PLENARY
AND
KEYNOTE
CONTRIBUTIONS
AND
PANEL
DISCUSSION

PL001

DESIGN AND FABRICATE POLYMERIC MEMBRANES FOR WATER REUSE, SEAWATER DESALINATION AND OSMOTIC POWER GENERATION

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Clean water, clean energy, global warming and affordable healthcare are four major concerns globally resulting from clean water shortages, high fluctuations of oil prices, climate changes and high costs of healthcare. Clean water and public health are also highly related, while clean energy is essential for sustainable prosperity.

Among many potential solutions, advances in membrane technology are one of the most direct, effective and feasible approaches to solve these sophisticated issues. Membrane technology is a fully integrated science and engineering which consists of materials science and engineering, chemistry and chemical engineering, separation and purification phenomena, environmental science and sustainability, statistical mechanics-based molecular simulation, process and product design.

In this presentation, we will introduce our efforts on membrane development for water reuse, seawater desalination and osmotic power generation.

PL002

CHANGING LANDSCAPE IN POLYMER RESEARCH: CHALLENGES AND OPPORTUNITIES

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Polymer research landscape has changed significantly in last 15 years. The polymer conversion industries have reached a level of maturity with an almost irreversible impact on fundamental research on polymer processing. No longer do we see full scale reports in current literature on the dynamics of screw extrusion, flow behavior in injection molding, rheological issues of stretch blow molding, or structure formation in film blowing, although no one believes that all fundamental problems in polymer processing have been unequivocally solved. The availability of funding largely dictates the scope of contemporary polymer research. Consequently, a large majority of active researchers are currently pursuing the unknowns in biomaterials processing or materials development in the areas of thin films, nanocomposites, multifunctional materials that change color, emit light, harvest solar energy, change shape on application of stimuli, etc. The fundamental principles of mass, momentum, and energy balances still apply to these new problems, but the length scales of interest are a now a few orders of magnitude smaller than what we are used to. In this talk, several examples will be presented to relate the length and time scales to polymeric materials performance in applications involving hysteresis in rubber compounds, drug delivery, air clarification, and coalescing filtration. In the first example, polymer building block synthesis from monomers and their organization in the mesoporous macroscale structures will be discussed in relation to airborne nanoparticle filtration as well as drug release. In the second example, nanoscale surface engineering of carbon black particles will be discussed with the objective of obtaining low rolling resistance rubber compounds. The third example discusses the use of polymer nanofibers with interpenetrating network morphology in removing water droplets from ultralow sulfur diesel fuel where a balance of surface energy and surface area is a key parameter.

Keywords: polymer processing, nanomaterials, functional materials, mesoporous

PL003

BIOPOLYMERS AND REACTIVE PROCESSING

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Introduction: The purpose of the abstract is to describe the preparation of biopolymers with reactive processing and establish the basic principle for the development of urgently-needed biomaterials with reactive processing.

Methods: Surface modification and reactive extrusion were used to fabricate biopolymers based on the thermoplastic elastomer and polyolefin, the biocompatibility, antibacterial activity and function of the biopolymers were investigated.

Results: We proposed kinetics equations for reactive processing and demonstrated that the grafting reaction and molecular structure of final products were dependent on the "cave effect" of macromolecular initiator, monomer concentration and temperature; Furthermore, we designed novel catalysis and grafting-assistant system to enhance the grafting degree of products to 5 times that of products with conventional system, and paved new way to modify commodity polymers chemically and biologically by the combination of reactive processing and surface engineering.

Based on the fundamental research, we set up the new technology for preparation, industrial assembly and integration of functionalized polyolefin film. The film possessed the antifogging period for more than 14 months. In addition, we established the new technology for reaction assembly, controlling couple reactions between the different functional groups, as well as grafting and in-situ compositing during reactive extrusion. With these new technologies, anti-irradiated and biocompatible biopolymers with high strength and elasticity were developed, which showed the potential to completely replace the polyvinyl chloride (PVC) and eliminate the harm of plasticizers in PVC biomedical supplies.

Discussion: The current knowledge of reactive processing and development of biopolymers were summarized. In addition, how the surface structure affected the biocompatibility and functionality of biomaterials were detailed discussed. The urgently-needed biomaterials in industry and the perspective of biomaterials prepared by reactive processing were proposed.

Keywords: Biopolymers, Reactive processing, Biocompatibility

PL004

INNOVATION – A METHOD MAKES IT EASY!

Roger La Salle

Matrix Thinking, Melbourne, Australia

The word innovation has been so misused in recent time that not only has it’s very meaning been lost, so too the means to undertake innovation in a simply systematic and structured way that always yields an outcome.

The session presents the “how to” of innovation.

Keywords: Innovation, invention, opportunity, matrix thinking, creativity

PL005

THE FUTURE OF MAKING THINGS

Matthew McKnight

Autodesk, Sydney, Australia

Everywhere we look today, we see fundamental changes in how things are designed and made. Across the world and the world's industries things have evolved as new technologies are transforming the way people create products, buildings, infrastructure, stories, and more.

And we know that technology has always disrupted how things are made. And we know that technology will continue to allow customers to break new ground in the way things are designed and made. And this creates new opportunities and challenges for the future going forward and in the ways that we are going to create a better world.

This presentation will give you Autodesk's perspective on three important characteristics of the future of how things are going to be made. First, what sorts of disruptions are shaping the way consumers and producers make buildings, infrastructure, stories, and products? What are the implications of those disruptions for the way we're going to work? And what techniques can we employ to manage those disruptions as we enter upon this new era of making things.

PL006

ADAPTATION OF RECYCLING TECHNOLOGIES AND BUSINESS MODELS FOR PLASTICS IN A CIRCULAR ECONOMY

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Introduction: Over the last 10 years there have been rapid advances in recycling technologies for plastics packaging and the accelerating adoption of these materials in closed loops by brand owners and supermarkets, however there are substantial technical and business challenges facing the recycling and polymer processing industries now and in the near future related to the collection of plastics in developed and developing countries.

Methods: The evolution of closed loop recycling technologies for plastics has been based on high speed automatic sorting to achieve high purities and robust decontamination technologies that can restore the materials to food grade quality. This has been achieved with PET, HDPE and PP by utilizing the concept of a "challenge test" that defines the degree of decontamination that a recycling process can achieve. The emergence of new regulations for food contact recycled plastics in Europe has created a need to be able to distinguish between packaging that has been used for food grade or non-food grade applications in the last cycle. The recycling of films and black plastics is still challenging both economically and technically.

Results: New recycling technologies based on using fluorescent labels have emerged that can sort plastics into categories based on the prior application as well as specifying food grade status. This is specifically required in PET and HDPE food grade recycling where the purity limits have been set at 95% and 99 % respectively by EFSA in Europe. Recent sorting results have shown that high speed automatic sorting can achieve purity levels of at least 99% and yields in the region of 90%.

Discussion: The emergence of recycled polymers of high purity and with consistent physical properties has allowed these materials to be used in place of virgin plastics at levels in the range of 25% to 50%. This has allowed brand owners and product retailers to close the loop on packaging in both food grade and non-food grade applications. While these achievements have been reached for some applications and have created a growing demand for post consumer packaging, there is still a leakage of plastics waste from this cycle that ends up in waterways and oceans creating negative impacts for coastal regions, sea-life and bird-life and ultimately human life. The strategies for limiting and reversing this leakage need to be enacted at international and local levels.

Keywords: Plastics, Recycling, Food-grade, Oceans, Closed-Loop

KN001

ISSUES IN THE EXTRUSION OF LARGE DIAMETER SMOOTH AND CORRUGATED PLASTIC PIPE

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Large diameter PE (Melt Index 0.1-0.3) , PP (Melt Flow Rate about 0.3) and Rigid PVC (K-value 66-68) pipes are used for sewage and storm-water management. Diameters frequently exceed 1000 mm. Double wall pipes with a smooth inner wall and corrugated external wall exhibit enhanced stiffness and certain advantages over concrete and steel installations. Pipes sections are frequently joined by belled couplings at one end, fitting the next. Such pipes are expected to withstand heavy loads as cars, trucks and other vehicles may travel over the soil below which they are buried. They are expected to pass certain compression tests and they are designed to last for at least 50 years without serious reduction of the water carrying capacity and load bearing characteristics.

Single screw extruders are used for PE and PP and counter-rotating twin screw extruders for PVC. The molten polymer must be free of unmelts and of excellent quality as it arrives at the die entry and must have a good melt strength as it exits. Static mixers are usually beneficial for temperature homogenization and gear pumps can also be beneficial for precise output control to the die. Dies are usually of the “spiderleg” variety. Behind the spiderlegs, weldlines form which may have detrimental effects on the mechanical properties. Careful control of temperatures is required in the die to prevent problems associated with heat transfer imbalance. To reduce the cost, Calcium Carbonate filler is frequently added. As a result, the melt viscosity increases and consequently the temperature rise due to viscous dissipation. The end product has increased stiffness and reduced ductility. In PVC extrusions several external and internal lubricants must be added to facilitate the flow and increase the degree of gelation (fusion). Partially melted PVC exhibits some sort of microcrystalline 3D structure and upon recrystallization may not produce a pipe of the required mechanical properties.

Problems associated with weldlines can be minimized by increasing temperature and pressure (longer die). Special spiderleg designs are sometimes used to enhance molecular inter-diffusion across the interfaces forming a weldline. Temperatures must be kept relatively low to avoid polymer degradation and to have good melt strength, which is particularly important for profiled (corrugated) pipes. However, for PVC if the temperature is low the polymer may not be fully fused. There is a narrow operating temperature window for PVC. Calcium Carbonate filler must be used with moderation due to potential negative impact on mechanical properties. For high output of good quality pipe, fillers and other additives must be well dispersed and distributed in the polymer mass and the extruder must be operated under carefully monitored and controlled conditions.

Keywords: Die design, Weldlines, Fillers, Mechanical Properties

KN002

ASSEMBLING BLOCK COPOLYMERS FOR ENHANCED OIL SAFETY AND SPILL RECOVERY

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Accidental spills during oil storage and transportation can cause irrecoverable damage to environments and human health. Recently we have investigated the enhancement of oil safety and spill recovery by use of assembling block copolymers (BCPs) to stabilize high internal phase emulsion (HIPE) gels [1-7]. Oil safety can be enhanced via a novel and safe approach to transform oils into assembled BCP stabilized HIPE hydrogels. The BCP, namely (4-vinyl pyridine)-*block*-poly(ethylene glycol)-*block*-poly(4-vinyl pyridine) ($4VP_m$-EG_n-$4VP_m$) can assemble and significantly stabilize HIPE hydrogels. The assembled BCP is effective to trap a variety of oils, including xylene, toluene, canola oil, blended vegetable oil, gasoline, diesel and engine oil. The volume fraction of the dispersed oil in hydrogels can be up to 89%. Oils trapped in these hydrogels are releasable by tuning pH values of the aqueous phase, and after naturalization the aqueous phase with BCPs is reusable to stabilize HIPE hydrogels. Oil spill recovery can be achieved with assembled sulfonated polystyrene-*block*-poly(ethylene-*ran*-butylene)-*block*-polystyrene (SSEBS) [4-5]. SSEBS reacted with polystyrene-*block*-poly(2-vinyl pyridine), polyproplenimine dendrimers, -NH_2 modified Fe_3O_4 particles or benzoxazine molecule to form polymer organogels with nanostructures. These polymer organogels were used to stabilize HIPE organogels [2-4], and porous polymers (HIPE xerogels) were obtained after removal of water and solvents from the HIPE organogels. These porous polymers have a low density, and the sizes of pores vary from several to tens of micrometres. These xerogels can absorb a variety of oils and organic solvents, showing high absorption rate and absorption capacity. The absorbed oils or organic solvents can be easily recovered by simple squeezing out, and these xerogels can be used over 20 times. The xerogels can be collected with help of a magnet by incorporation of Fe_3O_4 particles. Therefore, assembled block copolymers are also an excellent candidate for enhanced spill recovery.

Keywords: Block copolymer, high internal phase emulsion, oil safety, spill recovery.

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KN003

REMOVAL PROTEINS FROM NATURAL RUBBER LATEX AND APPLICATION

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Introduction: Removal of proteins from natural rubber is one of the key-technologies to cure a serious issue of the latex allergy. i.e. hypersensitive allergy (Type I) which is mediated by immunoglobulin E (IgE). Various techniques to remove proteins from natural rubber have been developed in the last three decades. Among techniques, the deproteinization with urea and surfactant and non-polar organic solvent are of great interest to prepare low-protein and non-protein natural rubber latex. In the present study, an attempt to prepare deproteinized natural rubber (DPNR) with urea, surfactant and acetone was carried out. The protein content of the product obtained was determined through Kjeldahn method. The stability of resulting latex was evaluated through mechanical stability test (MST).

Methods: High ammoniated natural rubber (HANR with nitrogen content of 0.297%) latex was purchased from Golden Hope Plantation. Deproteinization of HANR was made by incubating latex with 0.1%w/w urea, 1%w/w sodium dodecyl sulfate (SDS) and acetone for 1h followed by centrifugation at 12.10^3 rpm. The deproteinized natural rubber latex was dried in reduced pressure at 50ºC for a week (DPNR).

The resulting samples were subject to Kjeldahn test and MST.

Results:

Table 1: nitrogen content of resulting DPNR

Number of centrifugation	1	2	3	4
Sample	DPNR1	DPNR2	DPNR3	DPNR4
Nitrogen content (%)	0.01	0.007	0.005	0.005

Table 2: MST result for resulting sample

Sample	HANR	DPNR1	DPNR2	DPNR3
Time for coagulation (s)	360	720	700	650

Discussion: nitrogen content of natural rubber decreased significantly after incubation with urea and acetone. The MST result shows that natural rubber latex is stable after the removal of proteins. The results confirm the efficiency of urea and acetone onto the removal process.

Keywords: deproteinized natural rubber, natural rubber latex, stability

KN004

ALIGNMENT OF NANO-CARBON MATERIALS BY EXTERNAL FIELDS

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Introduction: Polymers generally have low mechanical and electrical properties compared to structural fibres such as glass fibres and carbon fibres, resulting in poor structural and functional performance in the through-thickness direction of composite laminates. Recent research on nano-reinforcement, such as carbon nanotubes (CNTs), carbon nanofibres (CNFs), and graphene nanosheets (GNS), have indicated promising reinforcement efficiency as well as the ability to enhance electric and thermal properties of the polymers. However, nano-reinforcements are commonly dispersed in polymers by ultrasonication or shear force leading to random distribution and orientation. External fields such as electric and magnetic fields have been shown to offer a convenient approach to preferentially align nano-carbon materials. The aim of this presentation is to report recent progress in aligning and chaining nano-carbon fillers to selectively enhance the mechanical and functional properties of thermoset polymers and fibre composites.

Methods: Nano-carbon materials (carbon nanofibers and graphene nanoplatelets) are first dispersed in liquid epoxy resin before adding curing agent. Alternating electric field is then applied to align the nano-carbon material during the curing process of the epoxy. Mechanical, thermal and electrical properties of the resultant nano-composite material are then measured in directions parallel and perpendicular to the alignment direction.

Results: The electrical conductivity of the nanocomposites with aligned CNFs and GNPs are increased by about ten and seven orders of magnitude, respectively. The percolation threshold of the nanocomposites containing aligned nano-reinforcements is about 50% lower that of their randomly-orientated counterparts. The values of the fracture energy of the nanocomposites containing 0.5 wt% of randomly-oriented CNFs or GNPs increased by up to about 200%, compared to the unmodified epoxy. An additional improvement in fracture energy of up to about 40% has been achieved by aligning the nano-reinforcement transverse to the crack growth direction.

Discussion: The efficacy of the alignment of the nano-reinforcement on the improvement in the electrical conductivity and the fracture energies of the nanocomposites has been found to diminish at higher concentrations of the nanoreinforcement. Further research is needed to align nano-carbon materials of high concentration.

Keywords: Include 2 to 5 keywords at the bottom of your abstract, separated by commas

KN005

FLAMMABILITY OF POLYMER COMPOSITES WITH NATURAL FIBRES

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Introduction: Extensive studies have been carried out on the thermal decomposition and fire resistance of polymeric materials to reduce their high flammability. Although addition of flame retardant (FR) has proven to be effective in fire retardancy, some of them containing halogens, have negative effects on the environment and human health [1]. Thus, it is desirable to develop an environment friendly fire retardant system for polymeric composites. Natural fibres are increasingly being considered as a group of alternative reinforcement materials in composites due to their certain inherent advantages, namely biodegradability and CO_2 neutrality, over the synthetic materials. Wool as a natural protein fibre is naturally a less flammable material because of a relatively high content of cysteine (10 wt%), which is a sulphur containing amino acid, and nitrogen (15-16 wt%) in the fibre [2]. It is also observed that wool fibres produce char in an intumescent manner upon combustion. On the other hand, lignocellulose fibres, such as flax and kenaf, although, which might act as combustion sources in composites, the amount of lignin content can contribute to beneficial char formation and provide a thermal barrier [3]. Therefore, the fire growth can be controlled by selecting suitable combination of materials in the composites. The char-forming tendency of the natural fibres can be increased with the addition of phosphorus based FR [4]. In particular, as a halogen-free intumescent FR, ammonium polyphosphate (APP) contains phosphorus and nitrogen, which can contribute to an improved fire retardancy for polyolefin under combustion [5]. In this research, two different types of natural fibres, namely wool and kenaf, have been selected to investigate the effects of fibres with FRs on the flammability of thermoplastic polymer composites. In addition, the burning behaviour of thermoset polymer composite with natural fibre has also been explored. Standard flammability test methods (e.g. cone calorimeter and UL-94) have been employed to evaluate the fire performance of materials and the char structure has been studied by scanning electron microscope (SEM). A preliminary study has been carried out on fire dynamics simulation and some results will be presented.

Methods: The constituent materials in this research are commercially available polymers, such as thermoplastic PP and thermoset epoxy resin, natural fibres (e.g. wool, kenaf and flax) and other additives, such as APP and maleic anhydride PP. The short natural fibre (average fibre length of 2.9 mm)-PP composites were fabricated by melt blending and compression/injection moulding processes. Furthermore, the resin transfer moulding (RTM) was used to create flax based thermoset polymer composites. The flax fabric and an infusion grade epoxy resin were selected as reinforcement and matrix, respectively.

Thermal characterisations of the raw materials and composites were conducted by thermogravimetric analysis (TGA). Flammability of the neat polymer and composites was examined using the vertical burn test (UL-94) and the cone calorimeter test. In particular, the cone calorimeter provided a large range of quantitative data of fire-reaction properties, such as heat release rates and smoke production, for a detailed analysis of composites flammability. Microstructures of fire residues were also examined under the SEM. In addition, mechanical properties of the composites were evaluated by tensile, flexural and charpy impact tests. Fire simulation was based on a specially developed Fire Dynamics Simulator package.

Results: TGA results, **Error! Reference source not found.**(a), demonstrate that the neat PP does not create any residues, but the addition of wool and APP increases the amount of residues (19.1 %) at 700 °C due to the combined effect of the fibre and FR on char formation. Moreover, the cone calorimeter results indicate that the char forming ability of wool and FR in the composite remarkably reduce the peak heat release rate (PHRR) (81.2 %) compared to that of the neat polymer. **Error! Reference source not found.**(b) shows char surface formed

during the cone calorimeter test. Furthermore, the composite containing wool and FR can also achieve a direct self-extinguishment (V-0 rating). Lignocellulose fibres, such as flax and kenaf, do not produce char as dense as the wool char; however, the presence of lignin in fibres and reaction with FR under combustion lead to effective char formation, thus reducing the composites flammability.

KN006

OVERCOME THE CONFLICT BETWEEN STRENGTH AND TOUGHNESS IN POLYMERS AND COMPOSITES

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Abstract: Strength and toughness are two most important prerequisites for polymer applications. Unfortunately, these two properties are often in conflict [1-2]. In this presentation, an effective and yet practical approach is developed to simultaneously strengthen and toughen poly (L-lactide) (PLLA) using a simple rigid filler-g-rubber "reinforcing element". This element consists of a rigid graphene oxide (GO) sheet covalently linked with poly (caprolactone-co-lactide) (PCLLA) rubbery layer and a PDLA outer layer, which can be easily synthesized and incorporated into PLLA matrix to yield composites with well-tailored GO/PLLA interfaces. It is demonstrated that by adding the "reinforcing element", i.e., GO-graft-rubber-graft-poly (D-lactide), PLLA exhibits much higher tensile strength and toughness, which could be attributed to the rigid GO and rubbery PCLLA working in tandem during deformation, and the strong interaction between PDLA and PLA matrix due to formation of stereocomplex. [3-11] It is further demonstrated that our reinforcing strategy is much better than those tradition methods, i.e. using either rigid filler or rubber particles separately, or the combination of the two. This approach could be considered as a general design principle for reinforcing composite materials where both strength and toughness are the key concerns. Furthermore, theses designed concept has also been successfully demonstrated in various other polymer systems. [12-13]

Keywords: Strength. Toughness. Composites. Polymers.

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KN007

PROCESSING OF WOOD BIOPOLYMER COMPOSITES

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The use of wood plastic composites (WPCs) has been rapidly growing in the past decades. Recently, polyhydroxyalkanoates (PHAs) have received substantial attention as biodegradable and biorenewable polymers with properties very similar to petroleum-derived plastics such as polypropylene. They are particularly attractive for composite applications because of the low melt viscosity for better compounding and the ultimate biodegradability at end of life, regardless of disposal environment. This project represents the first attempt to engineer a high performance wood-biopolymer composite from pulp and paper waste. This aim is to develop an optimised composite formulation through a study on the effect of the inclusion of processing conditions as well as processing additives on pine wood flour or fibre composites with PHA. To explore the commercial viability of the composites, the materials were produced both at laboratory scale and at pilot plant scale using industrially-relevant levels of wood filler loading (50 wt%) through extrusion.

KN008

PROCESSING-INDUCED CLAY ORIENTATION AND MICROMECHANICAL PROPERTIES OF NYLON NANOCOMPOSITES

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Introduction: In this study, the nanoindentation technique is used to study the anisotropy characteristics of mechanical properties of the injection-molded nylon 6 (PA6)/clay nanocomposites. The elastic and plastic properties as well as creep behavior of neat PA6 and its nanocomposites have been comparatively evaluated as a function of clay loading. An attempt has been made to correlate the observed mechanical properties with the morphological changes due to the addition of nanoclay and the injection process.

Methods: The morphologies of the PA6/clay nanocomposites were studied by using a Philips CM300-FEG transmission electron microscope (TEM) under an accelerating voltage of 200 kV. Thin sections (with thickness of about 80 nm) for TEM observations were cut from the cross-section of the injection-molded bars under cryogenic conditions by using a Leica ultramicrotome with a diamond knife. The indentation tests were performed using an UMIS-2000H Nanoindentation system (Australian Scientific Instruments) with a Berkovich indenter (three-faced pyramid diamond).

Results: The indentation results indicate that clay addition enhances the polymer's hardness and modulus with increasing the clay concentration. With addition of only 2.5 wt% of clay, the modulus of the polymer has improved by about 74%, from 1.06 to 1.84 GPa, as compared with its neat counterpart; while with addition of 10 wt% of clay, the modulus is enhanced by approximately 128%. The TEM image clearly shows clay orientation (along the injection flow direction) induced by melt-processing. At higher magnification under TEM, the well exfoliated clay nanoplatelets were clearly observed. TEM image taken from the near-surface region shows the clay distribution pattern in the nanocomposite, illustrating an uneven distribution of clay in the injection-molded sample, as also confirmed by optical microscopy. That is, the content of clay increases from the sample surface to the inner region of the molded specimen. It is, therefore, expected that the inhomogeneous clay distribution in the injection-molded samples could lead to the different distribution of mechanical properties in the material. Nanoindentation is further used to detect the localized deformation behavior, and also enables one to explore the mechanical anisotropy and the hardness/modulus distribution profiles resulted from the melt processing. The orientation of polymer chains and the distribution of clay platelets significantly affect the localized mechanical behavior of the nanocomposites. The hardness and modulus along the injection-molded flow direction are higher than those measured in the direction perpendicular to the melt flow. The nanoindentation results also prove that the core portion of the injection-molded specimens of PA6 and its nanocomposites generally possesses higher hardness and modulus than the outer part of the specimens, which is caused by the processing-induced uneven distribution of both crystallinity and nanoclay within the molded products.

Discussion: The nanoindentation behavior and morphology of the injection-molded specimens of PA6/clay nanocomposites prepared by melt-compounding have been studied. The elastic and plastic properties as well as creep behavior of PA6 and its nanocomposites are comparatively evaluated as the function of clay loading by using nanoindentation technique. The anisotropic characteristics in mechanical properties are studied by indenting the injection-molded specimens in two different directions (i.e. parallel and perpendicular to the injection direction). The uneven distribution of both the clay nanofiller and the crystallinity of the polymeric matrix induced by melt-processing lead to the variation of the mechanical property of the nanocomposites in certain directions and locations within the molded specimens. The microstructural and morphological changes of PA6 upon incorporating with clay nanofiller are evidenced by transmission electron microscopy and small-angle X-ray scattering, which are closely correlated with the anisotropy of the mechanical properties observed by nanoindentation.

Keywords: Nylon, clay, orientation, nanocomposites, nanoindentation

KN009

JUST-IN-TIME BONE-SPECIFIC ADDITIVE BONE IMPLANT MANUFACTURE

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Additive Manufacturing (AM) allows for the generation of highly efficient lattice structures that are not feasible with traditional manufacturing processes. A particularly useful application of AM lattice structures is the fabrication of customized bone implants.

AM lattice structures can be fabricated such that strength and biocompatibility requirements are satisfied. Systematic design of the lattice elements can also ensure that the implant stiffness is statistically indistinguishable from the surrounding bone, thereby eliminating stress shielding effects.

This work reports on research at RMIT on a novel application of AM technologies such that a custom bone implant is designed and fabricated during a surgical procedure for just-in-time implantation. This innovation is especially relevant for osteosarcoma surgery.

KN010

ORIENTATION INDUCED β-IPP CRYSTALLIZATION AND RELATED PHASE TRANSITION

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We have checked the orientation-induced crystallization of iPP by recrystallizing its highly oriented fibres after incomplete melting. Considering that the morphological features of the thin fibres are difficult to be monitored, self-induced crystallization of iPP melts by its homogeneity fibres with varying melting extent was studied. The single iPP fibre/matrix composites were produced by a procedure in which the iPP matrix thin film was first heated to 200 °C for 10 min to erase possible effects of thermal history of the sample on the subsequent crystallization and then moved to a preheated hot plate, where the iPP matrix was kept in the molten or supercooled molten state at the moment of fibre introduction. As the iPP molten or supercooled molten thin layer reached equilibrium at the desired temperature, homogeneous iPP fibres tightly fixed on a metal frame were introduced into the iPP matrix at different temperatures. After introduction of the fibres, the single iPP fibre/matrix composites were moved quickly to another hot plate set at desired temperature for isothermal crystallization.

Through systematic studies, it was found that the kinetic requirement is a sufficient condition only to ensure the growth of the β-iPP crystals, while the fast growing α-iPP crystals will otherwise embed the generated β-nuclei. The local order and environment of the macromolecular chains just before nucleation taking place are important for β-nucleation of iPP. It is suggested that the formation of the β-iPP nuclei is restricted in a certain chain orientation window of the iPP melts. Considering that isochiral chains are involved in the β-iPP crystals, microdomains with isochiral chains may be produced through chains rotation. These isochiral chain aggregates transform into β-iPP nuclei during cooling process and initiate the growth of β-iPP crystals.

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Keywords: Polypropylene, Single polymer composite, Orientation-induced β-crystallization

KN011

ADVANCED MANUFACTURING TECHNOLOGY OF POLYMER REALIZED BY MULTIPLE DIVIDING AND COMBINING OF POLYMER MELT

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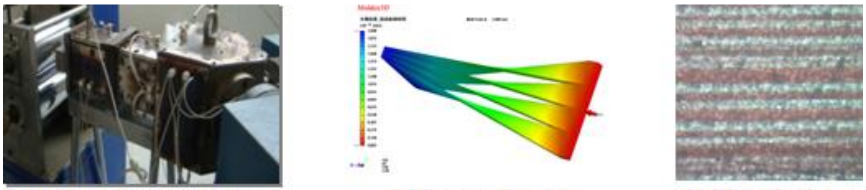
Since the emergence of synthetic phenolic resin in 1907, the synthesis, processing and application of polymer materials have boomed. Polymer materials are becoming increasingly significant in modern manufacturing industry due to their numerous advantages. However, the manufacturing mode in polymer processing is still unchanged: small products are produced by small devices, dies or molds, and large products are produced by huge devices. In order to solve the bottleneck problems in the manufacturing of micro products with high precision and large-sized component with complex construction, a concept of multiple dividing and combining of polymer melt (or can be called “differential and integral method (DI method in brief)” in maths) for advanced manufacturing technology of polymer was proposed. Based on this concept, nanofiber, micro parts, and micro-nano laminated membrane, and giant tyres, and etc were created by applying custom designed mold for melt multiple dividing and combining, and other assisting methods like high voltage or planetary gear pump. For example, micro-nano laminated membrane was created by using parallel units of lamination mold for melt multiple dividing and combining, and the thickness of each layer can be well controlled to reach tens of nanometers. In another implementation, split hot runners were used to generate micro flow melts to supply to the needleless melt electrospinning nozzles, which enabled the mass production of nanofiber from polymer melt. In addition, this idea was also introduced into 3D manufacturing of polymer melt, in which the polymer pellets were directly melt and then divided into controlled micro drops to form complex parts. A series o f new methods of polymer processing and molding, new equipments, and new technologies of product application have been invented based on this concept. Some industrial application results have proved the concept a valuable guide to break through the restriction of traditional manufacturing of polymer melt.

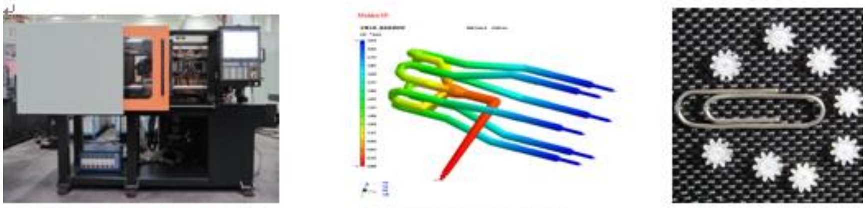
Keywords: polymer melt; multiple dividing, combining, mold



DI Multilayer Extrusion Machine

DI Extrusion Principle

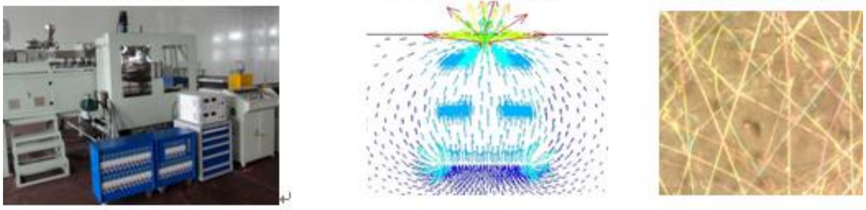
Multilayer Products



DI Injection Molding Machine

DI Injection Principle

Micro Gears



DI Melt Electro-spinning Machine

DI Electro-spinning Principle

Micro-Nano Fibers

FIGURE 1. Equipments, principle, and product of melt DI injection molding, DI nano-composites extrusion molding and melt differential electrospinning.

KN012

FABRICATION OF HIGH-PERFORMANCE STEREOCOMPLEXED POLYLACTIDE PRODUCTS WITH GOOD OPTICAL TRANSPARENCY VIA LOW-TEMPERATURE SINTERING

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Stereocomplexation between enantiomeric poly(L-lactide) (PLLA) and poly(D-lactide) (PDLA) provides an effective way to greatly enhance mechanical strength, heat resistance and hydrolysis resistance of eco-friendly polylactide (PLA). Unfortunately, although the fabrication of semicrystalline polymers including PLA generally involves melt processing at temperatures typically higher than their melting temperatures, it is still a huge challenge to obtain high-performance stereocomplexed polylactide (sc-PLA) products from melt-processed PLLA/PDLA blends due to the poor melt memory effect of stereocomplex (sc) crystallites to restore exclusive sc crystallization after complete melting at an elevated temperature of ca. 240-260 °C, which generally leads to only the formation of a product with mixed homochiral (hc) and sc crystallites, and the substantial thermal degradation of PLA chains induced by this processing. Herein, we report a facile and robust route to address these obstacles by low-temperature sintering of sc-PLA powder at temperatures as low as 180-210 °C for the first time. The results confirm that enantiomeric PLA chain segments can interdiffuse across interfaces of adjacent powder particles and subsequently co-crystallize into new sc crystallites capable of tightly welding the interfaces during the sintering process, thus sc-PLA products with 100% sc crystallites, excellent heat resistance and good transparency have been successfully fabricated. We believe this work could open a new avenue for the design and fabrication of high-performance, optically transparent sc-PLA-based products.

Keywords: polylactide, stereocomplex, sintering

KN013

NEW STATIC EXTENSIONAL MIXING ELEMENTS FOR TWIN-SCREW EXTRUSION: COMPUTATIONAL AND EXPERIMENTAL VALIDATION

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We have recently developed a new type of mixing element for twin-screw extrusion, dubbed the Extensional Mixing Element (EME), for the purposes of imparting extension-dominated mixing on polymer melts during processing. Even though extensional flows are much more efficient in dispersion processes during polymer compounding or blending, most mixing action in standard processing equipment is shear-dominated. The EME was built as a static mixer for the inside of the barrel of a twin-screw extruder, the unit riding along bearings and staying stationary while the rest of the extruder screw spins, forcing material through hyperbolic converging and diverging channels at a specific extension rate.

Here we demonstrate the improved dispersive mixing capabilities of the EME when compared to a standard shear kneading block (KB) in the blending of immiscible polymers (polypropylene/polystyrene blends at 80/20 wt.% ratio and of viscosity ratios up to 10) and the compounding of polymer/carbon nanocomposites with carbon fillers of different morphologies (spherical, high aspect ratio, 2D sheets). The results clearly indicate that the EME configurations show much improved dispersion by comparison with the KB one and, therefore, can be a game-changer in the field of polymer blending and compounding.

Keywords: extensional mixing, twin-screw extrusion, blending, compounding

KN014

BIAXIAL STRETCHABILITY AND FILM THICKNESS UNIFORMITY OF POLYPROPYLENE

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In recent years, polymer film is essential in our lives. Among them, polypropylene has good physical properties, for example, tensile strength, elastic modulus and transparency. Recently, it was found that the stretchability of polypropylene (PP) is improved by blending a small amount of low modulus polypropylene (LMPP). The LMPP is a low tacticity polypropylene. There are a few researches that reported the relationship between dynamics in a stretching process and physical properties. The purpose of this research is to investigate the effect of blending LMPP, which has different characteristic of resin such as tacticity and a molecular weight, on PP and to study the mechanism of the structure formation in a biaxial stretching process.

LMPP blends reduced the yield values during the stretching process and increased the stress build up ratio. As a result, they improved film thickness uniformity of biaxially stretched film and reduced film break during the production line. F300SP:A, S901:B, X901L:C, S400:D

Table1 Characteristic of resins

Sample	Resin	MFR [g/10min]	Mw × 10^5 [g/mol]	Mw/Mn [-]	Tm[℃]
F300SP	i-PP	3	3.6	5.0	160
S901	LMPP	50	1.3	2.0	80
X901L	LMPP	50	1.3	2.0	45
S400	LMPP	2000	0.4	2.0	75

AB,AC,AD mean 5wt%LMPP blends

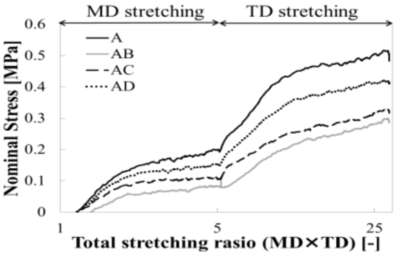

Fig.1 Stress-total stretching ratio curves temperature.

Furthermore, as the stretchable temperature window was widened to low temperature side, the thickness uniformity was improved in the wide stretchable

The blending LMPP to PP reduces the crystallizaton speed, the spherulite size and increases the thickness of amorphous phase in the lamella without changing the thickness of crystal phase, namely melting temperature.
As a result, the blending of LMPP on PP could improve the film thickness uniformity and expand the stretchable temperature width, especially the lower temperature window. The superstructure formation data during stretching process will be also presented in the presentation.

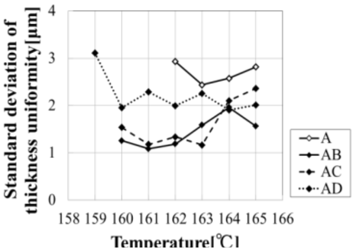

Fig.2 Thickness uniformity & stretchable temp.

Key words: stretchable temperature, thickness uniformity, low modulus polypropylene

KN015

GF/PP INJECTION MOLDING BY DFFIM

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Introduction: Composites has become widely using in recently years especially glass fiber composites. DFFIM is recent developed injection molding system for short fiber reinforced composites. In this system vent type injection machine with controllable unit is used and continues fiber can be inserted vent hole. The continues fiber cut to short fiber in the screw, and finally short fiber in the screw, and finally short fiber composites can be created. There are several merits of DFFIM

- Fiber contents controlled

- Different fibers inserted

- Surface treatment to continues fiber archived

Therefore our own composites can be fabricated. This paper, mainly discussed the influence of filament number of fiber bundles on the glass fiber reinforced polypropylene (GF/PP) composites. Furthermore, we discussed influence of sizing agent adhesion rate on the fiber dispersible in molding by using DFFIM process.

Methods: The injection molding machine (TI-30F6 type clamping force 30t) was made by Toyo Machinery & Metal Co., Ltd., while the vented plasticizing unit and the determination of the resin supply device (Hugrey Feeder HF-Ⅰ type) both were manufactured by Nippon Oil Machine Manufacture Co., Ltd. The glass fiber bundles were EX-1659 series supplied by Nippon Electric Glass Co., Ltd., Japan and which has already sized by Polypropylene (PP). There are two different kinds of glass fiber bundles: each bundle contains 2 000 glass fibers and 4 000 glass fibers respectively and the diameter of glass fiber is 17 micrometer. The PP obtained commercially from Sumitomo Chemical Co., Ltd., Japan, were chosen as resin and its trade name is PP (X101S Homo-polymer). The melt mass flow rate of PP is 30.

Results: It is found out that the filament number of fiber bundles fed has changed, the mechanical properties of GF/PP composites could be different even if they have the same fiber mass contents. It also found that the agglomeration of fibers occurred in composites could be improved through changing fiber bundles number.

Keywords: GFPP, Injection molding, Mechanical property, DFFIM

KN016

THE MOLD IN THE FOCUS

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Introduction: While injection molding machines have been developed to an advanced technological level, in many cases the mold, where the final part is shaped, is only a passive black box. This situation is the motivation to put the mold into the focus of research for improved part quality and process efficiency covering the following topics: simulation, sensors, actuators, multi-component injection molding, microstructured injection molded parts and quality control concepts. In this contribution, selected results from the fields of sensors, actuators and microstructured parts will be presented.

Methods: In a concept study a proof of principle of a wireless in-mold sensor for the detection of the melt front was performed. A movable pin is pushed against a resonant body by the passing melt front resulting in a distinct sound which is transported to the mold surface via structure-borne sound and detected by a microphone. The results are compared with the signal of a conventional temperature sensor.

In the field of actuators a new concept to actively influence the forming of weld lines (especially important for short fiber reinforced materials) is presented. A movable insert redirects the melt front in the region of a weld line and thus influences the shape of the weld line as well as the local fiber orientation. The insert is finally pushed out of the cavity by the increasing melt pressure and is removed to its starting position after demolding by a spring.

For the production of microstructured injection molded parts the filling stage as well as the demolding stage are crucial for optimal part quality and stable process conditions. An instrumented measuring mold was developed to measure the demolding energy as quantitative method to evaluate the influence of polymer, process, structure geometry and mold surface on the demolding process.

Results: The acoustic sensor was able to detect the arriving melt front, even for two cavities using one microphone, but two resonant bodies with different eigenfrequencies to distinguish them.

The actuators used to influence the weld line geometries resulted in impressively improved mechanical properties. The strength at break under flexural load was increased by up to almost 70%.

The results of the developed demolding measurement mold showed for example the capability of mold coatings to improve the demolding or also the different demolding behaviour of different polymers combined with their processing conditions.

Discussion: The contribution shows the importance and potential of the mold in improving or even enabling challenging products. Information from the inside of the mold and, moreover, active intervention of the shaping process in the mold can help extending the possibilities of an advanced injection molding process.

Keywords: Injection molding, sensors, actuators, demolding, microstructures

KN017

EXTENSIONAL FLOW MIXING OF IMMISCIBLE POLYMERS WITH NANOPARTICLE STABILIZATION

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Polymer blending allows one to combine the attractive attributes of two or more polymers while compensating for the unfavourable ones. Most polymer mixtures are thermodynamically incompatible, and blending gives rise to a two-phase microstructure. This morphology generally determines the mechanical and rheological properties of the blend which then determine its applications. Morphology development typically involves deformation of the dispersed phase followed by drop breakup. However, drop coalescence competes with this process, and ultimately there is a balance between these two competing processes. An extensional flow field is known to promote drop breakup and is especially important for viscosity ratios exceeding 3.8, while coalescence is attenuated by compatibilizers that modify the interface between the polymer phases. Nanoparticles with tuned surface chemistry may also be used as compatibilizers. A combination of extensional flow and nanoparticle stabilization should, therefore, result in a fine, stable morphology.

Blend systems examined include polycarbonate (PC)/styrene acrylonitrile (SAN) and polystyrene (PS)/linear low-density polyethylene (LLDPE). However, results are presented primarily on blends of high-density polyethylene (HDPE) dispersed in polystyrene (PS). Here, the viscosity ratio exceeds 3.8 over a very wide range of deformation rates. Coarse blends having a range of dispersed phase concentrations were formulated using shear flow in an internal mixer or in a twin-screw extruder. These were subjected to extensional flow in converging dies of different geometries and where more than one stretching episode was possible; the temperature, total strain and strain rates were varied in a systematic manner. Experiments were repeated in the presence of fumed nanosilica of different sizes and surface treatments that altered the extent of hydrophobicity of the nanoparticles. The mixing sequence was varied including preloading the nanosilica in the thermodynamically non-preferred polymer phase.

Scanning electron microscopy was used to determine the size and size distribution of the dispersed phase. The material was sectioned in the flow direction as well as perpendicular to it. In some cases, PS was dissolved with toluene leaving behind HDPE spheres. It was found that extensional flow reduced the volume-average diameter, especially with increasing strains and strain rates. Finding suitable conditions for the nanoparticles to selectively localize at the HDPE/PS interface was challenging, but relatively small amounts of nanoparticles dispersed in the PS matrix decreased the volume-average diameter of HDPE drops. When the silica was pre-loaded into the HDPE, very coarse initial blends were produced which then exhibited dramatic decreases in phase size with extensional flow. These and other results are properly organized and presented.

Keywords: Extensional flow blending, nanoparticle stabilization, HDPE/PS, fumed nanosilica.

KN018

CARBON NANOTUBES AND GRAPHENE BASED POLYMER NANOCOMPOSITES: RECENT DEVELOPMENTS

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Carbon nanotubes (CNTs) and graphene based polymer nanocomposites have gained enormous research interest in the academic as well as industrial community due to the outstanding traits associated with CNTs and graphene. However, the 'agglomerate' morphology of CNTs (or graphene) in the respective polymer matrix poses a challenge to translate the outstanding properties associated with CNTs/graphene.

In this context, multiwalled carbon nanotubes (MWCNTs) have been 'dispersed' with the aid of an organic modifier; Na-salt/Li salt of 6-amino hexanoic acid (Na-AHA, Li-AHA). Na-AHA modified MWNTs have been shown to exhibit a lower electrical percolation threshold in various polymer matrices, which include polyamide 6 (PA6), polypropylene (PP) and various binary and ternary blends of PP, PA6 and acrylonitrile butadiene styrene copolymer (ABS) blend [1-10]. Moreover, the role of organic modifier in developing hybrid composites of MWCNTs and expanded graphite (EG) will also be discussed. The talk will focus on the 'processing-morphology-property' relationship studies in the respective composites, which may serve as the basis for the development of MWNTs/graphene based polymer composites for industrial applications.

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KN019

SMART MAGNETORHEOLOGICAL SUSPENSIONS: FABRICATION, CHARACTERIZATION AND APPLICATION

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Introduction: Magnetorheological (MR) suspensions are the type of smart and intelligent magneto-responsive materials that possess outstanding phase transition characteristics from a liquid-like to a solid-like state under an applied external magnetic field. Therefore, MR suspensions have been applied for a wide range of industrial applications in the areas such as vibration dampers, microfluidics and shock absorbers. Soft-magnetic carbonyl iron (CI) particles are known to be superior candidate of MR suspensions due to their high saturation magnetization and appropriate particle size, however, they have severe sedimentation problem due to the large density mismatch between the magnetic particles and medium oil. Magnetite (Fe_3O_4) and its composites have also attracted much attention due to the relative low density compared with CI particles. Therefore, our efforts on improving the stability of MR suspensions and MR characteristics of the magnetic particles along with their rheological analysis will be delivered.

Methods: Various polymerization techniques such as dispersion polymerization and Pickering emulsion polymerization in addition to solvent casting were applied for preparing the composites with magnetic core and polymer shell for suitable magneto-response as well as dispersion stability.

Results: Coating the surface of CI particles produced favourable core-shell structure along with apparently decreased density for synthesized composite particles with PMMA, PS, PVB, and PANI (Fig. 1). MR performance of the polymer/magnetic nanocomposites were investigated via steady shear and oscillation mode tests using a rotational rheometer under applied magnetic fields. Yield stress and flow curve were analyzed based on the model equations which are analogous to electrorheological fluids, while their dispersion stability were investigated using a Tubiscan.

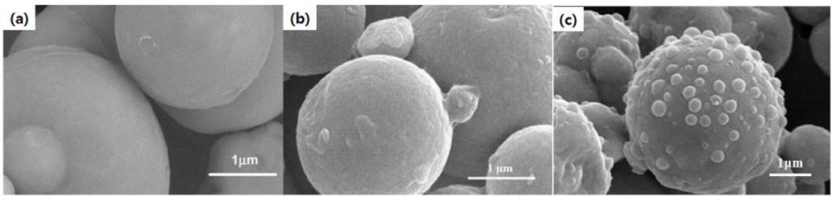

Fig. 1: SEM of magnetic hybrid particles: a) CI/PMMA, b) CI/cross-linked PMMA and c) CI/PS

Discussion: The magnetic hybrid nanocomposites with a polymer is a novel process to decrease the particle density for better dispersion stability. Therefore, the operation of MR suspensions and their re-dispersion could be more controllable, thus bringing a positive influence on their MR properties. In addition, the Pickering emulsion polymerization using iron oxides is considered to be an interesting method for fabricating smart magneto-responsive hybrid materials.

Keywords: Magnetorheological, Suspension, Core-shell, Magnetic particle

KN020

INFLUENCE OF BLENDING, NUCLEATION AND ANNEALING ON MORPHOLOGY AND PROPERTIES OF INJECTION MOULDED POLY (L-LACTIDE)

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Introduction: Polylactide (PLA) is one of the nature based polymers, which is already commercialized for several applications, but it is still strongly under research and development concerning both the polymer basis and the processing technology to overcome some material immanent disadvantages and to ensure optimal structure-property relationships. Because PLA shows a very slow crystallization behavior under high cooling rates - like usual in injection molding - it tends to solidify in the amorphous state that is resulting e.g. in insufficient heat resistance. The disadvantageous brittleness as well as the rather slow crystallization behavior of polylactide (PLA) leading to insufficient mechanical properties and limited application performance can be influenced by different procedures like blending with other polymers, addition of nucleation agents as well as annealing during or after processing.

Methods: Blends of PLA and ethylene-co-vinyl acetate (EVA) were melt mixed using a twin screw extruder ZE25/36D (Berstorff). The blends were injection molded by an injection molding device ES 200/50 HL (Engel). The annealing of the injection molded specimens was realized in a compression molding tool under pressure at specific temperatures. The investigation of melting and crystallization behaviour was performed using a DSC 820 (Mettler Toledo). The phase morphology was characterized by optical microscopy, scanning electron microscopy as well as atomic force microscopy. Mechanical testing was performed using a tensile tester Z005 (Zwick) and impact strength tester HIT 5.5P (Zwick). Heat deflection temperature (HDT) was measured by means of a HDT tester (Coesfeld).

Results and Discussion: Injection molding of PLA with increased crystallinity is only possible by using suitable nucleation agents, but also annealing - especially off-mold annealing - is an advantageous way to improve the crystallinity of PLA parts and their heat resistance and modulus at passable injection molding cycle time. It could be shown that blending of PLA with EVA is a promising way, which leads to PLA blends with heterogeneous phase morphology that results in an improved impact strength. The investigation revealed that only low amounts of EVA (approx. 7.5%) are sufficient to increase the impact toughness of PLA markedly. For the generation of an optimal stiffness-toughness balance the impact modified PLA has been annealed for increasing the crystallinity and Young´s modulus. Annealed PLA-EVA blends did not show a drop-down of the HDT values with increasing EVA content until 7.5 %.

Keywords: PLA, EVA, blends, injection molding, stiffness-toughness balance

KN021

SUPER TOUGHNED BIODEGRADABLE POLYLACTIDE BLENDS WITH NON-LINER COPOLYMER INTERFACIAL ARCHITECTURE OBTAINED *VIA* FACILE IN-SITU REACTIVE COMPATIBILIZATION

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Both industry and academia have shown great interest in biopolymers in recent years, including polylactide (PLA). PLA, which is the main representative of the biodegradable and bio-resourced polymers, is a linear aliphatic thermoplastic polyester that is generally produced through ring-opening polymerization of the lactide monomer that is obtained from the fermentation of renewable resources, such as corn. Although it is expected be a sustainable alternative to traditional petroleum-based plastics, its low flexibility, low impact strength, poor thermal stability during melt processing, low melt strength and slow crystallization rates could limit its widespread application.

In this work, these problems are addressed through a facile melt blending of PLA with a soft and biodegradable polymer, poly[(butylene succinate)-*co*-adipate] (PBSA). *In-situ* compatibilization of these immiscible blends was achieved via melt mixing the blends with a multifunctional reactive oligomer that led to the formation of non-linear copolymer architecture at the interface. Joncryl was used to not only compatibilize PLA/PBSA blends but also to improve the thermal stability, melt strength and crystallizability of the PLA. It was hypothesized that at the interphase of the two polymers, there are *in situ* generated copolymers, which are non-linear due to the multi-functionality of the Joncryl.

Scanning electron microscopy showed a drastic reduction of the dispersed phase size upon compatibilization, even at very low quantities of the chain extender. Rheological probing of the structures revealed gel-like behavior in oscillatory experiments and enhanced viscosities for the compatibilized blends, and long-chain branched topology for the components. The impact strength of PLA improved from 4.6 to 38.4 kJ/m^2 for the blend with 40wt% PBSA and 0.6wt% chain extender. Likewise, the elongation-at-break increased from 6% for PLA to 179% for the blend containing 40wt% PBSA and 0.6wt% chain extender. Importantly, these super-tough blends lost little of their tensile strength while simultaneously exhibiting improved thermal stability and better crystallizability. The toughening is attributed to improved interfacial adhesion and the resultant morphology, while the formation of LCBs enhanced the melt strength, strain hardening and crystal nucleation of the components. The thermal stability is ascribed to the chain extension and hence improved the molecular weight.

In summary, significant improvement in toughness along with the concurrent enhancement of crystallizability, melt strength, strain hardening and thermal stability will expand PLA's applications.

***Keywords**:* Multi-functional chain extender; Polylactide/Poly[(butylene succinate)-co-adipate] blends; Reactive compatibilization, Super-tough

KN022

PHOTODEFORMABLE LIQUID CRYSTAL POLYMERS AND BIOINSPIRED APPLICATIONS

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To mimick the structure and function of biological systems, the search for smart materials that respond to external stimuli with shape or size change has attracted increasing attention. Azobenzene-containing liquid crystal elastomers (LCEs) possess large and reversible shape changes characteristics through the orientation change of liquid crystals (LC) induced by light and allow the temporal, localized, remote and isothermal triggering actuation. Hence, scientists take nature as a best source of inspiration and make it possible to develop diverse light-driven LCE actuators such as walking devices inspired by worms, oscillatory cantilevers inspired by hummingbirds and microrobots that behave like human hands and arms. Recently, stimuli-responsive microactuators were fabricated from LCEs using replica molding technique and inkjet printing technology, which have promoted the development of the field of surface-responsive surfaces where small geometric variations often lead to dramatic changes in surface properties, such as roughness and wettability. However, existing photodeformable CLCPs show poor processibility owing to chemical crosslinking, which thus are incompatible to common solution and melt processing.

Here, we report a new linear liquid crystal polymer (LLCP) with the unique combination of excellent processibility, macroscopic self-organization, mechanical robustness, and reversible photodeformation. The number-average molecular weight of the LLCP reached 3.6×10^5 g mol^{-1}, which is at least one order magnitude larger than generally used azobenzene LC polymers. Tensile tests show that the LLCP fiber owns moderate elastic modulus (96 ± 19 MPa), high toughness (319 ± 41 MJ m^{-3}), high strength (~ 20 MPa) and large elongation at break (2089 ± 275 %). Thanks to the rational structure design and the excellent mechanical properties of the LLCP, we were able, for the first time, to fabricate structurally defined and tubular microactuators (TMAs) via a solution processing method. The microactuators exhibit the good capabilities to propel a wide diversity of liquids over a long distance with desirable velocity by photo-induced asymmetric deformation, which is a conceptually novel principle to precisely manipulate liquids. We further used the LLCP to construct a large nano-structured superhydrophobic surface by electrospun. In initial state, the water droplet rolled down the inclined superhydrophobic mat. Interestingly, the moving water droplets was pinned on any directed area upon UV light irradiation due to the increase of the adhesive force of the irradiated points on the mat. After visible light irradiation, the irradiated area returned to a low adhesion state and thus the droplets could roll down again. We anticipate that the above work will prompt the applications of photodeformable LCPs in fields ranging from controllable micro-scale liquid transfer and micro-reaction systems, to micromechanical systems (MEMS), lab-on-a-chip and beyond.

Keywords: Liquid crystal polymer, Azobenzene, Photoresponsive, Deformation, Microactuator

KN023

ADVANCED PROCESSING TECHNOLOGIES FOR POLY(VINYL ALCOHOL) BASED FUNCTIONAL MICRO/ NANOCOMPOSITES

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Introduction: Poly (vinyl alcohol)(PVA), a multi-hydroxyl polymer with high polarity, has excellent comprehensive properties, especially the good compatibility with most organic and inorganic materials, so is expected to be used as a novel plastic and to prepare environmentally friendly, high performances and functional PVA based micro/nanocomposites without introducing any coupling agents and interfacial modifiers. The key is to establish advanced processing technology to realize its thermal processing and get high performances. In this paper, the novel highly filled PVA based biomedical micro/nanocomposites with high performances were prepared by combing the molecular complexation and the solid state shear milling (S^3M) technologies developed in our research group, and their micro-injection molding processing was studied.

Methods: The melting behaviour of samples was analyzed by using a TA Q20 thermal analyzer (USA) at a heating rate of 10ºC/min from room temperature to 250ºC. The thermogravimetric analysis (TGA) was performed on a TA-Q50 (USA) from 30 to 600ºC at a scanning rate of 10ºC/min under nitrogen atmosphere. The morphology of sample was observed on an Inspect (FEI, Japan) SEM Instrument. Mechanical properties of samples were measured using Instron 4302 tensile tester (USA).

Results: Through molecular complexation formed among amido contained compounds, water and PVA, wide thermal processing window (wider than 80ºC) of PVA was obtained, and environmentally-friendly PVA based biomedical micro/nanocomposites, e.g., PVA/hydroxyapatite (HA), PVA/gelatine/HA and PVA/β-tricalcium phosphate(β-TCP), etc., were prepared in a quite large scale via thermal processing by taking advantages of the pretty good compatibility of PVA and organic and inorganic fillers. By adopting solid-state mechanochemical technology to modify the interfaces of fillers, the dispersion and interfacial compatibility of fillers in PVA were further improved, and high performances of PVA based composites were achieved by adjusting the multi-level structure of PVA products during processing. The micro-injection molding of PVA based composites, especially highly filled PVA based composites, was firstly realized on a MicroPower 5 micro-injection molding machine.

Discussion: Water state was the governing condition for the stable thermal processing of PVA and PVA based composites. The hydrogen bonding formed among PVA, water and amido contained compounds made water exist in PVA matrix as bound water, thus avoiding the intensive evaporation of water and realizing the stable thermal processing of PVA. The interactions of the hydrophilic groups (–OH, PO_4^{2+}) and the metal ion (Ca^{2+}) on the surfaces of the bio-micro/nano particles with water further manipulated the states of water in the composites and made more bound water formed. Therefore, more water could be remained in system and played a role of plasticizing, endowing PVA micro/nanocomposites with wide thermal processing window, wider than 80ºC.

Solid state shear milling (S^3M) based on our self-designed mechanochemical reactor, which acts as the three-dimensional scissors, offering strong shear force in both radial and tangential directions and squeezing force in normal direction, has excellent pulverizing, mixing, and activating effect on the materials in-between. Taking the advantages of the S^3M, the excellent dispersion of bio-micro/nanoparticles, even at high content (40wt%), in PVA matrix was achieved, thus improving the compatibility and processability of PVA based composites. The obtained PVA based composites had high tensile strength and improved water resistance.

PVA based biomedical micro/nanocomposites were typical pseudoplastic fluid, and had low shear viscosity at higher shear rate, satisfying the requirement of micro-injection molding for the high melt flowability. The micro-injection molding of PVA based composites was successfully realized on a MicroPower 5 micro-injection molding machine, the micro-injection molding process was analysed and the effects of the inorganic filler content, the injection speed, pressure and temperature on the structure and properties of the polymer micro-parts were systematically investigated. Under the high shear force and high temperature gradient of micro-injection molding, the micro-injection samples had higher crystallinity and higher mechanical properties as compared with the samples obtained by conventional injection molding. The micro-samples had excellent replication property, good cell compatibility and blood compatibility, and would have potential applications in drug delivery, drug release, articular cartilage, subchondral bone, etc.

Keywords: poly(vinyl alcohol), functional micro/nanocomposites, advanced processing technologies

KN024

FORMATION AND SELF-ORGANIZATION OF SURFACE NANODROPLETS TOWARDS POLYMERIC MICROPATTERNS

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Micropatterns of polymer provide a simple route towards modifying the surface properties and have found use in a diverse array of fields, including microelectronics, optics and biomedicines. It is possible to modify a surface at the nano, micro and the macro scales to produce unique physical characteristics and chemical functionality from microscopic monomer droplets before the polymerization. Polymerizable nanodroplets can be produced on a solid–liquid interface in a simple step of solvent exchange in which a good solvent of oil is displaced by a poor solvent. In our work, we experimentally and theoretically investigate the formation of monomer nanodroplets by the solvent exchange process under well-controlled flow conditions. We find significant effects from the flow rate and the flow geometry on the droplet size. We develop a theoretical framework to account for these effects. The talk will further discuss a basic principle for the symmetrical arrangement of surface nanodroplets during their growth under simple flow conditions. In our model system, nanodroplets nucleate at the rim of spherical cap microstructures on a substrate. We find that, while growing, the nanodroplets self-organise into highly symmetric arrangements, with respect to position, size, and mutual distance. We show and explain how the nanodroplets acquire the symmetrical spatial arrangement during their competitive growth and why and how the competition enhances the overall growth rate of the nucleated nanodroplets. This mechanism behind the nanodroplet self-organisation promises a simple approach for the location control of droplets with a volume down to attoliters. Those monomer droplets can be polymerized, producing desired polymeric microstructures on surfaces.

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KN025

3D PRINTED BIODEGRADABLE CAGE FOR THE TREATMENT OF SEGMENTAL BONE DEFECT

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This study developed a new biodegradable polymeric cage to convert corticocancellous bone chips into a structured strut graft for treating segmental bone defects. A biodegradable truncated-pyramid cage was designed and manufactured to serve as the bone graft. Commercially available PLA filaments with a diameter of 3.0 mm were used as the material for the bone cage 3D printing. The cage was fabricated using a fused-deposition-modeling (FDM) type 3D printer with a printing resolution of 200 mm [1-4]. A total of 24 adult New Zealand white rabbits underwent a left femoral segmental bone defect creation. The experimental results show that higher leg length ratios and 3-point bending strengths demonstrated improved final bony ingrowths within the bone defects for rabbits implanted with the 3D printed cages. Through this bone graft converting technique, orthopedic surgeons can treat segmental bone defects by using bone chips but with imitate characters of structured cortical bone graft.

The present experimental results indicate that using 3D printing PLA can be remodeled into a cage of any geometric shape to fill the bone. With this 3D printed cage, the orthopedic surgeons will be able to convert small corticocancellous bone chips into a structured bone graft to avail both the osteoconductive and mechanical properties. Through this bone graft converting technique, the surgeons can merge different sources of bone graft to serve as an adequate strut bone graft for the treatment of large bone defects without experiencing donor site morbidity and graft resource limitations.

Keywords: biodegradable bone cage; 3D printing; polylactide (PLA); structured strut bone graft.

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KN026

POLY IONIC LIQUID BASED FLEXIBLE ELECTROLYTE PLATFORM FOR CLEAN ENERGY: OPPORTUNITIES AND CHALLENGES

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This presentation will cover the challenges, opportunities and our most recent research endeavour in the development of advanced flexible material for clean energy conversion systems; and our recent findinds in steering the development of functional nanomaterials using click chemistry [1-9]. A profound drawback of the current electrochemical energy storage systems are their inability to operate at temperature higher than 100ºC for extended period due to electrolyte degradation and separator instability. This arises because conventional aqueous or low boiling organic electrolyte used in those systems cannot sustain high temperature. We employed a novel approach in the design of flexible membrane material and use ionic liquids (ILs) in various morphologies. ILs are liquid-phase organic salts (i.e., ionic compounds) with negligible vapour pressure, high thermal stability, and intrinsic solubility. The properties of non-volatility, low toxicity, and especially wide electrochemical potential window (as high as 5 V), make ILs very suitable for applications in electrochemical energy storage and safe electrolytes. Moreover, room temperature ionic liquid (RTIL) derivatives can be made with polymerisable moiety (PIL) that can be processed to films or for making polymer-based flexible electrolyte. Poly(ionic liquid)s (PILs) are a subclass of polyelectrolytes, the repeating unit of which has ionic liquid (IL) character. The incorporation of IL moieties into the polymer chain combines some of the unique characters of ILs with the common features of polymers. Our research shows that the relationship between ionic conductivity and network structure depends on both the concentration of ionic group and network flexibility. The synergistic effect produces immediately a variety of new (multi)functional materials with promising results for a variety of electrochemical applications.

Keywords: Poly ionic liquid, ionic conductivity, flexible electrolyte, clean energy

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KN027

CONTROLLED FOAMING OF POLYPROPYLENE/GAMMA IRRADIATED CROSSLINKED ELASTOMER BLENDS

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Currently a high demand in automotive industries motivated to make a comparative study between the polypropylene/elastomer (radiated and non-radiated) blends along with the effect of compositional variation and processing parameter dependence on foamability of polypropylene. The importance of crosslinking, which is achieved by exposing the elastomer under gamma radiation and therby influencing final foam morphology in foams has been described. The introduction of crosslinked elastomer into the polypropylene matrix improved the foamability of polypropylene. In this study, a film grade polypropylene (MFI=3 g/10min) is used as the base matrix and Vamac Ultra IP as the elastomer. The rheological, mechanical (tensile) and morphological properties of blends are studied by means of parallel plate rheometer; UTM (universal testing machine) and SEM (scanning electron microscopy) respectively. Foaming is done in a high pressure autoclave at three different temperatures using supercritical CO_2 as a blowing agent. SEM analysis and density measurements were done for the foamed samples.

The density of foamed blends decreased with increasing elastomer content. With the increase in elastomer content, domain size of crosslinked elastomer increased in blends and thus led to the bigger cells during foaming process, in spite of having its high gas entrapment capacity for its interconnected chains. Despite having reduced cell growth in PP/uncrosslinked blend (having low gas entrapment capacity); a foam microstructure could be attained with high cell density due to the smaller domains of elastomer in to the PP matrix. Cell size of foams increased with increasing foaming temperature. Foams obtained at 155 °C showed good balance of microcellular structure along with higher cell density. Tensile properties of foams showed a promising improvement and can be correlated with the foam morphology.

Keywords: polypropylene, gamma irradiation, batch foaming, supercritical CO_2

KN028

EVALUATION OF LONG-TERM PERFORMANCE OF PLASTIC PIPES FOR HOT WATER APPLICATION

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Abstract The polymer electrolyte fuel cells (PEFC) residential cogeneration system has been commercialized in Japan. The number of commercialized PEFC cogeneration systems have reached 150, 000 in total in 2015. The expected number of PEFC is 1,400,000 in 2020. The waste heat can be used for hot water supply and central heating. Hot water distribution pipes connecting a gas cogeneration system with the water heater and terminal appliances are very important. As the advanced residential cogeneration system is expensive, the longer lifetime of the heating and hot water supply system is required for consumers, the reliable plastic pipes have been developed. Polyethylene of raised temperature resistance (PERT) as non-crosslinked polyethylene has been used as pipe materials for hot water supply and space heating in Japan as well as conventional cross-linked polyethylene (PEX). In this study, three grades of PERT resin were selected and pipes were extruded with the similar design of antioxidants. The measurement of oxidation induction time and air permeability was conducted after hot water circulation test.

Keywords: polyethylene pipe, hot water circulation test, oxidation induction time, degradation, actual operating condition

Hot water circulation test Figure 1 shows an illustration of the device used in hot water circulation test. The straight and bent pipes specified by ISO 10508 used were 10 mm in the inner diameter, 13 mm in outer diameter, and 2,000 mm in length, and the fittings at both ends of the pipe were made of plastics. Hot water at 110 °C, supplied by the water heater, was constantly circulated. The internal pressure was 250 kPa which is the maximum operating pressure for heating. The circulation rate of the hot water was 2 L/min. The evaluation is continued while checking the deterioration condition by taking out the samples at regular intervals. Also, keeping the constant heating circuit, the circulation water was replaced at 10 L/week in order to sustain the concentration of the dissolved oxygen in the pipe.

Lifetime comparison The lifetime of the pipes at 110 °C at 250 kPa in the hydrostatic stress rupture test was compared with that in the hot water circulation test. As a result, the failure time was 14,705 hours in the hydrostatic stress rupture test, whereas the failure time was 13,452 hours in the hot water circulation test which was approximately 9 % shorter. Figure 2 also shows the OIT changes by DSC with testing time as a parameter of the circulated hot water and hydrostatic hot water. It is considered that antioxidants contained in a resin were eluted into the circulated hot water and the antioxidants were relatively consumed more quickly.

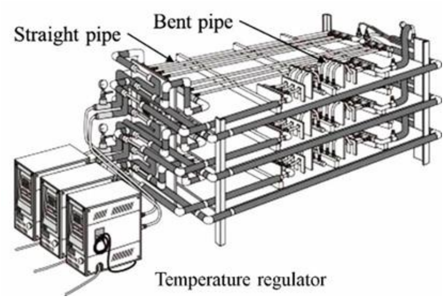

Figure 1 Hot water circulation test.

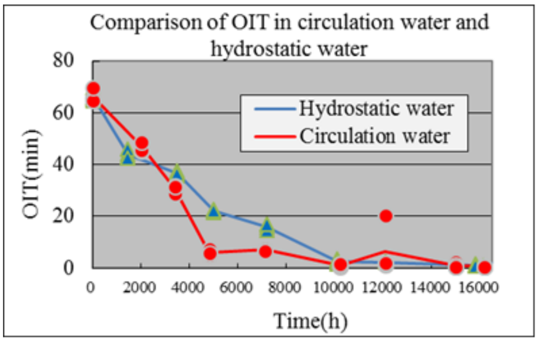

Figure 2 OIT changes with testing time as a parameter of circulated and hydrostatic hot waters.

KN029

APPLICATION OF HEAT TRANSFER CONTROL IN THERMOPLASTIC POLYMER PROCESSIN

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It is generally known that the physical properties of polymer material have strong dependency on temperature. Therefore, heat transfer monitoring and its control during the processing is very important (especially for thermoplastic materials), and they are the crucial issues for the stable performance of the final products. From the thermal engineering viewpoint, thermal history of the products can be actively controlled by the knowledge and techniques of the heat transfer engineering. Radiation heating which is essentially different from the conductive or convective heating was applied on probation to improve the polymer processing. In the manuscript, fundamental concept of the radiative heat transfer control for the polymer processing was introduced, and then its effect in several trials was described.

Keywords: Thermoplastic Polymers, Heat Transfer Control, Radiation Heating

KN030

CHARACTERIZATION OF HIGH-STRENGTH FIBERS

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Recent topics regarding the characterization of high-strength fibers will be discussed in this paper. The first topics is on the weathering resistance of high-strength fibers. It is known that strength of some types of high-performance fibers decreases quickly with exposure to sunlight. In some cases, results of acceleration test obtained using weathering test instruments may not match with the behavior occurring under “real situation”. In this research, weathering test of various high performance fibers was performed at the Showa station on East Ongul Island in Queen Maud Land, Antarctica, 69^{o}00’S 39^{o}35’E. Our main interest was on the effect of UVB wavelength of ultraviolet light (280 – 315 nm). In terms of the integrated intensity of sunlight, intensity in summer time is the highest, and those in spring and autumn times are similar, however, because of the formation of so-called “ozone hole” only in autumn time, intensity of UVB is higher in Autumn. We can report only preliminary results this time. Nevertheless, there are indications that some types of high-strength fibers are more susceptible to UVB exposure.

The second topics is on the characterization of high-strength poly(ethylene terephthalate) (PET) fibers utilizing laser Raman spectroscopy. In the course of researches for developing high-strength PET fibers, we have found that the PET fibers of high mechanical performances can be obtained if drawing and annealing processes are applied to the undrawn fibers which is prepared applying the low Deborah number condition in the melt spinning process. Through the modelling of the melt spinning process combining the numerical simulations for spin-line dynamics and course molecular dynamics, we proposed a concept that homogeneous state of molecular entanglement, which can be represented by the narrower distribution of molecular weight between adjacent entanglement points, is the key for the development of high-strength and high-toughness PET fibers. To verify this concept, laser Raman spectroscopy measurements were performed applying tensile load to PET fibers of various mechanical properties. Detailed data analysis for the peak at around 1616 cm^{-1}, which corresponds to the stretching mode of C-C bond in aromatic ring, revealed that the high mechanical performance PET fibers exhibit the characteristics of 1) narrow peak width and 2) small change of peak width under application of tensile load. These results matches with the concept of homogeneous state of molecular entanglement.

Keywords: high mechanical performance fibers, light resistance, poly(ethylene terephthalate) fibers, laser Raman spectroscopy, molecular entanglement

KN031

THERMOCHROMIC COMPOSITE FIBRES CONTAINING LIQUID CRYSTALS FORMED VIA MELT EXTRUSION

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A three-layered composite fibre has been generated via a modified wire-coating melt co-extrusion process. The continuous fibre consists of a thermochromic liquid crystalline (TLC) layer encapsulated between a transparent polypropylene outer sheath and a black polyether ether ketone inner core. The fibres exhibit clear thermochromic behaviour consistent with the behaviour of unincorporated TLCs, and have been formed into a textile.

Introduction: A wide range of fibres and textiles with colour changing functionalities have been developed and explored to date for both sensory and stimuli responsive applications. Various thermochromic systems, which change colour in response to a temperature change, have been harnessed to date for the formation of thermochromic fibrous products. This paper presents a novel method for the incorporation of thermochromic liquid crystalline materials (TLCs) into composite fibres for thermal mapping applications. TLCs have been exploited for accurate thermal mapping applications in medical, industrial and engineering fields

Methods: Seventy micrometer diameter round continuous monofilament PEEK fibre was sourced from Zyex. Two different TLC mixtures were incorporated into the composite fibres. The first was a fully sterol-based ternary mixture containing 20 wt% cholesteryl oleyl carbonate (COC), 40 wt% cholesteryl nonanoate (CN), and 20 wt% cholesteryl 2, 4-dichlorobenzoate (CD). Two methods were used to construct the fibres, a melt co-extrusion process (AB fibre profile) and a modified wire-coating co-extrusion process (ABC fibre profile). A twin screw 16-mm Prism Eurolab XL extruder coupled with a Barrell hot melt pump. A Teledyne Isco Series-D single pump system with thermostated liquid transfer line maintained at 60 °C was also used to deliver the TLC (feed B). These two components were harnessed to feed molten polypropylene (feed A) into a co-extrusion die at controlled rates to overcoat the PEEK fibre (Feed C)

Results and Discussion: The presence of the black inner PEEK core was found to be the key for the clear retention of colour within the fibres against both white and black backgrounds. The temperature-sensitive fibres and textiles can be applied to a variety of thermal mapping applications, such as in the medical and engineering fields, due to the tunable nature of TLCs.

Keywords: Biomedical Polymers, Thermochromic, Liquid Crystal, Co-extrusion, Bandage, Textile,

KN032

OXIDE BASED FLEXIBLE AND STRETCHABLE SENSORS FOR WEARABLE ELECTRONICS

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Introduction: Electronic devices are pervasive, with smartphones and wearable devices becoming the norm. The industry trend is towards lighter, energy efficient, and durable devices. Stretchable electronics, especially those that are wearable, is where the solution lies. Stretchable (and flexible) electronic devices are used in numerous applications ranging from electronics, energy, and healthcare. Integration of multifunctional oxide thin layers in stretchable devices would create enhanced functionality and performance. This integration has been limited by the brittle nature of oxides and high temperature processing requirements. In this work, we demonstrate the integration of a multifunctional metal oxide (zinc oxide, ZnO) on a prevalent, biocompatible, stretchable substrate, polydimethylsiloxane (PDMS). We exploit the microtectonic surface structure of the ZnO thin films that is uniquely obtained on stretchable substrates, to demonstrate high performance sensing devices.

Results and Discussion: A transfer technique presented in our previous work [1] was implemented to fabricate the ZnO/PDMS devices. The process relies on the poor adhesion of platinum to silicon which allows high temperature oxide thin films to be deposited and defined with standard micro fabrication techniques and subsequently peeled-off using PDMS. The microtectonic phenomena govern the stretchability of the thin oxide films. This phenomena occurs when thin, brittle oxide films are incorporated into elastomeric films, the brittle oxide layer forms micrometer-sized plates which overlap and slide over each other.

Oxygen-deficient ZnO films with a microtectonic surface morphology were defined with electrode pairs and operated as conductometric sensors. The oxygen-deficient nature of the ZnO allows for higher adsorption of the test gases (hydrogen and nitrogen dioxide) which directly translates to superior sensitivity. The electrical resistance characteristics of the strained and unstrained microtectonic ZnO/PDMS sensor were acquired *in situ* under sequential exposure to zero air, hydrogen, and nitrogen dioxide. It is seen that the microtectonic sensor shows a higher sensitivity (>20%) and a significantly faster response than the rigid analogue [2]. This is attributed to an enhanced surface area due to the microtectonic morphology which enables larger number of gas molecules to interact with the ZnO surface and also the gas permeable nature of PDMS which further maximizes the exposed area by allowing the diffusion of gas molecules.

The photosensitive nature of ZnO can be utilised for detecting UV radiation. Upon exposure to UV light, the resistance of the device decreases. The oxygen-deficient nature of the ZnO films used in this study attracts ambient oxygen, resulting in its adsorption on to the oxide surface. The microtectonic morphology of the ZnO provides a larger surface area for the oxygen adsorption, and hence, a greater proportion of unpaired carriers. This effect results in enhanced OFF/ON ratios seen in our devices.

Conclusion: The demonstrated gas and UV sensors are transparent, lightweight, stretchable, and highly sensitive. They are relevant for portable hazardous gas detection, due to their low energy consumption, robustness, and curvilinear adaptability. The transfer process is very versatile and the ability to utilize the process to combine any functional oxide material with a stretchable platform allows for a wide range of potentially harmful gases to be sensed. This research is a precursor to practical devices that range from wearable sensors, UV detectors, biocompatible sensors, and high sensitivity environment monitoring.

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Keywords: gas sensors, UV sensors, wearable electronics

KN033

ADVANCES IN DEVELOPMENT AND CHARACTERISATION OF ANHYDROUS PROTON-CONDUCTING POLYMER ELECTROLYTE MEMBRANES

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Introduction: Proton transport has been recognized as an essential process in many biological systems, as well as electrochemical devices including fuel cells and redox flow batteries. Recent advances in characterisation techniques, in particular the combination of quantum chemical calculations and solid-state NMR methods, bring about a more fundamental understanding of the proton transport mechanisms, and therefore allow for a more rational design of new proton-conducting materials.

Methods: Various protic ionic liquids (PIL) and/or organic ionic plastic crystals (OIPC) has been explored as the potential candidates for proton-conducting membranes. To further enhance the mechanical property and electrochemical properties, the anion part of an ammonium based PIL was tethered onto a polymer chain by forming a comb-like polymer. A combination of PFG-NMR and solid-state NMR method was used to study the relationship between the structure and proton transport properties.

Results: A new PIL guanidinium triflate and its composites with triflic acid has been investigated. The proton transport mechanism was elucidated by comparing the diffusion coefficients obtained from NMR and conductivity measurement. A few orders of magnitude enhancement of conductivity is observed upon addition of HTf to the organic solid, and this appears to follow percolation behaviour with a threshold of approximately 2% HTf. Following that, I'll show the structure and properties of a novel all-solid polyelectrolyte membrane, [HN122] [PSTFSI]. The PFG-NMR results show a typical restricted diffusion behaviour for the mobile protons in this polymer membrane. Through a combination investigation of solid-state NMR and PFG-NMR, we were able to show that the superior proton conductivity is closely related to the self-assembled nano-channel structures in the material.

Discussion: 1) Protic ionic liquids are promising candidates for the next generation anhydrous proton-conducting materials. 2) Careful design of the polymer chemistry as well as the resulting nano-scale structure are both crucial to the development of a high-performance anhydrous proton conductor.

Keywords: polymer electrolyte, proton-conducting membrane, NMR

PANEL DISCISSION

CURRENT & FUTURE TRENDS IN PLASTICS

David Francis, *Marketing and Technology Manager*, *Qenos*, *David.Francis@qenos.com* will represent start of the value chain - polymer and trends from Australian perspective

David Kenworthy, *Managing Director, ZEZT and member of Vinidex Executive Team*, *david.kenworthy@zezt.com.au* will represent views of importance to polymer converter

Mitchell Killeen, *Director JV and BD Lyondell Basell*, *Mitchell.Killeen@lyondellbasell.com* for representation on polymer trends from overseas

Prof John Vlachopoulos, *McMaster University, Canada*, *vlachopj@mcmaster.ca* on University/Industry

Questions:

1. The Australian Government is promoting an innovation agenda. How does your organisation define innovation ? Is it different to R&D?

2. Academics are often measured by publications and patents. Research does not always set out to address an identified problem in the market. Companies, on the other hand, are measured by profit, underpinned by new products. What is the best way to balance market driven research and blue sky research?

3. The plastics industry often receives negative press around sustainability. What does sustainability mean to your organisation? How do we ensure that the sustainability message for our industry is accurately reflected to the broader public?

4. What are the required skills and competencies required for polymer engineers and scientists to drive a sustainable polymer industry into the future? How do we ensure that polymer professional will have the right skill set, today and in the future?

5. Several industries have experienced disruptive change that has required rapid evolution of business models, and of products or services. A recent example of this is the introduction of Uber as a competitive force to the taxi industry. What are the potential disruptive changes/threats to the polymer processing industry, considering factors such as the speed of design and change, new materials, process control, and supply chain planning.

Supplementary Question (subject to time)

6. What are the profitability drivers for our industry?