

Nanopolymers
13-14 September 2011
Radisson Blu Scandinavia Hotel, Düsseldorf, Germany

Abstracts of the papers to be presented will include:

The market for nanotechnologies

After ten years of intense public funding and some equally intense public scrutiny, nanotechnologies are still far from being a mature. Although great strides have been made in both our understanding of nanoscale phenomena, and our ability to harness them in industrial processes, there are many other emerging technologies competing for scarce public funding.

As other recent emerging technologies such as biotechnology, microelectronics and the Internet have demonstrated, it can take twenty to thirty years for new technologies to have the impact that pundits often initially predict will take two to three years.

Nanotechnology is now reaching the stage where market pull is beginning to be significant, and increasing opportunities exist to deploy the technology is addressing major global risks such as insufficient water, energy and food production.

Tim E Harper, Cientifica, UK

New hybrid nanostructured organic-inorganic polymeric materials with silsesquioxane cores

The aim main of the present work is to discuss the synthesis and some properties of novel hybrid materials based on macromonomers and octafunctional silsesquioxanes (Q_8M_8H). α,ω - or ω -undecenyl macromonomers were first synthesized by anionic deactivation and characterized by SEC to determine molar mass, and by 1H NMR (and Maldi-TOF MS for selected samples) to check composition and functionality. On a second step they were reacted by hydrosilylation with Q_8M_8H , whereupon chemical links are formed between the precursor chains and the spherosilsesquioxane compound to yield novel hybrid macromolecular star-shaped structures constituted of poly(ethylene oxide) (PEO), poly(styrene) (PS), poly(isoprene) (PI), poly(styrene-*b*-isoprene) (PS-*b*-PI) or poly(isoprene-*b*-styrene) (PI-*b*-PS) branches and octafunctional silsesquioxane core (Q_8M_8H). The resulting products were characterized by Size Exclusion Chromatography and static light scattering to assess molar mass and functionality. Well defined octafunctional PS, PI or PS-*b*-PI star-shaped polymers could be prepared. Their solution properties were examined in good solvent for PS stars and in good and selective solvents (for the PI or PS components) for PS-*b*-PI star-shaped polymers. PS and PEO

(poly(ethylene oxide) networks could also be obtained by coupling well-defined α,ω -diundecenyl PS macromonomers (or α,ω -diallyl PEO macromonomers) with octafunctional silsesquioxanes via hydrosilylation. Some results on the behavior of the networks exhibiting octafunctional silsesquioxane crosslinking points will also be presented.

[1] H. Harris, K. Fischer, M. Schmidt, P.J. Lutz, *Polymer Preprints*, 2010, 51 (2) 326.

[2] H. Harris, B. Nohra, O. Gavot, P.J. Lutz, *Macromol. Symp.*, 2010, 291/292, 43.

H Harris, P.J. Lutz, Institut Charles Sadron CNRS/University of Strasbourg, France

NanoFibrillar Cellulose (NFC)-an emerging material for large-scale applications

There has been extensive research and development activities in the field of nanocellulosic materials during recent years, although microfibrillated cellulose was developed already during the late 70s at ITT-Rayonnier in USA.

A major impediment for the large scale use of NFC has been the high energy use (excess of 25000 kWh/tonne NFC) for its energy use. This problem has now been alleviated by a series of different pre-treatment procedures of the fibres prior to the subsequent mechanical cell wall delamination.

Today, there are many companies in the process of commercializing MFC and several pilot plants are available are companies are planning up-scaling. A pilot plant for the nominal production of 100 kg/day (dry based NFC) has also been taken into operation at Innventia AB.

The current contribution will highlight critical issues in the production of NFC and discuss various applications and hurdles to overcome in order to make NFC production for various end-use applications viable.

Tom Lindström, Mikael Ankerfors & Christian Aulin, Innventia AB, Sweden

Impregnating thermoplastics with novel additives by means of a carrier particle

μ -Sq beads are micrometer sized spherical polymer particles that have been commercialised by Exilica Limited. μ -Sq beads have an internal amorphous porous network that allows the beads to absorb a variety of liquid chemicals, including fragrance formulations. The beads are also easily dispersed into common commercial thermoplastic matrices and can be used as transport vehicles to carry chemical actives into such matrices. The beads are robust enough to handle aggressive mechanical compounding processes and are also stable in similar thermal processes up to 300°C. The compounded beads can then slowly release their contents to migrate out through the host matrix. Experimental results in this talk will show the internal porous nature of the beads, and show examples of how the compounded beads can

be used as chemical carriers in thermoplastics with special attention given to fragrances and organic anti-bacterial agents.

Dr Daniel Lynch, Exilica Limited, UK

Nanocomposites for improved flame retardancy - what we know and what is still unsolved

Nanocomposites have been investigated since 15 years as a new material science concept to improve the flame retardancy of polymers. The presentation will give an overview about the mechanism of flame retardancy by organoclays and other nanostructured flame retardants. Advantages of nanocomposites based cables will be highlighted for the new European Directive CPD, which requests improved flame retardancy of products. Also improvements for long life time behaviour, water sensitivity and processing temperatures will be discussed with possible solutions.

Dr Günter Beyer, Kabelwerk, Belgium

The patent situation for nanopolymers

In 2001 the European Patent Office (EPO) has created a working group for monitoring the trends in nanotechnology patenting. Nanotechnology patents presently account for 1% of the total patent applications in Europe, but their number is increasing steadily. The majority of the applications is concerned with nanomaterials, tailored surfaces, sensing and electronics. In the area of nanopolymers the main activity is in the area of nanocomposites. The US and Japan are the big players in the field. In general patents containing nanotechnology of some kind can be searched via the espacenet portal of the EPO. The presentation further contains detailed information on the nanotech patent landscape, the big companies that are active in the area and related products.

Richard Michalitsch, European Patent Office, Germany

Regulatory challenges for nanomaterials in the EU

The presentation will review the existing and upcoming legal requirements for nanomaterials. It will describe the challenges related to the establishment of a definition to support regulatory clarity and legal certainty as the basis of the safe and responsible introduction of these materials in the market.

The presentation will review the legal background in the EU but will discuss these developments in a global context, in comparison with other jurisdictions and international organizations such as ISO and OECD. The presentation will focus on the role of REACH providing the necessary oversight for nanomaterials as a possible regulatory model for other jurisdictions and review the other regulatory instruments used. Finally the presentation will discuss the importance of industry's cooperation in the

establishment of a sensible regulatory framework on harmonized scientific basis, fostering sustainable innovation and production.

Dr Anna Gergely, Steptoe & Johnson LLP , Belgium

Hybrid filler networks in hydrocarbon polymer compounds: the unexpected role of organoclay building blocks

The most promising “new nanomaterials”, such as CNT, Organoclays and Graphene, consist of primary particles which are, at least in principle, individually dispersible in Nanocomposites. On the other hand, “standard nanostructured materials”, such as Carbon Black and Synthetic Silica, consist of rather large aggregates, which play a mayor role in the reinforcing behaviour of such fillers.

Pirelli’s approach to Nanocomposites is based on the development of Hybrid Filler Systems, i.e. of compounds featuring both standard nanostructured fillers and new nanomaterials, in particular Organoclays.

The study of the initial modulus of vulcanised compounds as a function of the Organoclay content gave evidence of the formation of hybrid networks.

The role of the individual Organoclay Building Blocks, i.e. the pristine Clay and the Cationic Surfactant, in the formation of filler networks was investigated: unexpectedly, Ammonium Salts appeared to be the most active filler network promoters.

Michele Coombs^a, Valeria Cipolletti^{a,b}, Maurizio Galimberti^{a,b}, Giannini Luca^a

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Nanostructured polymer films: applications of polymer brushes to colloidal nanocomposites

The talk will focus on the state-of-the-art techniques and strategies for making nanostructured polymer materials and films. Key to the approach is the use of chemical grafting and precursor strategies to nanoscale thin film surfaces - direct attachment of functional polymers on surfaces. This can be done on thin film coatings on flat surfaces to colloidal nanoparticles using surface-initiated-polymerization (SIP) and precursor electropolymerization. The use of surface and interfacial sensitive analytical methods is also key to understanding nanostructuring. A variety of chemistry from living radical polymerization to metathesis polymerization is presented. Patterning and colloidal templating can also be demonstrated as having an effective role in demonstrating phenomena and utility of such materials. Examples of practical and industrial applications will be given on the following: electro-optical display devices,

sensors by imprinting, turn-on an turn-off self-cleaning surfaces, nanocomposite coatings for anti-corrosion and anti-microbial applications.

Prof Rigoberto C.Advincula, University of Houston, USA

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Applications of CNTs and modified nano-clays

The aim in modern car design is to incorporate fast design change, weight reduction, reduced manufacturing steps, greater reliability and easier recycling. Smithers Rapra was a key member of PEGASUS, a European sixth framework program project to assist the European automotive sector achieve this. One of the outputs from PEGASUS was an Integrated Design and Engineering Environment, a knowledge based system, that addressed the issues of car design already listed. The other outputs were new materials and processing techniques. Many of these developments came together in the final demonstration piece for the project. This was a rear panel for the Daimler Smart ForTwo car and incorporated two different nano-materials. The panel was intrinsically coloured with a nano-pigment based on a smectite clay modified with organic dyes. This had the advantages of reduced pigment requirement and improved quality mouldings over conventional pigments. The rear light cluster

included a conducting polymer based on CNTs that could replace some of the metal required, reducing weight and allowing the conductive pathways to be moulded in.

Colin Chilles, Smithers Rapra, UK & Dr Arunee Venables

Biocomposite materials for food packaging and high performance applications

This presentation will focus on two application areas of biocomposite materials where the Institute of Nanotechnology is currently active. Firstly the major elements of nanotechnology developments and the state-of-the-art relating to the use of nanotechnology in biodegradable and edible food packaging has recently been analysed and the findings of this research will be reported. Secondly this presentation will report on the progress of NanoCelluComp, an EU funded 7th Framework Program project that kicked-off in early 2011 which aims to develop a technology that will utilise the high mechanical performance of cellulose nanofibres obtained from food processing waste streams. These cellulose nanofibres can be combined with bio-derived matrix materials for the manufacture of a 100% bio-derived high performance composite material that could replace randomly oriented and unidirectional glass and carbon fibre reinforced plastics in a range of applications including transport, wind turbines, biomedical, sport and consumer goods.

Keith Dingwall, Institute of Nanotechnology, UK

Inno.CNT – a novel cooperation model to conquer new markets for CNT based products

Carbon Nanotubes (CNT) are known for several decades and this class of materials has been an object of intensive scientific and technical investigations in the recent past. Based on exciting scientific results they have achieved enormous attention and attraction within the research community. However, the technology transfer from the laboratory to industrial scale production of CNT took a long time, so that CNT on a commercial scale and quality with competitive prices and suitable properties are just available since few years ago. But despite of diverse highly promising technical opportunities, offered by CNT, and their potential availability the commercial use of CNT based materials and their applications are currently not in that development stage as expected before. Besides of challenges in the technology and application development along the value chain also IP related issues within the complex landscape of patents and also potential HSE issues can be identified as a potential hurdle for the market penetration.

In order to develop the fundamentals for key technologies and applications for CNT and to overcome the challenge of a broad commercialization along the value chain, a cluster of 27 internally interlinked projects with a total budget of app. 90 million € using a partial financial support of the government has been set up in Germany. 90 partners from academia and industry (large, medium and small entities) are participating in that six year runtime interdisciplinary public-private partnership, the Innovation Alliance CNT (Inno.CNT: www.inno-cnt.de).

Three of the projects are cross-sectional platforms considering key technical steps of production, functionalization and dispersion of CNT. 22 Projects are dedicated to develop sustainable uses of CNT based materials and applications on the field of Electronics, Energy/Environment, Mobility and Light Weight Construction. Finally two cross sectional projects are taking care of Health, Safety and Environmental issues of CNT in production, use and end of life stages.

The perception on the political level and that of the general public as well is decisive for the final success of the Alliance in delivering commercial viable innovations on several societal relevant fields, e.g. such as energy conversion, saving and storage. Because of that communication of innovation related benefits and especially of serious efforts in making sure that the materials and applications are save within their production and use is a key element within the Alliance.

The presentation will highlight several challenges of the CNT based value chain for energy related applications and exemplary approaches how to overcome them as efficiently as possible.

Dr Péter Krüger, Bayer MaterialScience AG, Germany

Overview of the FP7 project “CONTACT - tailored supply chain development of the mechanical and electrical properties of CNT-filled composites

CONTACT is an “Initial Training Network” (ITN) funded by the European Commission's "Marie Curie" programme. CONTACT involves 10 partner organizations from 7 different European countries and 15 PhD students as well as 3 post docs (<http://www.contactproject.eu/>). The project will run from 1st October 2009 to 30th September 2013. This type of project aims in the education and training of young researchers. The [training](#) aim of CONTACT is to prepare the recruited researchers for careers in the field of nanotechnology. This involves both multi-disciplinary scientific training, secondments in both academia and industry, and courses in complementary ("soft") skills such as language courses in the country of the hosting organization.

The [research](#) aim of CONTACT is the tailored industrial supply-chain development of CNT-filled polymer composites with improved electrical and mechanical properties. This will involve the optimization of CNT synthesis including the doping of the CNTs with hetero atoms and the functionalization of the CNT surface. The dispersion of CNTs in low viscous liquids and the processing of thermoplastic CNT compounds are investigated as well as the modeling and characterization of CNTs and CNT composites. Newly developed technologies will be upscaled for applications in four innovative industrial case studies: civil engineering, wind blades for wind mills, electrically conducting injection molded parts and electrodes for redox-flow batteries.

The paper gives an overview of the project as a whole describing single research topics and showing the interaction between the partner institutions leading to an added value for the training of the PhD

students and improving the results of the individual projects. This will be done by an exemplary presentation of single results and their discussion.

Dr Christof Hübner, Fraunhofer ICT, Germany

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