizing ambipolar organic transistors through control of interface electronic structure will be presented. This has enabled realization of ambipolar light-emitting field-effect transistors, in which the position of the recombination zone can be moved to any position along the transistor channel by varying the applied gate, and source-drain voltages. We will also review recent progress towards manufacturing of organic transistor circuits by high-resolution printing techniques.

# **Flexible Polymer Battery Technology**

*Alison Voice, Simon Wellings, Hugh Hubbard and Ian Ward  
School of Physics & Astronomy, University of Leeds, Leeds, LS2 9JT*

## **A B S T R A C T**

Polymer Gel Electrolytes (PGE) based on polyvinylidene fluoride (PVDF), lithium salts and appropriate solvent systems, developed at Leeds University, have been shown to form tough rigid films with conductivities approaching  $10^{-2}$  S/cm. A continuous process has been developed for the construction of rechargeable lithium cells by extruding the PGE as a melt and directly laminating between the anode and cathode electrodes. On cooling, the solid PGE acts as electrolyte and separator and binds the cell laminate together from within requiring no external case. This process has been successfully applied for the fabrication of cells with electrodes developed by SpectraPower Inc. in a commercial process enabling cell laminates with PGE thickness less than 0.05 mm and with energy densities approaching 170 Wh/kg. A prototype manufacturing facility has been set up to produce rechargeable cells of high specific capacity and high energy density. This facility enables rechargeable lithium ion cells to be produced on a continuous process as flat sheets opening the way for novel battery geometries.

Present activities are focussed on attempts to commercialise the technology with the assistance of TECHTRAN and to develop new versions of the polymer gel electrolytes for a wider range of applications, such as smart cards, electrochromics and RFID.

## A Decoupled Carrier Mechanism for Conductivity in Polymer Electrolytes for Lithium Batteries.

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D.C. Apperley,

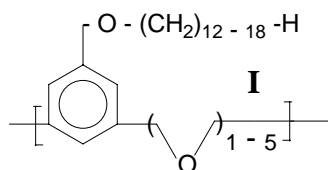
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A Pryke,

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Conventional solvent-free polymer electrolytes, typically based upon amorphous forms of poly(ethylene oxide) (-CH<sub>2</sub>CH<sub>2</sub>-O)-, are well-established as ion conductors in which ion mobility is *coupled* to the motions of the polymer chains, bringing about disintegration and formation of ion-binding sites and generation of free volume. The conductivity may be described by the VTF relationship  $\sigma = \sigma_0 \exp[-B / (T - T_0)]$  where B is a constant and T<sub>0</sub> is a reference temperature related to the glass transition temperature of the polymer-salt system. Within such systems lithium salts LiA (e.g. LiBF<sub>4</sub>, LiClO<sub>4</sub>, Li(CF<sub>3</sub>SO<sub>2</sub>)<sub>2</sub>N) are dissolved in a variety of ionic and aggregated forms, both charged and uncharged and associated or unassociated with the polymer chains, i.e. Li<sup>+</sup>, A<sup>-</sup>, LiA, Li<sub>2</sub>A, Li<sub>2</sub>A<sub>2</sub>, Li<sub>3</sub>A<sub>2</sub>, LiA<sub>2</sub><sup>-</sup>,... Conductivity and solid-state NMR indications of ion mobility thus monitor an overall steady-state of such forms. However, in PEO – based systems the coupled association of free Li<sup>+</sup> with adjacent polyether oxygens dominate the conductivity leading to an inevitable steep decline as the temperature decreases.

The amphiphilic low dimensional polymer **I** systems CmOn : LiA offer the possibility of selectively promoting the formation of certain forms of the lithium salt. The coalescence of



side chains -(CH<sub>2</sub>)<sub>m</sub>-H into hexagonal phases create lamellar structures which are liquid-crystalline (smectic) above the side chain melting temperatures T<sub>m</sub> ~40-52°C. The planes of side chains are interlayered by the skeletal 1,3-phenylenes and polyether loops having n = 1 to 5 oxygens. For n = 1 the polymer is very weakly ionophilic and its almost immeasurably

low conductivity suggests that the salt (1 mol per 2 mol of polymer repeats) is largely present as uncharged aggregates LiA and / or Li<sub>2</sub>A<sub>2</sub>. However, in CmO1 : LiBF<sub>4</sub> (1 : 0.5) <sup>7</sup>Li and <sup>19</sup>F NMR indicate that the uncharged aggregates are highly mobile with NMR linewidths (~0.5kHz) which are virtually independent of temperature between -20 and 60°C without regard for side chain melting at ~50°C. This provides the basis for a *decoupled carrier mechanism* of conductivity at (sub-)ambient temperatures if the uncharged species such as LiA can be ‘doped’ with Li<sup>+</sup> to give charged species such as Li<sub>2</sub>A<sup>+</sup> in which the single charge is now more diffusely carried by a larger complex ion more weakly interacting with channels in the polymer matrix. ‘Doping’ of uncharged species is brought about by copolymerisation with segments of the more ionophilic polymers having n = 4 or 5 (~20mol%) which have significantly greater conductivity than for n = 1 but which exhibit significantly broader NMR linewidths at ambient and sub-ambient temperatures (6-10kHz for <sup>7</sup>Li and 12-13kHz for <sup>19</sup>F) owing to multiple Li<sup>+</sup>... oxygen associations. Li<sup>+</sup> ‘hopping’ may then proceed within channels · · Li<sub>2</sub>A<sup>+</sup> · · LiA · · LiA · · → · · LiA · · Li<sub>2</sub>A<sup>+</sup> · · LiA · · → · · LiA · · LiA · · Li<sub>2</sub>A<sup>+</sup> · ·

However, in crystalline phases of **I** interfacial boundaries present severe barriers to the transfer of ions across the film. A second weakly-ionophilic unstructured polyether (**II**) functions as an ion / aggregate bridge to give overall conductivities in the range 10<sup>-3</sup> to 10<sup>-4</sup> S cm<sup>-1</sup> with low temperature dependence over a wide temperature range. The microphase separated structures of these systems will be described.

# Functional Supported Biomembranes

*Richard J. Bushby  
Centre for Self Organising Molecular Systems  
University of Leeds*

## ABSTRACT

### Aim:-

I will outline the potential areas of application of supported biomembranes and where the field stands. I will include polymer-supported systems (even though these are not the ones we favour)

### Outline:-

Motivation for work in the field  
Methods of supporting biomembranes  
Characterisation  
Ion-channel activity  
Redox membrane proteins  
G-coupled protein receptors (possibly)  
Supported membranes + Cytoskeleton (possibly)  
Supported membranes + Cell wall  
Conclusions

# Polymer applications in tissue engineering and drug delivery

John Haycock

Department of Engineering Materials, University of Sheffield

## ABSTRACT

Our work spans the use of hydrolysable polymers for the tissue engineering of skin and nerve, with parallel approaches to deliver therapeutic drugs from biomaterial scaffolds. We are also developing reconstructed tissue models for the *in vitro* testing of pharmaceutical, industrial and cosmetic chemicals. Hydrolysable polymers have been used as medical implants for several years; however they are seeing an increase in use for creating three dimensional scaffolds in tissue engineering. The processing of scaffolds for tissue reconstruction raises some basic questions regarding structure and organisation. One approach is to create fibres by electrospinning using materials such as polyglycolic acid / polylactic acid blends or copolymers. Random non-woven fibres with these materials are able to support the growth of skin keratinocyte and fibroblast cells together, and enable some degree of cellular organisation. However, these materials can also be organised for engineering other tissues such as peripheral nerve, where the growth and uniaxial direction of Schwann cells is needed.

A second area emerging from this reconstructed tissue work is the development of *in vitro* models for cytotoxicity screening. We have now developed simple electrospun models from polystyrene that enable skin cells containing transfected reporter constructs to grow in 3D. These models have a major advantage in that they respond to test agents that cause an inflammatory response in the body that would otherwise go unnoticed using existing standard *in vitro* test models. A third complementary area in tissue engineering is the local delivery of drugs from engineered scaffolds and implanted devices. We are designing novel anti-inflammatory drugs that can attach to a wide range of biomaterial surfaces that alter the surface properties using calixarene – peptide molecules. When cells come in to physical contact with bioactive surfaces they alter the cellular response to inflammation *in vitro*. Such approaches may therefore have potential in optimising implantable devices where inflammatory rejection is a problem.



# Biomimetic polymeric membrane-enclosed structures

Giuseppe Battaglia

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## ABSTRACT

Today, the ability of biological membranes to form functional and dynamic structures with tuneable size that can vary from a few nanometers (vesicles) up to meters (neurons) has been mimicked by synthetic amphiphiles. New advances in polymeric chemistry and physics have recently allowed the design of a new class of amphiphilic membranes (1) based on amphiphilic block copolymers. These “super” amphiphiles have molecular weight much higher than the biological amphiphiles and therefore they generate highly entangled membranes providing the final structure with improved mechanical properties. This unique structure also has the intrinsic advantage that once it is formed the kinetics of destabilization can be very slow and consequently the lifetime of the supra-molecular structures they assemble is much longer than their biological analogues. Polymeric membranes form assemblies that have remarkable similarities with biological analogues, such as vesicles (1, 2), tubular myelins (3), and tissue-like structures (4). These membrane-enclosed structures have the unique ability to encapsulate hydrophilic compounds within their enclosed aqueous core, hydrophobic compounds within their membranes, and amphiphilic compounds aligned on the hydrophilic-hydrophobic interface. Furthermore, the wholly synthetic nature of such copolymers allows the application of different compositions and functionalities over a limitless range of molecular weights and consequently of membrane thicknesses.

Herein, we present the different routes to control the architecture based on amphiphilic polymeric membranes. Furthermore, how these structures can be of asset for biomedical applications.

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# **Materials Research in the 21st Century**

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## **A B S T R A C T**

Recent breakthroughs in materials research are opening up exciting new opportunities for applications of advanced materials. Areas of particular interest include nanomaterials, hybrid organic-inorganic systems, molecular electronics, and the use of high throughput experimentation. At the same time, patterns of innovation that were established in the 20th century have undergone a transition, especially in relation to the proportion of cutting-edge materials research being done in start-up companies rather than major corporations. We shall explore these issues in the light of evolving global R&D strategies, both for identifying new sources of innovation and for expanding industrial research efforts overseas, particularly into India and China. In addition, we shall look at some of the international trends in both the funding and output of materials research.

# **INNOVATING FOR IMPACT – MARKETING AND TECHNOLOGY PERSPECTIVES**

*Dr. Terri Jordan,  
Global Marketing Director*

*&*

*Dr. John Grasmeyer,  
Global Technology Manager*

*Victrix plc  
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## **A B S T R A C T**

Victrix is the world's leading manufacturer of VICTREX® PEEK™. The company is headquartered in the UK with dedicated sales, market development and technical specialist teams located around the world, and has enjoyed continuing growth in recent years.

This paper will look at delivering “real” innovation – innovation which contributes to profitable growth – and balancing the demands of “market pull” with “technology push” in a dynamic and customer-focused global business environment. How can a common understanding of future market needs and customer “wants” be achieved by both Marketing and Technology functions? How can a market need be translated seamlessly into a development target – and does this mean there is innovation behind it? Is the customer always right? What scope exists for real innovation in a fast-moving commercial environment? We'll aim to discuss these points from both a commercial and a technical perspective. Come prepared to let go of your strongly-held views of innovation, and take on fresh eyes and a curious stance as we explore a new realm of possibilities together!

**“Innovating for a better future  
From making life healthier, simpler and easier  
to  
'things that think'  
[Chemical manufacturing, digital fabrication and technology for the  
individual]”**

**Dr. Raymond Oliver F.R.Eng., F.I.Chem.E  
Director, Science Futures Group  
One NorthEast  
Newcastle upon Tyne  
September 2006**

**Abstract:**

The 21<sup>st</sup> century will be the century of materials! We will by 2100 understand how to fully manipulate and control both the nano and molecular manufacture of materials by design.

Innovation at the interface of Materials and Biology therefore is probably the most important area of applied technology for the foreseeable future and will be a central thrust of 21<sup>st</sup> century technology.

It will produce and enable a huge range of consumer and health related product applications which in turn will lead to even greater integration and use of increasingly invisible material systems and devices, 'around-the-body', 'on-the-body' and 'in-the-body'.

This talk will focus therefore on the convergence of Biology, Polymers and Electronics which will be driven increasingly by the needs of the individual.

How these needs may manifest themselves will be discussed through long term scenarios and trends putting the human at the centre of (all) technology.

Finally, some of these beneficial applications will require new innovative fabrication and manufacturing routes to implementation. A number of these will be highlighted during the talk.

# Synopsis: “Innovation Management: What Technologists Need to Know”

*Dr R Mitchell  
Cambridge and Cranfield Universities*

## **A B S T R A C T**

Every innovation is unique, but the problems of innovating successfully – and particularly of doing so continually – are to some extent generic. There is now an increasing body of academic work which is of proven relevance to practitioners.

In this presentation we first describe a simple framework which separates and clarifies the key issues of innovation management in companies. We then describe a number of issues that technologists wishing to get their innovation adopted should be aware of, and some helpful tools for addressing them.

In most companies, innovation and improvement are not governed entirely, or even mainly, by new products. R and D expenditure is usually less than 10% of a company's turnover, and Research is rarely more than a percent or two. Most product innovation involves incremental improvements to existing lines

Few companies will take on a really new technology unless it offers substantial benefits to offset the effort required to introduce it, and to justify the risk that is inevitably involved. Innovators need to be very clear what the advantages of their products are, and how they can be improved or developed steadily as time goes on. The feature analysis developed by Noriaki Kano is very helpful here.

Innovators also need to understand why obviously excellent ideas often meet far more resistance than expected. All change has a cost – be it physical or psychological – to the individuals involved. This must be balanced by corresponding benefits for the change to be adopted. “Nice to have” improvements seldom fly. The so-called Change Equation of Michael Tushman shows what must be done. The academic study of the diffusion of innovations within society (Everitt Rogers) shines further light on why some innovations fail and some succeed. Successful innovations share certain predictable characteristics.

Finally, a successful new product must make money for the company in the longer term. The work of David Teece shows how a company can recognise new products where they can hope to retain a dominant position from those that are vulnerable to takeover by competitors.

# **AN INNOVATIVE APPROACH TO INNOVATION**

*Sue Nelson*

*Writer and Broadcaster*

## **ABSTRACT**

Author, broadcaster and former BBC science correspondent, Sue Nelson, discusses her creative approach to communicating science - from presenting Radio 4 programmes and co-writing *How to Clone the Perfect Blonde* - to the constraints of reporting television news. Her latest venture is writing science-based dramas so Sue will examine the role a scientist plays in both fiction and the real world with the aim of convincing people that scientists need an innovative approach to getting across scientific and technical innovation.

# MuPP Project

*Tom McLeish, Director, IRC in Polymer Science & Technology*

## A B S T R A C T

The Microscale Polymer Processing Project is the biggest single Polymer IRC project and is funded largest responsive mode ever awarded by EPSRC's Materials Programme. Linking all four IRC sites together with groups in Oxford, UCL and Cambridge, it also benefits from very active involvement and support from a strong industrial partnership: ICI, Lucite International, Innovene, Dow, BASF, Basell, DSM, Mitsubishi. The current 4-year phase of the project is aimed at developing and applying modelling tools, from the molecular to macroscopic levels, to the co-design of new polymers and processes. A key part of its methodology is working with very well-characterised monodisperse and controlled-architecture melts as test-bed for the theoretical programme.

I will review progress in the three "streams" of the project – TOOLBOX (developing and testing the new science and modelling tools generic to the project), 2-PHASE (applying them to the special case of filled and blended polymers) and CRYSTAL (application to the phenomenon of flow-induced crystallization). Highlights include: the identification of chain stretch times and chain overlap as two independent variables in flow-induced crystallization, the prediction of highly polydisperse and multiply-branched polymer melt rheology directly from the catalyst-driven polymerisation chemistry, the modelling of complex flows of comb-polymer melts and the first ever complete non-linear rheology set on a monodisperse polymer melt (of isoprene).

The two key project tools of REPTATE (rheological data and modelling software) and *flowSolve* (viscoelastic molecular-based flow-solving calculator) will briefly be demonstrated.

# Muscular Block Copolymers

*Anthony J. Ryan, Paul Topham, Colin J. Crook, Jonathan R Howse,  
Stephen P. Armes and Richard A.L. Jones.  
Department of Chemistry & Department of Physics and Astronomy,  
University of Sheffield*

## ABSTRACT

A scalable synthetic muscle has been constructed that transduces nanoscale molecular shape changes into macroscopic motion. The working materials, which deform affinely in response to a pH stimulus, are self-assembled block copolymers comprising nanoscopic hydrophobic domains in either a weak polyacid or a weak polybase matrix. Devices have been assembled where the muscle does work on a cantilever and the force generated has been measured. When coupled to a chemical oscillator this provides a free running chemical motor that generates a peak power of 20 mW/kg by the serial addition of 10nm shape changes that scales over five orders of magnitude. It is the nanostructured nature of the the gel that gives rise to the affine deformation and results in a robust working material for the construction of scalable muscle devices. A "push-me pull-you" device has been constructed such that the simultaneous expansion and contraction of polyacid and polybase materials are coupled in response to an oscillating reaction.



# Polymer Processing at the IRC

*Prof Phil Coates FEng  
Associate Director,  
IRC in Polymer Science & Technology,  
School of Engineering, Design & Technology,  
University of Bradford*

There is increasing awareness of the importance of understanding and controlling processing the recognition that processing is a key factor in determining the structure of polymer products, and hence their properties. It is also evident that the current commercial strength of bulk commodity polymers is in part related to the success of modifying these materials, usually involving a processing step such as blending. The Polymer IRC has since its inception essentially been a combination of polymer synthesis, polymer physics and polymer engineering, so has always had a processing aspect. Early programmes included the following:

- (a) melt processing and modelling studies, including process rheometry, which were at the heart of our rheo-optical measurements – and which we have developed into the extensive in-process measurements capabilities across a wide range of leading-edge techniques (and a full computer modelling laboratory strongly supported by the modelling software industry) and in new processing developments, including micro and nano moulding and a range of reactive processing studies; this research is undertaken mainly at Bradford and Leeds, but with extensive collaborations with Durham especially in the MuPP programmes, and with both Durham and Sheffield in associated processing-structure studies;
- (b) solid phase deformation processing and modelling (Leeds and Bradford) which built on orientation processing and constitutive relationship studies; this has continued in strength, including the recent focussing of major solid phase deformation facilities in a new laboratory at Bradford, including our key invention in this area, the die-drawing process, and ongoing finite element modelling, constitutive relationship studies,
- (c) composites processing – short and longer fibre composites, including modelling of strength and fracture behaviour, and extensive studies on orientation prediction for short glass fibre injection moulding; reactive processing of composites (Reinforced reaction injection moulding of a range of polymers and reinforcements including oriented polymers, including developments of processing technologies); the invention of the hot-compaction process (commercialised as CURV); we maintain interests in particular aspects of this work.

All of these areas have involved us in developments of the technology and sensors for controlled processing of melts, solids and composites; materials characterisation under process histories; exploration of adapted or new materials – including a range of biomaterials; and modelling of the processes – all aimed at the high goal of controlled property products.

Some examples of these and recent developments in the polymer processing area will be discussed. The Polymer IRC remains committed to a leading role in the importance of processing in the structuring of successful products.

# Filament Break-up and Drop Formation in Polymeric Fluids

Oliver Harlen and Srinivas Yarlanki

School of Mathematics, University of Leeds

## ABSTRACT

Polymers are increasingly being used as additives in low viscosity liquids, such as the inks used in inkjet printing or agrochemical sprays. Even at very low concentrations the presence of high molecular weight polymers can significantly affect how jets of these fluids break-up into drops.

As surface tension thins the filaments of fluids between drops, the polymer molecules in these filaments become highly extended and resist further extension. This can lead to the so-called “beads-on-a-string” structure where the drops remain connected by a thin strand of fluid in which the viscoelastic stress from the highly extended polymer molecules stabilises the filaments against thinning by surface tension. As well as surface tension and viscoelasticity, both fluid inertia and viscosity are important in determining the position at which break-up occurs and hence the presence and size of satellite drops.

Characterising the relevant rheology of such liquids is challenging, due to low viscosities (1 - 10 mPa s) and high extension rates ( $10^3$ -  $10^4$  s<sup>-1</sup>) involved. One important experimental technique is the capillary thinning experiment, where a liquid bridge is formed between two plates and the extensional stress inferred from the rate at which the filament thins.

Although simplified analyses of these experiments exist, there is a need for full numerical simulations of these flows. In order to do this we have developed a new finite element simulation using a moving grid technique that incorporates fluid inertia, surface tension and viscoelasticity. In this presentation I will show comparisons of the simulation results with simplified analytic models and experimental results.

## **Molecular Self-Organisation and Self-Assembly**

*Robert W Kelsall  
Centre for Self Organising Molecular Systems  
University of Leeds*

### **A B S T R A C T**

Molecular self-assembly and molecular self-organisation are currently enjoying enormous interest as the driving force behind ‘bottom-up’ nanotechnology – the concept of building nanostructures from individual atoms and molecules. At Leeds, we have some 13 years experience of research in various aspects of molecular self-organisation and self-assembly, embodied by the Centre for Self Organising Molecular Systems (SOMS). To date, the main research areas have been discotic liquid crystals, lipid membranes and self-assembling peptides.

Discotic liquid crystals of the triphenylene family have been synthesised at Leeds, and exhibit a range of interesting properties, including self-organisation into a columnar hexagonal phase. The liquid crystal layers are electrically conducting, with a high degree of conductivity anisotropy, leading to proposals of applications as ‘molecular wires’. However, to date, the most successful commercial application has been as optical coatings for liquid crystal displays, to provide increased viewing angles. Possibilities also exist for use in organic field-effect transistors, optical modulators and in chemical sensors.

The SOMS Centre is also investigating the use of supported, suspended and tethered lipid membranes as the basis for biosensors and bio-interrogation devices. These relatively simple membrane structures serve as a well-defined, well-controlled model of real biological membranes. Ion-carrier and ion-channel proteins can be incorporated into the membranes, to permit studies of ion-transport phenomena. Lipid bilayers have been suspended over aqueous reservoirs, with localised access provided by micromachined or lithographically defined apertures, forming prototype sensor systems which are amenable to array scaling.

Research on self-assembling peptides has revealed a hierarchy of spontaneously formed structures including tapes, ribbons, fibrils, fibres and gels. The assembly processes can be triggered by pH, temperature or mechanical stress. Diverse applications are being pursued, including biomineralisation, tissue engineering, drug delivery, and surface coatings.

Future research directions in the SOMS Centre will involve developing strategies for scale-up and control of self-assembly and self-organisation processes, in order that they be harnessed more effectively for practical and commercial applications.

# **Exploiting the Innovator's Dilemma: Making Breakthroughs Happen**

*Eric J. Amis*

*National Institute of Standards and Technology, Gaithersburg, MD  
20899*

## **A B S T R A C T**

When new innovation emerges, it is reasonable that the current technical leaders would be in the best position to capitalize on it. These leaders typically have the most resources, the best ties to the community, and the expertise to know how to promote new breakthroughs. In his provocative book, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Harvard Business School Press), Clayton Christensen showed that precisely because of these supposed advantages, many successful and well-run companies fail when faced with radical innovations. Among other things, they fail to see how breakthroughs that initially yield worse performance can disrupt, and ultimately displace, conventional expertise. Combinatorial and high-throughput methodology may be one of these breakthrough technologies for discovery and optimization in materials science. If "Combi" is a disruptive innovation, how can we exploit it for success? Several examples will be discussed to illustrate applications to polymer physics and polymer chemistry for the generation of libraries of materials and analysis that can be self-reporting, multi-gradient, pseudo-gradient, and beyond.

# WELL DEFINED MULTI END-FUNCTIONALISED POLYMERS AS ADDITIVES TO MODIFY SURFACES AND INTERFACES

*A. Pillay Narrainen, L.R. Hutchings\*, W.J. Feast, I. Ansari, R.L. Thompson & N. Clarke  
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## ABSTRACT

Fréchet-type poly(aryl ether) dendrons with different peripheral groups 'X' and can be attached to a variety of linear polymer chains by modification of the functionality Y at the focus of the dendron see figure 1. For example, if Y is a benzyl bromide group the dendron may be used as an initiator for ATRP. Depending upon the nature of the functional group 'X' at the periphery these materials can be added to a bulk polymer to modify the properties at a surface or interface.

The diffusion of such functionalised polymeric additives through the bulk polymer to a surface/interface has been investigated using ion beam analysis and the effect of these materials on surface properties, for example hydrophobicity/hydrophilicity/lipophilicity has been assessed by solvent contact angle measurements.

A discussion of the synthesis and synthetic possibilities of this system will be presented along with results from the ion beam analysis and contact angle measurements

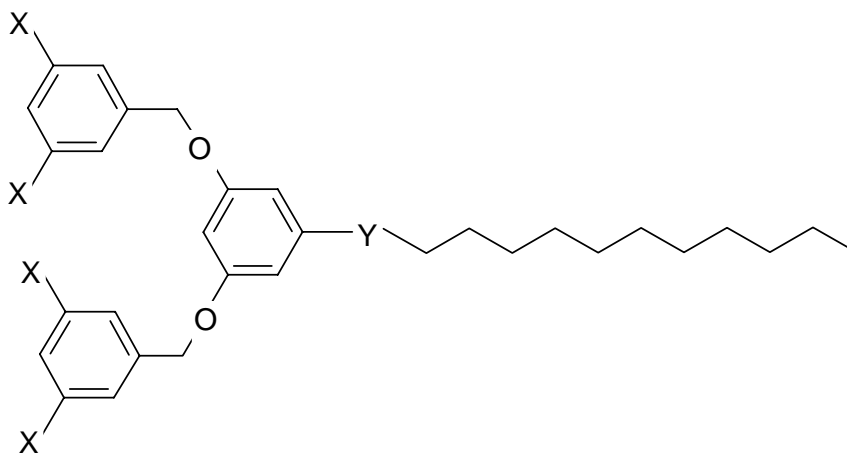


Figure 1. Dendron functionalized polymer

# **Responsive polyelectrolyte layers as smart surfaces and actuators**

*Richard A.L. Jones\**

*Dept of Physics and Astronomy, University of Sheffield*

## **A B S T R A C T**

Polyelectrolyte brushes – systems comprising a single layer of polyelectrolyte molecules grafted by one end to a solid substrate – represent interesting examples of surfaces whose properties can be reversibly tuned by changes of environment. We have studied the responsive properties of weak polyacid and weak polybase brushes, whose conformation and properties can be drastically changed by environmental changes that lead to changes in the degree of charge dissociation. Well characterised, covalently anchored brushes are synthesised by surface initiated living radical polymerisation, and their conformation and properties investigated by techniques such as neutron reflectivity, scanning force microscopy and single molecule force spectroscopy.