



Symposium 19

Properties after Processing



Predicting the Mechanical Performance of Glassy Polymers directly from Processing Conditions.

Engels Tom A.P.¹, Govaert Leon E.¹, Meijer Han E.H.¹

¹ Eindhoven University of Technology - Eindhoven - the Netherlands
t.a.p.engels@tue.nl

Nowadays, product design is supported by a large number of numerical tools that aid the various steps in the design process. Amongst these tools are numerical codes that allow simulation of mould filling and subsequent cooling in injection moulding, and finite element packages that are able to evaluate the mechanical response of the final product under the desired loading conditions. These two examples illustrate the two design regions that can be distinguished with respect to numerical codes, i.e. the processing of the product and the use of the product. Unfortunately, there is, up till now, no real interaction between the two. The processing region focuses on the melt state and the use region focuses on the solid state, each region requiring its own numerical tools and set of material parameters. It is, however, the processing step which in part determines the behaviour in the solid state. A new method is presented that directly predicts the development of yield strength distributions in injection molded products of glassy polymers. The approach is based on the results of a study on the temperature dependence of the evolution of the yield stress during annealing of polycarbonate below T_g . In combination with the process-related thermal history, derived from numerical simulations of the injection molding process, yield strength values are predicted, including their dependence on the mold temperature used. It is demonstrated that the method quantitatively predicts both short- and long-term failure of polymer products, thus making it a powerful tool for true product optimization.

S19-911

Mechanical Properties of Silica/PMMA Micro Injection Moldings

Hamada Hiroyuki¹, Kobayashi Yuka¹, Yamada Kazushi², Leong Yew Wei¹, Watanabe Takuro³, Suzuki Hajime³, Ito Hiroshi³

¹ Advanced Fibro Science, Kyoto Institute of Technology - Kyoto - Japan, ² Venture Laboratory, Kyoto Institute of Technology - Kyoto - Japan, ³ Yamagata University - Yamagata - Japan
Hhamada1@aol.com

PMMA composites incorporated with silica particles of different sizes were fabricated by using a micro-injection molding machine. A rectangular mold with a cavity thickness of 0.3 mm was used. The state of dispersion was analyzed by using typical optical microscope, SEM and TGA measurements. The silica particles were not distributed uniformly throughout the length of the specimen. In this study, the effects of particle size, injection conditions, and silica particle distribution on mechanical properties were discussed. Tensile properties were examined and it was found that the specimens with non-uniform distribution of silica particles exhibited low tensile strength.



Effects of the processing conditions on the reactive compatibilized PBT/ABS blend toughness prepared by twin screw extrusion

Ambrósio José Donato ¹, Larocca Nelson Marcos ², Pessan Luiz Antonio ², Hage Jr. Elías ²

¹ UFSCar-PPGCEM - São Carlos - Brazil, ² DEMa-UFSCar - São Carlos - Brazil
donato@ccdm.ufscar.br

PBT/ABS blends were prepared by twin screw extrusion using methyl methacrylate-glycidyl methacrylate-ethyl acrylate (MGE) copolymer as a reactive compatibilizer. The compatibilized PBT/ABS blends toughness was evaluated through IZOD impact strength at several temperatures. The blend extrusion was done using different screw profiles and changing the die dimensions. In addition, the screw speed and the feeding rate were changed as extrusion variables. The impact testing specimens were machined from a narrow sheet obtained through a flat die. As the kneading block thickness decreases the room temperature impact strength does not change, however the ductile-brittle impact temperature transition is significantly decreased. By increasing the number of kneading blocks from one to four no impact strength change behavior was observed. The die length has promoted a significant influence on the impact strength behavior for narrower kneading blocks. As the screw RPM was increased the impact strength has shown a decrease along the whole temperature testing range, however no change was observed in the ductile-brittle temperature transition was observed. The most significant parameter which has promoted larger influence on the impact strength behavior was the feeding rate. For any other condition, as the feeding rate was increased the impact strength and the ductile-brittle temperature transition have shown a strong increase. The PBT/ABS blend morphologies obtained by TEM have shown a very fine morphology, as the ABS disperse phase become smaller and better distributed in the PBT matrix, for the blends obtained at higher feeding rate. As conclusion it can be expressed that both screw profile, die dimensions and, mainly, the extrusion conditions may strongly affect the in situ compatibilized PBT/ABS blend toughness under impact testing.

S19-1021

The Interlamellar Phase Controls the Stiffness of Semi-Crystalline Polymers

Tucker Charles L. ¹, Pham Thu N. ¹

¹ University of Illinois at Urbana-Champaign - Illinois - USA
ctucker@uiuc.edu

This paper is concerned with modeling the effects of process-induced microstructure on properties of semi-crystalline polymers. We show that the properties of the amorphous interlamellar phase, and particularly the variation of these properties with interlamellar spacing, have a profound effect on the small-strain stiffness of semi-crystalline polyethylene. Semi-crystalline polymers are sometimes modeled as two-phase composites, with the crystalline phase viewed as the reinforcement and the amorphous phase viewed as the matrix. A micromechanics model can then predict the overall stiffness as a function of percent crystallinity, crystallite shape and orientation, and crystal and amorphous properties. We examine a wide variety of micromechanics models (Mori-Tanka, self-consistent, differential scheme, etc.) and show that no two-phase model can predict the way that PE stiffness varies with crystallinity. Clearly, this viewpoint misses something important. Recent Monte Carlo calculations by In't Veld, Hutter and Rutledge (*Macromolecules*, 39:439-447, 2006) show that the interlamellar phase in PE can be stiffer than bulk amorphous PE by more than an order of magnitude. This is due to the constraints on chain conformation when the chains are confined between lamella, in a layer approximately 10 nm thick. Interlamellar stiffness should vary with interlamellar spacing, but we only have Monte Carlo data for one spacing. As an approximation, we develop a three-phase model in which the amorphous interlamellar material is modeled as a composite of bulk amorphous PE, sandwiched between layers of amorphous "interphase" PE. By setting reasonable values of the interphase stiffness and thickness, this three-phase model accurately reproduces data of stiffness vs. crystallinity, for both spherulitic PE and as-spun PE fibers. The three-phase model can be extended to treat other products, such as blown films, incorporating structural data from models or experiments.



EFFECT OF CARBON NANOTUBES ON THE PROPERTIES OF FILMS OF POLYPROPYLENE PREPARED BY FILM BLOWING

Iannace Francesca ¹, Acierno Domenico ¹

¹ *University of Naples - Naples - Italy*
fiannace@unina.it

The influence of carbon nanotubes on mechanical and bi-elongational properties of films of polypropylene prepared by means of film blowing technique were studied. The carbon nanotubes (CNT) adopted as fillers were contained in a polypropylene pre-compounded with 20% by weight carbon nanotubes (masterbatch). The tensile properties of the blown films were tested either in the blow-up direction (BD) either the take-up direction (TD). Different tensile behaviours of the blown films were displayed in the two directions as a consequence of the biaxial orientation of molecules during the film blowing. Excellent improvement of the mechanical properties (Young's modulus and strength) for certain weight fraction of CNT of the blown composite films compared to the neat PP were displayed. Furthermore, the bubble formation and stability in the film blowing process of PP nanocomposites are correlated to their underlying rheology, structure, and crystallization behaviour.

S19-285

Effect of molecular weight and distribution on hot tack strength of polystyrene

Miyata Ken ¹, Kakuda Masaki ², Takahashi Tatsuhiro ¹, Sugimoto Masataka ¹,
Taniguchi Takashi ¹, Koyama Kiyohito ¹

¹ *Yamagata University - Yamagata - Japan*, ² *Sanko Gosei Ltd. - Toyama - Japan*
ken@yz.yamagata-u.ac.jp

To investigate relationship between hot tack strength and entanglement behavior, some kind of polystyrene which have mono- and poly- dispersed molecular weight were adopted. Effects of molecular weight distribution on hot tack strength and rheological properties were discussed. Hot tack tests were performed under three different peeling rates with 1.0 to 100 sec of heat seal time for all tests. The surfaces after tests were observed by optical microscope. The number of newly generated entanglements on a polymer chain under several conditions was calculated by measuring dynamic shear viscoelasticity. As a result, we could determine critical generated newly entanglement number to show certain hot tack strength. The number obtained certain hot tack strength was about 1 per a chain. After developing certain hot tack strength, the interfacial failure mode also changes from adhesive failure to cohesive failure.



In-situ assessment of structure evolution in a clay/polymer model system during flow

Reyna-Valencia Alejandra ¹, Deyrail Yves ¹, Bousmina Mosto ¹

¹ *Laval University - Quebec - Canada*
alejandra.reyna.1@ulaval.ca

In this lecture, we will discuss the process of intercalation/exfoliation in clay/polymer nanocomposites using a systematic approach to assess the role of individual shear flow parameters in the development of structural features. The study relies on a unique characterization approach that couples rheology with time-resolved x-ray diffraction and light scattering. Our model system consists of Cloisite 30B and diglycidyl ether of bisphenol A as the polymer matrix. The rheological behaviour of the blends submitted to a given flow history is connected to structural changes via their x-ray diffraction and light scattering signatures obtained simultaneously. Keywords: nanocomposites, shear flow, morphology, kinetics, fundamental characterization, rheo-optical methods.

S19-341

Lifetime predictions of glass fibre reinforced polyamide 6.6 composites and application to construction parts

Geier Simon ¹

¹ *University of Stuttgart - Stuttgart - Germany*
simon.geier@ikt.uni-stuttgart.de

The aging behaviour plays a decisive role in industrial production to ensure long-time quality of polymeric parts. The aging can be divided into physical and chemical mechanisms which require different approaches for exploitation. In the present study, main focus was given to accelerated aging experiments at elevated temperatures (125 to 200 °C in air and 80 to 100 °C in water) using laboratory conditions to predict the lifetime of 30 m.-% glass fibre reinforced polyamide 6.6 tensile bars. Describing the effect of temperature on the reaction kinetics, an Arrhenius-type equation was used to characterize chemical aging mechanisms. For this purpose the impact of aging time and different loading on the mechanical performance of PA6.6 GF30 was determined. The influence of storage time on aging reveals a strong decrease in the impact strength, whereas the elongation at break is less effected. Additionally, the reversible water sorption behaviour and the effect of water content on mechanical properties were studied. Moreover, well-defined aged samples were characterized by means of physical and chemical test methods. Using these information, the analysis of aging states of given polymeric parts subsequent to a practical use can be applied for product optimization and identification of possible aging causes. Finally, an approach is presented to apply the lifetime prediction of tensile bars on small sample geometries, as only available at construction parts, providing a high precision of measurements. By means of a correlation function between impact strength and shear modulus of the aged tensile bars, the experimental shear modulus of the aged parts was converted into impact strength values.



Evaluation of dynamical-mechanical properties of NC2-RTM6 laminates

Cioffi Maria Odila Hilário ¹, Táparo Rafael de Souza ¹, Voorwald Herman Jacobus Cornelis ¹, Rezende Mirabel Cerqueira ², Ambrosio Luigi ³, Ortiz Edmundo Cabral ⁴

¹ UNESP - São Paulo - Brazil, ² AMR-CTA - São Paulo - Brazil, ³ IMBC-CNR - Napoli - Italy, ⁴ ITA-CTA - São Paulo - Brazil
cioffi@feg.unesp.br

Structural polymer composites have been widely applied in the aeronautical field. However, composite processing which uses unlocked molds should be avoided in view of the tight requirements and also due to possible environmental contamination. The Resin Transfer Molding (RTM) process is an optimal option to substitute the more traditional composite molding process considering being a closed-mold pressure injection system which allows faster gel and cure times. This process provide also component quality, process repeatability and production rates optimized due to the potential for automation. Since the mold is closed and the low viscosity resin is injected into the mold, in this process, the edge effect could be promote incomplete wetting of the fiber reinforcement, dry spot formation and other defects in the final composite. Knowledge of material properties is essential to design structures as aircraft landing gear. It is known that the vibration frequency effects on the polymer matrix composites can affect the structure performance. Then, to analyze the frequency dependency is essential to establish the operational range of structure application. In this work, NC2/RTM6 composite has been successfully developed by using RTM process. Viscoelastic material characterization through sinusoidal excitation has been conducted using 2980 TA Instruments dynamic mechanical analysis equipment at different frequency range (1, 5, 10, 100 Hz) and temperature range from 25°C to 250°C. The obtained *results show important correlations. Among them it can be cited a better performance of the laminate with the frequency increase. In this case, the glass transition temperature increase is observed. Non-destructive inspection using ultrasound analyses and morphological aspects observed by optical and scanning electron microscopies are also considered to discuss the dynamical-mechanical results.

S19-548

Is the bulk modulus of thermoset polymers viscoelastic?

Jansen K.M.B. ¹, Patel M. ¹, Saraswat M.K. ¹, Ernst L.J. ¹

¹ TU Delft - Delft - Netherlands
k.m.b.jansen@tudelft.nl

The mechanical properties of a viscoelastic material are characterized by the tensile, shear and bulk modulus as well as the poisson ratio. For isotropic materials only two of these material parameters are required. Experimentally the tensile and shear modulus can be determined most easily but the problem is that due to measurement uncertainties this often results in unreliable (negative) predictions for the poisson ratio and bulk modulus. Viscoelastic simulations are therefore usually performed by implementing the measured viscoelastic elongation modulus in combination with a constant poisson ratio or bulk modulus. Although this is a practical way of dealing with viscoelasticity, it may lead to incorrect predictions since it is well known that the poisson ratio and bulk modulus are temperature and (probably) time-dependent. In the present study we therefore investigated in detail the temperature and time dependency of the bulk modulus for several thermoset polymers, including an unfilled novolak epoxy, a silicon rubber and a highly filled epoxy moulding compound. The materials were subjected to a series of pressure jumps at different temperatures after which the volume changes were recorded. For all materials it was concluded that the time dependency of the bulk modulus was negligible with respect to the effects of temperature and pressure. This time independency is then discussed in relation with the specific volume and the coefficient of thermal expansion.



Structure, deformation and failure of flow-oriented semi-crystalline polymers

Schrauwen Bernard ¹, van Breemen Lambert ², Spoelstra Anne ², Govaert Leon ²,
Peters Gerrit ², Meijer Han ²

¹ DSM Engineering Plastics - Geleen - The Netherlands, ² Eindhoven University of Technology - Eindhoven - The Netherlands
Bernard.Schrauwen@dsm.com

Deformation and failure of thin, injection molded and extruded polyethylene and polypropylene samples was studied. Injection molded samples are loaded in the flow and in the direction perpendicular to flow under both impact and tensile testing conditions, while extruded samples were only subjected to tensile tests. The relation between deformation behavior and flow-induced crystalline orientation was investigated. The amount of orientation was varied by changing the processing conditions. Distribution and structure of flow induced orientations were characterized by optical microscopy, X-ray diffraction techniques and transmission electron microscopy. Hermans' orientation functions were either determined from the flat plate wide angle X-ray diffraction patterns or calculated from full pole figures. Deformation was found to be anisotropic and related to the oriented structure. For all polymers studied, an increase of extended chains (shish) in the loading direction is proposed to cause an increase in the yield stress, and a lamellar structure oriented perpendicular to loading direction leads to an increase in strain hardening. In the extruded samples, were a low level of extended chains and a high level of oriented lamellae was found, the resulting combination of yield stress and strain hardening resulted in homogeneous deformation. Brittle-ductile transitions in impact toughness of the molded samples could also be explained from differences in yield stress and strain hardening. Toughness enhancement was found to be most efficiently with increasing strain hardening and the effect was less pronounced in the polypropylene samples.

S19-692

Structure Development and Replication Properties of Micromolded Plastics Parts in Injection Compression Molding

Ito Hiroshi ¹, Suzuki Hajime ¹, Kazama Kunihiko ², Kikutani Takeshi ²

¹ Yamagata University - Yamagata - Japan, ² Tokyo Institute of Technology - Tokyo - Japan
ihiroshi@yz.yamagata-u.ac.jp

Thin-wall injection molded products with micro-scale prism surface of polycarbonate (PC) were produced by using precision injection compression molding (ICM) process to analyze the effect of molding conditions on the replication of surface pattern and higher-order structure development of products. Flow length was increased by ICM process as compared with injection molding. Compression delay time in ICM, which was defined as to start time after molten resin injection, was the most important for improving flow length. Residual stress was influenced by the compression conditions, and it was increased with increasing the compression delay time. The optical retardation also was influenced by the compression condition. In particular the retardation was decreased at longer delay time. Replication ratio showed higher in comparison with injection molding process. The ratio was also influenced by the compression condition, and the ratio decreased drastically at longer delay time. The replication ratio in the vicinity of the flow end was lower than any other position. Especially the ratio decreased at surface pattern with high aspect ratio of 2.



CORRELATIONS BETWEEN DYNAMIC-MECHANICAL PROPERTIES AND FATIGUE LIFE OF GLASS FIBER-REINFORCED POLYPROPYLENE COMPOSITES COMPATIBILIZED WITH MALEATED POLYPROPYLENE

Sousa José Alexandrino ¹, da Cruz Michelle Christina ¹, Calil Junior Carlito ²

¹ *Materials Engineering Dept., Universidade Federal de São Carlos - São Carlos - SP. - Brazil,* ² *Department of Structural Engineering, Universidade de São Paulo - São Carlos - SP. - Brazil*
jasousa@ufscar.br

Although the influence of maleated polypropylene (PP-g-MAH) compatibilizer on short-term mechanical performance of glass fiber (GF) reinforced PP composites has been well established, very little published literature is available on the influence of the composite interface/interphase characteristics on fatigue properties of these materials under long-term cyclic loading. Thus, in order to obtain quick qualitative data on the influence of PP-g-MAH compatibilizer performance on the fatigue life of 30% short GF-reinforced PP composites, a correlation was established between the properties determined by dynamic-mechanical thermal analysis (DMTA) of composite samples subjected to prior short-term cyclic loading and the experimentally determined fatigue life of these same materials. The main conclusions of this work indicate that the mechanical damping (tan delta) values, related to the fiber-polymer interfacial friction, reduce with PP-g-MAH concentration and levels-off at low compatibilizer content (5%). This decrease in tan delta values with compatibilizer content indicates an increase in the composite interfacial compatibility and was found to be inversely proportional to the number of cycles to failure determined by long-term fatigue testing.

S19-716

Compounding and characterization of amorphous PET nanocomposites

Greco Antonio ¹, Strafella Alessandra ¹, Maffezzoli Alfonso ¹

¹ *University of Salento - LE - Italy*
alfonso.maffezzoli@unile.it

Poly(ethylene terephthalate) (PET) is a low-cost, commodity polymer that finds use in a wide variety of applications in some cases covering even those of performances polymers. Incorporation of nanodispersed clay can have a significant impact on PET properties, including flame resistance, oxygen permeability, elastic modulus [1]. Different techniques are used to produce polymer nanocomposites. Polymer melt intercalation is a promising approach to fabricate polymer-layered silicate (PLS) nanocomposites using conventional polymer-processing techniques. The high melting temperature of PET, and the long mixing times required to achieve good exfoliation, are usually associated to significant degradation of the organic modifier of the nanofiller [2]. In this work, PET based nanocomposite were obtained by melt mixing of organically-modified montmorillonite clay (OMC) with amorphous PET (aPET) at low temperatures (150°C). This compound, loaded up to 30% w/w of filler, is then used as masterbatch with semicrystalline PET. In order to avoid polymer hydrolysis during melt compounding, the static mixer was modified to work under nitrogen atmosphere. Different amounts of nanofiller were incorporated in the amorphous polymer matrix. X-ray analysis showed that intercalation and probably exfoliation take place during static mixing. As a consequence, the nanocomposites showed a significant increase of melt viscosity with respect to the base polymer. Water and oxygen permeability of the the aPET nanocomposites were measured, showing that the incorporation of the nanofiller can significantly improve the transport properties. Also, significant mechanical properties improvement was achieved. Preliminary results on the properties of aPET masterbatch with semicrystalline PET indicated an improvement of PET properties. REFERENCES1 A.Pegoretti, J.Kolarik, C.Peroni, C.Migliaresi, Polymer, 2004,45, 2751-27592 C.H.Davis, L.J.Mathias, J.W.Gilman, D.A.Schiraldi, J.R.Shields, P.Trulove, T



A Study of Shear-Refinement of mechanically treated melts through comparison with Disentangled References obtained from Solutions.

Ibar JP ¹, Allal A. ², Agassant Jean-Francois ³

¹ IPREM-Universite de Pau - Pau - France, ² IPREM-UMR5254 Universite de Pau - PAU 64013 - France, ³ CEMEF Ecole des Mines - Sophia Antipolis - France
jpibar@alum.mit.edu

Shear-Refinement": the observed influence on subsequent viscoelastic behavior (e.g. viscosity) of a pre-shearing treatment of a polymeric melt. While most of the work on Shear-Refinement was done more than two decades ago, and mostly concerned branched Polyolefins [1], recent interest is quickly re-emerging [2-3], and new techniques of shear-refinement are capable of producing large viscosity reduction ratio on a variety of polymers [4-5]. Advances in rheology for the last 40 years, have led to a better understanding of the influence of the chain configuration on its flow characteristics, such as viscosity. The reptation model is in its full maturity stage. Yet, many questions remain for a full understanding of what an entanglement is, in particular to explain the challenging results obtained by shear-refinement, especially under conditions of shear, extensional flow and melt oscillation [4-5]. The incidence of branching on the value of the tube renewal relaxation time might explain some of the shear-refinement results [2], but linear disentangled polymers may present a real challenge to existing models of flow. In this work, disentangled samples of PMMA and PS are manufactured at any desired degree of disentanglement from solution, and their properties (TA, rheology) compared with shear-refined samples obtained from mechanically treated melts. 1. M. Rokudai, S. Mihara, and T. Fujiki, "Influence of shearing history on the rheological properties and processability of branched polymers". *J. Appl. Polym. Sci.*, 23:3289, 1979. 2. S. Bourrigaud, "Etude de la modification des propriétés rhéologiques induite par l'écoulement : application à l'extrusion-couchage », Ph-D, Université de Pau (2004). 3. S. Berger, "Einfluss der Mechanischen Vorgeschichte auf das rheologische Verhalten von Langkettenierzweigtem Polypropylen", Ph_D Thesis, University of Erlangen (2005). 4. J.P. Ibar, "Viscosity Control for Mo

S19-877

Nanoindentation as a method to characterize anisotropy of injection-moulded polypropylene (PP)

Vite Marion ¹, Loubet Jean-Luc ², Mélé Patrice ³, Bec Sandrine ², Albérola Nicole D. ³

¹ LTDS and LMOPS - Lyon and Le Bourget Du Lac - France, ² LTDS - Lyon - France, ³ LMOPS - Le Bourget Du Lac - France
marion.vite@ec-lyon.fr

Nanoindentation is a well-known method to mechanically characterize materials at nano- or micro-scale. The aim of this paper is to show how this technique can be employed to show anisotropy related to different orientations of semi-crystalline polymers. The polymer analysed was an injection-moulded polypropylene (PP). Several studies have previously shown that this process leads to a multilayered structure parallel to the surface of the mould. Nanoindentation enables to correlate mechanical properties at a micro-scale with microstructure of the material determined by differential scanning calorimeter (DSC), densitometry and X-Ray diffraction (XRD), techniques which requires careful handling due to the restricted dimension of each layer and difficulties in sample preparation. More precisely, optical microscopy observations revealed that the polymer structure is complex in the injected parts. Four layers were identified, from the surface to the core of the PP: skin (thickness $t = 30 \mu\text{m}$), shear zone ($t = 80 \mu\text{m}$), holding zone ($t = 200 \mu\text{m}$) and core ($t = 400 \mu\text{m}$). The thicknesses of these different regions depends on the processing conditions. The traditional characterization methods of polymers allowed to highlight the changes in crystallinity in these different zones. Results of nanoindentation tests showed that the skin and the shear zone were more anisotropic than other ones. A preferred orientation was detected perpendicular to the flow direction. Nanoindentation tests also allowed to show that the skin is a complex and a structured phase. At its surface (about $1 \mu\text{m}$ thick) the skin presents a higher elastic modulus and/or hardness compared to the "bulk skin" ($15 \mu\text{m}$ depth). This result can suggest that a particular crystalline structure and/or orientation of polymer chains occurs in this region.



A New Solid-State Constitutive Model for Melt-State Oriented Amorphous Polymer Products

De Focatiis Davide ¹, Buckley C. Paul ¹

¹ *Department of Engineering Science, University of Oxford - Oxford - United Kingdom*
davide.defocatiis@eng.ox.ac.uk

The ability of the designer to predict the solid-state performance of polymer products with process-induced molecular orientation is critically dependent on the existence of constitutive models applicable to both solid and melt states. Additionally, a desirable goal for such models is to incorporate information about the chemical structure of the polymer, such as molecular length or architecture. This enables the concurrent design of compatible materials and processes to produce optimised products with the desired properties. Solid-state constitutive models of polymeric materials have traditionally separated the contributions to the stress into (a) the local glassy interactions and (b) an underlying rubber-like entanglement network. Success in modelling the effects of melt-state processing using this approach relies on empirical equations describing the stretching and relaxation of the entanglement network, and there is little hope for the introduction of molecular awareness. In the work to be described, the evolution of the entanglement network is described by a system of multi-mode Rolie-Poly equations. The glassy interactions are instead governed by a system of representative anisotropic units which orient with the deformation and whose fluidity decreases with increasing orientation. The structure of the material is also modelled, through a set of differential equations involving the evolution of the fictive temperature. Using this approach it is possible to capture the key rheological features of the behaviour of polymer melts and the mechanical response in the glassy state with the same model and parameters. The behaviour of the model is compared with measurements of the solid-state tensile response of monodisperse amorphous polystyrene oriented at a range of temperatures above T_g. Results demonstrate that the new model can adequately capture the effects of a wide range of processing conditions and resulting orientations with the desired molecular awareness.

S19-1011

Effects of Processing Techniques and Fibre Load on the Properties of Wood Plastic Composites

Bouafif Hassine ¹, Koubaa Ahmed ¹, Perré Patrick ², Cloutier Alain ³

¹ *UQAT - Quebec - Canada*, ² *LERMAB - Nancy - France*, ³ *Centre de Recherche sur le Bois - Quebec - Canada*
ahmed.koubaa@uqat.ca

We investigated the relationship between the structure and properties of High Density Polyethylene (HDPE) filled with eastern white cedar wood particles in relation to processing techniques; namely injection moulding, compression moulding and extrusion. Wood particles, having similar size, were compounded into pellets at 25%, 35% and 45% by weight with HDPE using a twin-screw extruder. The obtained pellets were then used to produce test samples through mould injections and mould thermo-compression. Obtained pellets were also processed in a single-screw extruder to produce 1 cm width by 0.5 cm thick sticks. Tensile, impact and three-point bending tests were performed in order to evaluate the performance of the produced composites in the dry and wet conditions according to the different manufacturing techniques. Results indicated significant effect of the processing method on the physical and mechanical properties of the wood plastic composites. For example, injection moulding process led to much higher tensile and flexural strengths compared to the extrusion process. As injection moulding had been used, the flexural and the tensile strength of HDPE had nearly doubled with the addition of 45% wood particles, but they dropped slightly when the extrusion technology was used. Wood plastic composites prepared by injection moulding process showed the lowest moisture uptake and thickness swelling. The higher mechanical properties and better dimensional stability of the injected composites were due mainly to a better wood fiber alignment and dispersion as shown by the Scanning Electron Microscopy (SEM) analysis.



Modeling of Thermal Aging Effects on Mechanical Properties of Graphite/Epoxy Composite Laminates

Ozcelik Orhan ¹, Aktas Levent ¹, Altan M. Cengiz ¹

¹ University of Oklahoma - Oklahoma - USA
altan@ou.edu

During the last three decades, thermal aging of graphite/epoxy composite laminates has been studied in detail. Most studies aimed at generating experimental data for the isothermal aging induced property degradation, such as weight loss and reduction in the laminate strength. Despite the availability of considerable experimental data for isothermal aging, predictive aging models applicable for a time-dependent, arbitrary thermal profile have not been developed. In the present study a differential thermal aging model to predict the weight loss and strength reduction of graphite/epoxy composite laminates is developed. To develop the model, eight identically prepared, 24-ply unidirectional AS4/3501-6 laminates are fabricated in an autoclave at 350°F and 30 psi. More than 600 test specimens prepared from these laminates were isothermally aged at 100, 150, 175, 200, 225 and 250°C. After 2000 hrs of aging at 100, 150, 175, and 200°C, the specimens suffered 1.52, 10.1, 19.4, and 35.7% short beam strength (SBS) reduction, and 0.12, 0.44, 1.29, and 2.95% weight loss. Aging at 225°C caused as much as 60% SBS reduction and 4.98% weight loss after 1775 hrs. The specimens aged at 250°C lost 63% and 3.5% of their initial SBS and weight after 72 hrs of aging. Differential predictive models based on this experimental data were developed that can predict the percentage weight loss and SBS when the laminate is subjected to a non-isothermal, time-dependent temperature profile. Both models were verified by demonstrating that the SBS reduction and weight loss of AS4/3501-6 laminates can be predicted with less than 10% error for various non-isothermal temperature profiles.

S19-1110

Evaluation on the fatigue strength of RTM composite

Costa Midori Yoshikawa Pitanga ¹, Bená Luis Fernando Palhares ¹, Voorwald Herman Jacobus Cornelis ¹, Cioffi Maria Odila Hilário ¹, Prado Viviane Jordão Sano ², Ancelotti Jr. Antonio Carlos ³

¹ São Paulo State University - UNESP-FEG - São Paulo - Brazil, ² Product Development Engineer - Materials Engineering - EMBRAER - São Paulo - Brazil, ³ Materials and Process Development Engineer - Embraer - São Paulo - Brazil
midori@feg.unesp.br

Materials development in the aeronautical industries focused optimized performance and cost reduction of airplanes. The laminate composites are attractive materials due the high specific stiffness and strength. In this research, the carbon fiber-reinforced epoxy composite was manufactured using Resin Transfer Molding (RTM), an advantageous process employed to manufacture components with complex geometries and high finishing quality. The RTM is a closed mold process which avoid toxic volatiles spread around the work environment. On the other hand, the closed mold and the low viscosity resin injected into the mold could cause several kinds of defects, consequently, promotes stress concentration sites and turn complex the mechanical behavior study. Then, the fracture event is depending on kind and the orientation of defects, which are present during the load application. Fatigue resistance is an important property evaluated in mechanical components subjected to cyclic loading as landing gears. Composite materials are inhomogeneous and the mechanisms of damage accumulation include fiber breakage, matrix cracking and delamination. Each reinforcement/resin system must be studied to evaluate the fatigue properties. In this research, fatigue specimens of plain weave carbon fiber reinforcement/RTM6 monocomponent system composite were produced according to the ASTM D 3039. Axial fatigue tests were carried out according to ASTM D 3479 by an universal testing machine INSTRON 8800 and a sinusoidal load of 10 Hz frequency and load ratio R = 0.1 was applied.



Processing of clay-based polypropylene nanocomposites by melt manipulation injection moulding for improved mechanical performance

Bilewicz Marcin ¹, Viana Júlio C. ¹

¹ *University of Minho - Guimaraes - Portugal*
jcv@dep.uminho.pt

In non-conventional injection moulding, such as shear controlled orientation in injection moulding (SCORIM), high levels of shearing are applied to the molten polymer during the solidification phase. When processing clay-based polymer nanocomposites, these high shearing may be beneficial for a higher level of clay orientation and a better dispersion and exfoliation of the nanoclays, thus imparting an improved mechanical behaviour. In this work is investigated the mechanical behaviour of polypropylene (PP) reinforced with different amounts (0, 0.5, 1, 3, 5 and 10 wt%) of nanoclay (montmorillonite, MMT) produced by SCORIM. Conventional injection moulding is also used for comparison purposes. The moulding microstructures are characterised by polarized light microscope (PLM), wide-angle x-ray scattering (WAXS) and transmission electron microscopy (TEM). The mechanical characterization includes flexural and fracture tests at low testing velocity and Charpy impact tests, all tests performed at room temperature. Fracture surfaces are observed by scanning electron microscopy (SEM). Processing and composition modify markedly the microstructure of moulded PP nanocomposites. The addition of MMT affects the microstructure of the mouldings (e.g., skin-core structure, the development of semi-crystalline morphologies, level of clay orientation and deagglomeration). In general, the fracture energy is maximised for an incorporation of 5 wt% of MMT with gains of more than 100% in absorbed energy. The addition of MMT does not change significantly the flexural modulus, but enhance greatly the impact toughness. Low melt temperatures and high shearing times lead to the best mechanical performance. Polymer property reinforcement is determined by the incorporation of nanoclays and by processing, both being highly interrelated.

S19-1292

Processing of Polymer Nanocomposites

SIMON George Philip ¹

¹ *School of Physics and Materials Engineering, Monash University - Victoria - Australia*
george.simon@spme.monash.edu.au

This talk will overview our use of nanoparticles – in particular nanoclay and nanotubes - to both enhance the properties of polymer nanocomposites, and in particular to improve the functionality of the resultant materials. This generally involves making use of more than one of the nanoparticles properties and in some cases looking at the possibilities of synergies in higher order mixtures (compared to just binary blends). The effect of processing on nanocomposites will be stressed, be it injection moulding, weld line behaviour, reactive thermoplastic processing or using more novel techniques such as Equal Channel Angular Extrusion to impose a simple shear system on thermoplastic nanocomposite billets. In nanoclay composites, properties that are influenced include tensile, fracture, gas permeability and fire retardancy behaviour. In the case of nanotubes, this involves electron emission and electrical conductivity, as well as other behaviours such as mechanical properties. In this latter case, the manipulation of the nanotube surface properties is key, and various methodologies we have undertaken with multi-wall carbon nanotubes will be shown.



Understanding of annealing effect on fracture behavior by essential work fracture analysis

Chan Chi-Ming ¹, Lin Yong ¹

¹ Hong Kong University of Science and Technology - Hong Kong - China
kecmchan@ust.hk

In a previous study, we reported that the Izod impact strength of a polypropylene (PP)/nano-sized CaCO₃ (20 wt%) composite increased to 180 J/m after annealing. The impact strength of the annealed samples was close four times of that of un-annealed counterparts. X-ray diffraction spectra revealed that the β phase almost disappeared after annealing, excluding the possibility that high toughness comes from the high-impact-toughness β phase. In addition, in DSC heating curves we observed that the main melting peak shifted up by 3°C and an endothermic shoulder appeared at about 155°C. The endothermic shoulder is attributed to the formation of tangential lamellae, which is supported by transmission electron microscopic observations. We proposed that annealing reinforces the ligament strength by the formation of tangential lamellae and the perfection of crystal domains. The reinforced ligaments promote a higher degree of plastic deformation before crack propagation, leading to an increase in the fracture energy. In order to verify this hypothesis, the fracture behavior of annealed PP/CaCO₃ nanocomposites will be studied by the essential work of fracture (EWF) method. According to the theory of EWF, the total energy needed to fracture a specimen can be separated into two components: the specific essential work (γ) of the fracture, which associates with the energy needed to generate a new surface and the specific plastic work (ϕ) of the fracture, which represents the plastic work involved in a unit deformed volume. If the ligament strength is reinforced by annealing, a higher γ is expected because more energy is needed to destroy a structure with perfect crystals and tangential lamellae. The specific plastic work term, ϕ , is also expected to increase by annealing.

S19-1370

The dynamics of ultra-thin polymer films

D'Amore Alberto ¹, Grassia Luigi ¹

¹ The Second University of Naples – SUN - Aversa - Italy
alberto.damore@unina2.it

Many studies on thin polymeric films are motivated by the advanced nanotechnologies. Polymer films are more reliable in terms of homogeneities than small molecules films because their amorphous structure is virtually free of flaw or even pinholes at nanoscale. Unfortunately thin polymeric films can exhibit a negative coefficient of thermal expansion (NCTE) and unexpectedly large T_g depression with respect to the bulk. These occurrences are difficult to be handled as the T_g is the maximum “service” temperature for a given polymer while unusual thermoviscoelastic behaviour is shown by NCTE. Indeed, such behaviour is observed if the film thickness is lower the nominal random coil diameter (ultra-thin film). The above anomalous behaviour is source of many controversies. Almost all the literature data confirm a relationship between the T_g depression and the molecular weight, M_w, while few data report the existence of stable NCTE correlated with M_w. The controversies are enhanced by the fact that thin films have to be in a glassy amorphous state, which is still an open chapter of Materials Science. In this framework we developed a theory (based on a constitutive link between structural and viscoelastic phenomena) capable of predicting the thermo-viscoelastic response of isotropic glassy materials subjected to thermal and/or mechanical loadings, taking into account the following items: a) thin films are viscoelastic anisotropic structures (during the film formation the macromolecules undergo self-squeezing and bi-axially stretching); b) the film formation process is such that tensile stresses are frozen-in; c) the film glassy structure remains somewhat swollen (about 10% with respect to the bulk structure). Item a) comes from a deep look at the few available experimental data, while items b) and c) come directly from the deGennes conjectures. This approach will show that the anomalies of the ultrathin film can be reliably predicted, a case never appeared before.



Time dependent mechanical behavior of nanofilled thermoplastic vulcanizates

Le Hai Hong ¹, Ilisch Sybill ¹, Heidenreich Daniel ¹, Radosch Hans Joachim ¹

¹ MLU - Halle-Wittenberg - Germany
hai.le.hong@iw.uni-halle.de

The long term mechanical behavior of thermoplastic vulcanizates (TPV) based on polypropylene (PP) and different rubbers (NBR and EPDM) which were modified by extender oil and filler (CB) has been characterized by means of stress relaxation experiments. The discussion of the results was carried out using the two-component model, allowing a consistent description of the time and temperature dependent material behavior. The morphology of TPV and the phase specific distribution of oil and CB which depend on the content and type of oil and CB as well as the regime of mixing have been characterized by means of Atomic Force Microscopy (AFM), Dynamic Mechanical Analysis (DMA) and Differential Scanning Calorimetry (DSC). It was found that the distribution oil and CB strongly affects the athermal stress component related to the contribution of structural changes. The main viscoelastic relaxation process is determined by the α -relaxation process of the crystalline PP phase which is not influenced by addition of oil and CB.

S19-131

Preparation of Crosslinked EVA Nanocomposite Films and Investigation of Mechanical and Gas barrier properties

RAMAZANI S.A. Ahmad ¹, Shafiee Mojtaba ¹

¹ Sharif University of Technology - Tehran - iran
ramazani@sharif.edu

Effects of crosslinking agent and clay content on the morphology, barrier and mechanical properties of the EVA organoclay nanocomposite films prepared by phase inversion method were studied. Dicumyl peroxide (DCP) has been used as crosslinking agent for virgin and polymer nanocomposites. Nanostructure and morphology of the prepared nanocomposite films were investigated by X-ray diffraction (XRD) and Transmission electron microscopy (TEM). XRD and TEM indicated that EVA nanocomposites had predominantly intercalated morphologies. Gas permeability determination was performed using bobble flow meter method. The obtained results showed that the permeability of EVA films dramatically decreases by addition of organoclay and DCP. Mechanical test showed that tensile modulus and tensile strength of EVA films increase with addition of organoclay and also EVA and EVA nanocomposites mechanical properties significantly improve in presence of crosslinking agent.



Preparation and Characterization of Poly(bisphenol A oxalate) and Studying its Chelating Behavior Towards Some Metal Ions

Khalili Fawwaz I ¹

¹ *University of Jordan. chemistry department - Amman - Jordan
fkhalili@ju.edu.jo*

Poly(bisphenol A oxalate) was synthesized by condensation polymerization of Bisphenol A and oxalyl chloride in dichloromethane under dry nitrogen atmosphere below 5 °C. The resulting linear alternating polymer was characterized by inherent viscosity, FTIR, ¹H-NMR, and ¹³C-NMR. The thermal behavior of the polymer was evaluated by differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA). The chelating behavior of the synthesized polymer towards some divalent metal ions was studied by the batch equilibrium technique as a function of pH and contact time. The isothermal behavior and kinetics of the metal ions uptake onto the polymer were also investigated. The polymer showed high rates of metal ion uptake toward Pb(II), Cu(II) and Mg(II), but low rates toward Ni(II) and Cd(II) in the measurement of metal uptake. Interestingly, the polymer was found to selectively chelate Pb(II) and Mg(II) ions in the concentration variation isotherm experiments.

S19-217

Material- and process investigation to generate carbon structures in natural fibre filled polymers for the use in fuel cells

Kauffmann Axel ¹, Zydzia Nicolas ¹, Bosch Eva ¹, Krischok Stefan ², Ahmed Imad ²,
Haensel Thomas ²

¹ *Fraunhofer Institute for Chemical Technology - Pfinztal - Germany*, ² *Technische Universitaet Ilmenau - Ilmenau - Germany
axel.kauffmann@ict.fraunhofer.de*

Fuel cells are becoming more and more interesting especially for mobile or portable applications. One key component of proton exchange membrane fuel cells (PEMFC) and direct methanol fuel cells (DMFC) is the bipolar plate. The main function of bipolar plates consists in providing electrical contact between the anodes and cathodes of neighboring cells in a PEMFC. At the same time, the gases involved in the oxydo-reduction reactions of the process entering and leaving the cell are transported by the structured surfaces of the bipolar plate. Currently such plates are made of metal, pressed graphite or high filled electrical conductive polymers. Bipolar plates need to be highly electrically conductive, durable, impermeable and corrosion resistant. Current bipolar plates of graphite fulfill this requirement but they are too expensive for mass production. Metal plates are of interest because of their toughness and easy fabrication options, but corrosion remains a significant difficulty. Highly filled polymers are often difficult to process because of the high filler quantity. This paper outlines an investigation of a new material, that can be cheaply processed in an injection moulding process and fulfills the requirements for the use in fuel cells. The investigated material is based on a thermoplastic processable material of a cellulose-fiber filled biopolymer. In a first step the material is processed in an injection moulding process to achieve the shape of a bipolar plate with a fine surface structure. In a second step the necessary properties like high temperature stability and electrical conductivity are achieved by pyrolysis, leading to the graphitized material. This paper shows some results of the processing technologies and the achieved material properties. Further on the characterization of the source materials and the reaction products effected



Influence of Foaming Extrusion Parameters on Extrudate Strength Properties

Sikora Janusz Wojciech ¹

¹ Lublin University of Technology - lubelskie - Poland
janusz.sikora@pollub.pl

For the studies of the influence of foaming extrusion parameters on extrudate strength properties, a mixture was used of polypropylene, high impact co-polymer of the trade name Moplen EP 440G produced by Basell Polyolefins and a new foaming agent of the trade name Expancel 950 MB 80 and Expancel 950 MB 120 produced by Akzo Nobel. In the studies, a co-rotating twin-screw extruder ZSK 18 MEGAlab by Coperion Werner and Pfleiderer GmbH was used. The extruder has roll screws of the diameter 18 mm and L/D = 24. A variable factor was a participation of expancel 950 MB ζ , = 1,0; 2,0; 3,0 and 4% and the rotational screw speed of the extruder, which changed step by step from $\nu = 120$ to $\nu = 160$ r/min with the step of 10. The result factors were the following: polymer mass flow rate G , kg/h, extrudate density ρ , kg/m³, foaming degree r , %, the biggest tensile stress σ_z , MPa, breaking stress σ_r , MPa, relative elongation at biggest stress ϵ_z , % and relative elongation at break ϵ_r , %. The received research results of polypropylene extrusion with a foaming agent expancel 950 MB 80 and 950 MB 120 were written down in the table and then appropriate dependences of result factors on variable factors were made. As a result of the conducted studies it was found that high rotational screw speed and therefore high shearing rate cause the destruction of the foaming agent shell and consequently lack of the foaming structure in the extrudate. Polypropylene with the foaming agent expancel 950 MB 120 has slightly worse strength properties, that is slightly lower value of the biggest tensile stress, breaking stress and relative elongation both at the biggest tensile stress and breaking stress, independently from the rotational screw speed.

S19-397

Flame Retardancy of Bisphenol A Polycarbonate by Adding Potassium Perfluorbutane Sulfonate in Combination with Polydimethylsiloxane

Dang Xiaorong ¹, Ren Wentan ¹, Zhang Yong ¹

¹ Shanghai Jiao Tong University - Shanghai - China
yong_zhang@sjtu.edu.cn

The flame retardant of potassium perfluorbutane sulfonate (PPFBs) in combination with polydimethylsiloxane (PDMS), as low as 0.2 wt% loading totally, was added to polycarbonate (PC) to get flame retarding PC (FRPC). It was effective to get a V-0 rating in the UL 94 test for the FRPC sample of 1.6mm thickness. The LOI is increased from 26.0% of the virgin PC to 30.5% of the FRPC. The transmittance of the FRPC sample of 2.0mm thickness was about 75% of the original PC, and the tensile strength and Izod Notched Impact increased by 3.3% and 8.9%, respectively. The TGA and DTA measurement revealed that the activation energy (E_a) of the thermal degradation of FRPC was about 100KJ/mol, less than that of PC. SEM showed that the exterior surface of the char layer of the burned FRPC was compact, almost without any finestrans, and the ratio of C/O/Si in this layer was about 70.73:22.46:6.81, as Energy Dispersion X-Ray(EDX) showed. This result confirmed the enrichment of Si elements on the interior surface, when the FRPC burned, since the average ratio of C/O/Si was about 82.57:17.02:0.09 according the formulation for preparation of the FRPC. Such enrichment of Si elements might be also a reason why the FRPC was more flame retardant. The FTIR spectrum of the char of PC showed that there were strong hydrogen bonds due to high concentration of various products containing hydroxyl groups. The alcohol stretching bands became broader and the characteristic carbonate band disappeared. In the FTIR of the FRPC char, however, the carbonate band was still at 1776cm⁻¹, which indicated that some other powerful groups like condensed aromatic compounds must form around the carbonate bond, which was another reason for the efficiency of flame retardance. As further evidence, the band at 760cm⁻¹ in relation to condensed aromatic rings increased, and the aromatic hydrogen bonds at 2970-3080cm⁻¹ decreased. Keywords: FRPC;Char Structure;EDX



Urea-Formaldehyde Resins for Low Formaldehyde Emission Particleboards

Siimer Kadri ¹, Kaljuvee Tiit ¹, Christjanson Peep ¹, Pehk Tõnis ², Lasn Ilmar ³, Saks Imre ⁴

¹ Tallinn University of Technology - Tallinn - Estonia, ² National Institute of Chemical and Biological Physics - Tallinn - Estonia, ³ Pärnu Plaaditehas AS - Pärnu - Estonia, ⁴ VKG Resins AS - Kohtla-Järve - Estonia
ksiimer@staff.ttu.ee

Formaldehyde (F) emission from urea-formaldehyde(UF)resin-bonded wood products is a major concern in the particleboard (PB) and plywood industry. During recent years, a lot of work has been done in Europe to reduce the value of the emittable F from PB to the world's toughest emission standard – the Japanese standard F****, applicable to fixed interiors and building materials. The synthesis of low-emittable F resins is studied by several authors using various modifiers. In the present study, UF resins were modified with different melamine levels and synthesis procedures. Considering the high price of melamine, the content of melamine is reduced to as low as possible depending on the obtained results. The synthesis was performed as a typical multistep procedure by the preadvancement of UF base resin. The chemical structure of resins was analysed by ¹³C NMR spectroscopy on a Bruker AMX500 NMR spectrometer at 125.77 MHz from DMSO-d₆ solutions, 20000–25000 scans were accumulated. Curing behaviour of resins was studied by simultaneous TG-DTA techniques. The measurements were carried out by the labsys instrument Setaram with the heating rate of 5°C min⁻¹ in nitrogen flow at temperature ranges of 30–450°C. Laboratory-made single-layer particleboards with the dimensions of 30×30 cm×14 mm were prepared on the basis of the softwood cutter chips at pressure of 1.5 MPa and temperature of 200°C with pressing time of 180 s. The consumption of resin was 11.3 mass% of wood particles and the content of urea as scavenger was 7.0 and 2.0 mass%. PB were made without paraffin. F emission from PB is significantly lower in PB, bonded with modified resins compared to control UF resin. The results of laboratory testing of PB will make it possible to start their industrial manufacturing at Pärnu Plaaditehas AS (Estonian PB factory, production capacity of 48,000 m³ per year) on the basis of melamine-modified UF resins.

S19-457

Effect of PDMS-PEO clay masterbatches on the morphology and mechanical performance of silicone rubber

Kaneko Manuela Andrade ¹, Romero Rafaelle Bonzanini ¹, Gonçalves Maria do Carmo ¹, Yoshida Inez V.P. ¹

¹ UNICAMP - São Paulo Campinas - Brazil
manuelaandrade@iqm.unicamp.br

Rubber composites were obtained from natural (MT) or organically modified (O-MT) montmorillonite clay and high molar mass poly(dimethylsiloxane)-gum (PDMS). The rubbers were prepared in an open two-roll mill, followed by a compression molding process, by adding clay to PDMS or by using a clay masterbatch compound, in which a low molar mass siloxane surfactant, poly(dimethylsiloxane-co-methylpropylethylene oxide siloxane), PDMS-PEO, was used to modify the clays. The composites were characterized by X-ray diffraction (XRD), small angle/wide angle X-ray scattering (SAXS/WAXS), scanning electron microscopy (SEM), electron transmission microscopy (TEM) and tensile tests. The results showed that the masterbatch compound improved the dispersion of the clay in the PDMS matrix. For this particular system the morphology is characterized by a combination of intercalated and partially exfoliated clay layers with few clay aggregates. The nanolayers dispersion achieved with the masterbatch technique resulted in a great improvement in the composite mechanical performance. The addition of only 5 phr of O-MT/PDMS-PEO into PDMS matrix, via masterbatch compound, improved the tensile strength as much as that obtained with the PDMS rubber composite filled with 30 phr of pure O-MT clay. In addition, the elongation at break was improved at least 126%. The expected effect of the masterbatch compound was not achieved with the MT clay, which remained in the masterbatch domains dispersed in the PDMS matrix.



Thermal conductivity analysis of poly vinyl alcohol composites with sodium sulphate, lithium sulphate and sodium acetate

Nasar Gulfam ¹

¹ NCE in Physical Chemistry, University of Peshawar - NWFP - Pakistan
gulfamnasar@yahoo.com

Thermal conductivity, like other physical properties of the composite materials depends on the nature, proportion and compatibility of the components of the composite materials. In this paper we have tried to find the relationship of thermal conductivity and the concentration and nature of the salts added to the polymers. We selected three systems for our study; Poly vinyl alcohol/ Sodium sulphate composite, Poly vinyl alcohol/ Lithium sulphate composite, and Poly vinyl alcohol/ Sodium acetate composite. Various concentrations of these salts were added to Poly vinyl alcohol, using triply distilled water as solvent. Films were casted, dried at room temperature and then appropriate sizes were cut from these films. Thermal conductivity of these samples was found out at room temperature using Quick thermal conductivity meter. Polyethylene, silicon and quartz were used as reference. It was found out that the thermal conductivity of all three systems is highly dependent of the nature and the concentration of added salt in the polymeric composite. Thermal conductivity of the Poly vinyl alcohol/ Sodium acetate composite increased with concentration while the in case of Poly vinyl alcohol/ Sodium sulphate composite, and Poly vinyl alcohol/ Lithium sulphate composite, the thermal conductivity decreased with concentration of the salts in the polymer composite.

S19-547

POLY (ETHYLENE TEREPHTHALATE) TERMO-MECHANICAL AND THERMO-OXIDATIVE DEGRADATION MECHANISMS

De Paoli Marco Aurelio ¹, Romão Wanderson ¹, Franco Marcos ¹, Eberlin Marcos Nogueira ¹, Corilo Yuri Eberlin ¹

¹ Unicamp Instituto de Química - Campinas SP - Brasil
mdpaoli@iqm.unicamp.br

Poly (ethylene terephthalate) (PET) was prepared by Whinfield and Dickson in 1946 and became one of the most important thermoplastics in world production as a result of its balance of excellent properties, like: mechanical, gas barrier and thermal. The main uses of PET are fibers, blow-molded bottles, biaxially oriented films and engineering polymers. Bottle-grade PET, btgPET, manufacturers tended, in recent years, to use a co-monomer to improve ductility, barrier to CO₂, processability and clarity. One of the most important btgPET co-monomers is diethylene glycol (DEG), where ether groups provide some degree of flexibility to a relatively stiff PET backbone. This slows down crystallization during injection and stretch blow-molding, which are used for bottle manufacture. However, DEG units are weak points in the thermal and thermo-oxidative degradation of btgPET. 1H NMR and MALDI-TOF measurements were used in this work to study the thermo-mechanical and thermo-oxidative degradation mechanisms of btgPET. 1H NMR measurements showed that, at the processing temperature, the kinetics of thermo-oxidative degradation is faster than for the thermo-mechanical and oxygen is the main reactant, attacking ether bonds of the ethylene glycol (EG) and DEG groups, respectively. Using the MALDI-TOF MS results it was possible to propose a new mechanism for the thermo-mechanical degradation of btgPET. Both techniques showed that oxygen preferentially reacts with the DEG units in the thermo-mechanical degradation. This was based on the analysis of samples submitted to several processing cycles.



STUDY OF HIGH MELT STRENGTH POLYPROPYLENE (HMS-PP) UNDER THERMAL AGEING

Oliani Washington Luiz ¹, Parra Duclerc Fernandes ¹, Lugão Ademar Benévolo ¹, Otaguro Harume ¹

¹ IPEN-USP - SÃO PAULO - BRAZIL
washoliani@yahoo.com.br

Polypropylene is an important commodity plastic because of its favorable price/performance ratio. Some structural modifications can be processed to achieve enhancement of properties. The irradiation of PP to obtain HMS-PP using high energy of gamma radiation, generate favorable changes, when used in adequate doses. On the other hand, the ageing or stability of HMS-PP obtained by this process have not been evaluated until yet. In thermal ageing of semicrystalline polymers, the mobility of molecular segments is increased by thermal activation even with no changes in the molecular size. In this study HMS-PP was obtained by the irradiation in atmosphere of acetylene as crosslinker agent. Thermal treatment was used as a post irradiation in order to effectuate the annihilation of the remaining radicals. The thermal stability of the HMS-PP was evaluated in stove at temperature of 90 °C, in presence of air at different periods of time. Physical and Mechanical properties were monitored during the ageing by the techniques of Thermogravimetry (TGA), Differential Calorimetry (DSC), Tensile Mechanical Test, Scanning Electronic Microscopy (SEM) and Optical Microscopy (MO). HMS-PP exposed to ionizing radiation, even at low doses (5, 12.5 and 20 kGy), often undergoes structural changes accompanied by molecular crosslinking and chain scission. Oxidative degradation on the network of HMS-PP, formed in the radiation process of PP, was revealed by the analytical results showed the susceptibility of HMS-PP to thermal oxidative degradation. Yellowing of the samples surface, loss of mechanical property of tension strength, oxidative products of degradation among other evidences were observed. In thermo-oxidative conditions, the formation of the oxidation products essentially involves a hydrogen abstraction by the peroxy radicals, leading to hydroperoxides as primary products and chemical degradation in the immediate crack tips. CNPQ 380795/2007-8

S19-579

POLYOLEFIN/CLAY NANOCOMPOSITE DRAWN FIBRES WITH AND WITHOUT COMPATIBILIZER: STRUCTURAL ANALYSES AND MECHANICAL PERFORMANCE

Marino Rosamaria ¹, Dintcheva Nadka Tz ¹, La Mantia Francesco Paolo ¹

¹ University of Palermo - Palermo - Italy
r.marino@dicpm.unipa.it

In this work the structural variations and mechanical performances of polyethylene/clay nanocomposite drawn fibres, also in the presence of compatibilizer, such as a commercial maleic anhydride grafted polyethylene have been investigated. The compatibilizer precursor was used for the improving the affinity between the polymer and organoclay. By adding the nanoparticles, the elastic modulus and tensile strength as a function of the draw ration increase and this rise is more pronounced for the system PE/PEgMA/CL. The reduction of the elongation at break during drawing is the same for all the examined samples. In order to evaluate the orientation of the macromolecules of the filled and unfilled systems with different affinity (with and without compatibilizer precursor), the total birefringence and calorimetric analysis have been performed. The morphological analysis for PE/CL system with reduced affinity between the polymer and clay, suggest the exfoliation of intercalated tactoids and some more intercalation of the same tactoids is. Moreover, for PE/PEgMA/CL system with greater affinity between the polymer matrix and clay, the extensional flow is more efficient. The initial intercalated morphology changes to some more intercalation and finally, at high anisotropic conditions in the presence of the compatibilizer precursor, evolves to delaminated clay structure.



Effect of Process Conditions on Morphology and Thermal Properties of Electrospun Polystyrene-g-Polycaprolactone

Magaraphan Rathanawan¹, Homraruen Pornsuda¹, Nithitanakul Manit¹

¹ *Petroleum and Petrochemical College, Chulalongkorn University - Bangkok - Thailand*
Rathanawan.k@chula.ac.th

Electrospinning process is a powerful method to make nanofibers. The nanofiber non-woven membranes are well suited for several applications such as filtration membranes, wound dressing, scaffolds and drug delivery devices. In this work, the synthesized polystyrene-g-polycaprolactone (PS-g-PCL) was dissolved in chloroform at various concentrations. Scanning electron microscopy was used to observe the morphology and fiber diameter. From the study, appropriate conditions for electrospinning of PS-g-PCL were obtained. The range of the average fiber diameter was between 490 nm and 6300 μm . At high concentration and applied voltage the fiber exhibit smooth and less-bead structure but fiber diameter becomes larger. Moreover, after adding a small amount of NaCl, the spinnability of the fiber was improved. Moreover, structure and thermal properties of the spun fibers was studied by XRD, DSC and TGA in comparison to the as synthesized PS-g-PCL.

S19-636

Influence of conditions of emulsion polymerization on physicochemical properties of acrylic and styrene-acrylic copolymers

Uryash Vladimir¹

¹ *Research Institute of Chemistry Nizhni Novgorod State University - Nizhni Novgorod - Russia*
ltch@ichem.unn.ru

Physicochemical properties of acrylic and styrene-acrylic copolymers prepared by emulsion polymerization in water medium were studied by the method of differential thermal analysis (DTA) in the range from -190 to 150°C . Samples were films formed by casting on a glass surface. They were dried at temperature $(20 \pm 2)^\circ\text{C}$ during two days and then for 1 h at $(105 \pm 5)^\circ\text{C}$ and pressure 0.6 Pa. DTA was carried out on a device of our own construction. An experiment was performed in atmosphere of helium. Quartz served as a standard. The mass of the sample and standard was ~ 0.5 g. Temperature of the sample with an uncertainty of 0.5°C and a difference in temperatures between the sample and the standard were measured with a chromel-copel thermocouple. The rate of heating during experiments was $50^\circ\text{C}/\text{min}$. Deviation from linearity did not exceed 1%. On thermograms of samples of double, ternary and quaternary carboxyl-containing copolymers from one to four relaxation transitions of endothermal character associated with the devitrification of the copolymers consisting of initial monomers in various ratios were seen. It was shown that the usage of comonomers with silane- and epoxy-functional groups leads to a decrease of compositional inhomogeneity of the copolymers. This reduces the number of individual phases and, consequently, diminishes the quantity of devitrification temperature intervals. Such copolymers are characterized with a raised resistance to water attack and rupture strength. The effect of conditions of emulsion copolymerization (variation of the nature of emulsifying systems, the composition of the copolymer and temperature condition of process) on the amount of relaxation transitions of endothermal character in the copolymers was brought out.



Crystallization Kinetics of Polycarbonate –Poly(buthylene terephtharate) Blend by Differentail Scanning Calorimetry

Kitkaew Napatsanan ¹, Manuspiya Hathaikarn ¹, Krailas Satida ²

¹ The Petroleum and Petrochemical College - Bangkok - Thailand, ² PTT Phenol Co.,Ltd - Bangkok - Thailand
pare_kao@hotmail.com

The combination of polycarbonate (PC) and poly(butylene terephthalate) (PBT), which is known as PC/PBT alloys, can have a great advantage from the properties of constituent polymers. The amorphous PC provides high impact resistance and toughness while the crystalline PBT provides enhanced chemical resistance and thermal stability. However, the properties of PC/PBT blends rely on the formulation and processing conditions. It is well know that the physical and mechanical properties of semicrystalline polymers depend on the degree of crystallization, which in turn affected by the crystallization conditions. The crystal structure and morphology are established during the solidified takes place through the nucleation and spherulite development. In this work, neat PC was compounded with PBT in various ratio without the adding of compatibilizer and mechanical properties are measured. The T_g, T_m, T_c and degree of crystallization of each ratio were investigated by DSC. The rate of nucleation, activation energy and pre-exponential factor are also calculated by Arrhenius equation.

S19-714

Modification of acrylic copolymer for production of nanofiber adsorbent metal ion compositions

Tabarzad Meysam ¹, Abdouss Majid ¹, Mousavi Shoushtary Seyed Ahmad ², Javanbakht Mehran ¹

¹ Department of chemistry , Amirkabir University of Technology - Tehran - Iran, ² Textile Department, Amirkabir University of Technology - Tehran - Iran
majidabdouss@yahoo.com

Ion adsorption on to solid chelating polymer materials is now considered as one of the most promising techniques for selective concentration, removal and recovery of metal ions from a wide variety of sources. Among different types of polymer adsorbent, polymer fibers have attracted great interest in recent years. Polyacrylonitrile (PAN), due to its chemical and thermal stability is a good substrate for the modification. In this work, polyacrylonitrile fibers have been modified with aminoethanol to provide new chelating ion-exchanger fibers. Modified pan fibers were prepared by convert of the nitrile groups into oxazoline functionality. Different variables such as concentration of aminoethanol, reaction time and temperature were investigated. The products were characterized with fourier transform infrared spectroscopy (FTIR) and were find ratio of polyoxazoline fibers to polyacrylonitrile fibers. The modified pans were used as an adsorbent in a series of batch adsorption experiments for removal of heavy metal ions such as copper (II), lead (II) and chromium (III) ions. The modified pan fiber with submicrometer fiber diameters ranging from 120 to 300 nm were produced by electrospinning in a mixture of N,N-dimethyl formamide (DMF) and dimethyl sulfoxide (DMSO). In similar conditions, the produced nanofiber was used as an adsorbent in adsorption experiments for removal of heavy metal ions. For production of stable suspensions, variable ratios of DMF to DMSO were used. Ion adsorption onto nanofibers compared with usual fiber.



Study on Cr(III) and Pb(II) ions adsorption ability by modified PAN fibers

Abdouss Majid¹, Javanbakht Mehran¹, Tahaei Partu¹

¹ Department of chemistry, Amirkabir university of technology - Tehran - Iran
majidabdouss@yahoo.com

Ion exchange today has a wide variety of important applications in industries such as pharmaceutical, food processing, chemical synthesis, biomedical, hydrometallurgy, water treatment, synthetic fiber production and chromatography. In this work, Polyacrylonitrile fibers(PAN) have been modified with diamine to provide a new chelating ion-exchange fibers. Modified PAN fibers were prepared by partial conversion of the nitrile groups in to amino groups using a solution of 3M ethylene diamine(EDA) by refluxing at 91°C. The aminated PAN were used as an adsorbent in a series of batch adsorption experiments for removal of chromium(III) ions. The Freundlich and Langmuir constants for adsorption of chromium(III) were determined. PAN fibers were reacted with different diamine compounds in similar condition. The lead (II) and chromium(III) adsorption ability and solubility of the diaminated samples were compared and also the separation of the heavy metal ions from aqueous solution containing complexing agent (tartarate and citrate) were investigated. Experimental results showed that modified PAN fiber with tetra methylene diamine(TMD) has highest Pb(II) ion adsorption capacity. Results also showed aminated PAN with ethylene diamine(EDA) has the most Cr(III) ion adsorption ability. Solubility tests showed, amination treatments give rise to the intermolecular crosslinkage in all samples. Keywords : PAN fibers, ethylene diamine, modification, tetra methylene diamine, adsorption capacity References [1] Shubo Deng, Renbi Bai and Paul Chen, Langmuir . 19 (2003)5058 [2] M.Zargaran, A.M.Shoushtari and M.Abdouss, J .APPI .Polym .Sci .(In press) 2006 [3] D.H.Shin, Y.G.Ko, U.S.Choi, W.N.Kim , Ind. Eng.Res. 43 (2004) 2060 [4]A.A.Shunkevich, Z.I.Akulich, G.V.Mediak and V.S.Soldatov, Reactive & Functional Polymer. 63(2005)27 [5] V.V.Ishtchenko , R.F.Vitkovskay , K.D.Huddersu

S19-738

Synthesis of a chelating fibrous polymer with thioamide groups and efficiency in retention of chromium(III) ions

Abdouss Majid¹, Javanbakht Mehran¹, Tahaei Partu¹

¹ Department of chemistry, Amirkabir university of technology - Tehran - Iran
majidabdouss@yahoo.com

Ion adsorption on to solid chelating polymer materials is now considered one of the most promising techniques for selective concentration, removal and recovery of metal ions from a wide variety of sources. In this approach, an effective chelative fiber is prepared by the coupling of polyacrylonitrile(PAN) and thiourea. This chemical process has been accomplished in two steps. Partial conversion of the nitrile groups of PAN fiber in to the ester groups were done with ethanol in acidic solution and then these fibers were reacted with thiourea in solution. The modified PAN were used as an adsorbent in a series of batch adsorption experiments for removal of chromium(III) ions in different PH. The coupling process, mechanical and physical properties and capacity were confirmed through FT-IR, TG, DTG, SEM, AAS and Vibromat and Fafograph instrument. Keywords : PAN fibers, thiourea, modification, thioamide, adsorption capacity References[1] V.V.Ishtchenko , R.F.Vitkovskay , K.D.Huddersuman , Applied Catalysis A . 242 (2003)221 [2] V.V.Ishtchenko , R.F.Vitkovskay and K.D.Huddersuman , Applied Catalysis A . 242 (2003)123 [3] Y.J.Kim and C.R.Park , Carbon . 43 (2005),2397-2429 [4] Shubo Deng and Renbi Bai , Water Research . 38(2004)2424



Influence of Maleated Polypropylene on Hygrothermal Ageing of Polypropylene/PP-g-MAH/Glass fiber Composites

Sousa José Alexandrino ¹, Cruz Michelle Christina ², Motezuki Joice Erica ¹, Lopes Paulo Edson ³

¹ Materials Engineering Dept., Universidade Federal de São Carlos - São Carlos - SP. - Brazil, ² Volkswagen Caminhões e Ônibus - Resende - RJ. - Brazil, ³ Petrobrás Transporte S. A. - Ribeirão Preto - SP. - Brazil
jasousa@ufscar.br

Glass fiber (GF) reinforced polypropylene composites compatibilized with maleated PP (PP-g-MAH) were subjected to hygrothermal ageing, in order to investigate the influence of the polar compatibilizer's content on the fiber-polymer interface integrity upon ageing. Tensile test specimen of 30% short GF-reinforced PP with varying content of PP-g-MAH (0; 0,25; 0,5; 1; 2; 5 e 10 % wt) and also of control PP/PP-g-MAH matrix were aged in water at 80°C for 24/48/120/240 hours. At a given compatibilizer content, the data on relative tensile strength (TS) of PP composites, normalized with respect to the TS of matrix PP, clearly indicated a deterioration of this property with increasing ageing time. At a given ageing time, the loss in relative TS of the composites initially reduces with increasing PP-g-MAH content up to an optimum compatibilizer content, above which there is a gradual reduction in this property at long ageing time.

S19-769

PROCESSABILITY OF A COMMERCIAL BIODEGRADABLE POLY(LACTIC ACID)

De Maio Filomena ¹, Sorrentino Andrea ¹, Pantani Roberto ¹, Titomanlio Giuseppe ¹

¹ DICA - University of Salerno - Salerno - ITALY
fdemaio@unisa.it

The development of biodegradable polymers came about as one response to the world's solid waste dilemma. Unfortunately, up to now there remain fabrication problems, such as the high cost of the materials and the difficult processability. As a result, several attempts have been made to solve these problems. The aim of this work was to characterize a commercial poly(lactic acid) (PLA) and explore its potential as injection moulding material. To that purpose, a PLA was injection moulded in a simple rectangular cavity by changing many relevant variables of the process, i.e. holding pressure, flow rate during filling, mould temperature. Additionally, a Starch-PLA composite was compounded and molded, and compared to neat PLA. The morphology characterization indicated uniform dispersion of Starch in the PLA matrix. The mechanical and thermo-physical properties of PLA and Starch-PLA molded samples were studied and compared using dynamic mechanical analysis (DMA), differential scanning calorimetry (DSC), rheology and PVT tests. Rheology characterization provided evidence that the effect of both shear deformation and long annealing time is toward a reduction of final mechanical properties of the samples. DMA results confirmed that the storage and loss moduli of the Starch-PLA composites increased with respect to the PLA. The results of the DSC experiments indicated that the addition of starch increased the crystallization rate and enthalpy of the biocomposites compared to neat PLA. Such studies are of great interest in the development of environmentally friendly composites from biodegradable polymers.



Cell Adhesion onto Plasma Coated PVC Pieces

Rangel Elidiane Cipriano ¹, de Moraes Francine Scomparim ¹, de Souza Eduardo S. ¹,
Schreiner Wido H. ², Cruz Nilson C. ¹, Duek Eliana ³, Lucchesi Carolina ³

¹ UNESP - Paulista State University - São Paulo - Brazil, ² UFPR - PR - Brazil, ³ PUC Sorocaba - São Paulo - Brazil
elidiane@sorocaba.unesp.br

The great versatility of polymers has promoted their application to a series of ordinary situations. The development of specific devices from polymers, however, requires modifications to fit specific stipulations. In this work, the surface properties of the system composed by polyvinylchloride, PVC, covered with thin films were investigated. Amorphous carbon hydrogenated films were deposited onto commercial PVC plates from acetylene and argon plasmas excited by radiofrequency (13.56 MHz, 70 W) power. The proportion of acetylene in the feed was varied against that of argon (5.3 to 55.3%), keeping the total pressure constant at 2.5 Pa. Deposition time was 1800 s. Film microstructure and elemental composition were analyzed by X-ray photoelectron spectroscopy, XPS. Contact angle measurements were performed using the sessile drop technique. The adhesion of cells onto the treated PVC surface was determined as a function of the incubation time using fibroblastic cells. Cytotoxicity tests were also performed through the absorbance of the immersion solution using an Elx800-UV device from Bio-Tek Instruments. Surface hardness was evaluated from nanoindentation data while wear experiments were conducted in a pin on disk system. From the XPS analysis it was detected oxygen and nitrogen contamination in all the samples. It was also found that the sp³/sp² ratio depends on the proportion of argon in the plasma. At lower argon concentrations, mechanical properties, and wear resistance were all improved with respect to the uncoated PVC. In such conditions, the surface wettability is low indicating a moderate receptivity to water. Cell proliferation occurred in all the samples, including the bare PVC. However, high growth rates, even higher than for the control sample, were observed as the covering was prepared at 55.3% of argon in the discharge. There was no evidence of cytotoxicity independently of the deposition condition.

S19-828

Characterization of blown films of PA6/MMT nanocomposites

Beatrice Cesar Augusto Gonçalves ¹, Branciforti Márcia Cristina ¹, Bretas Rosario Elida
Suman ¹

¹ UFSCar - PPGCEM - São Paulo - Brazil
bretas@power.ufscar.br

In this work, a high molecular weight polyamide 6 (PA6) was mixed in a twin screw extruder with organophilic treated nanoclay (Cloisite® 30B). The screw profile used was a medium dispersive configuration. The nanocomposites were obtained at two different nanoclay concentrations: 3 and 5 wt %; blown films were made, using a single screw extruder with an annular matrix. The nanocomposites were characterized by X-ray diffraction (WAXS) and dynamic rheological measurements in an ARES rheometer (Rheometric Scientific) with 25 mm cone-plate geometry. It was confirmed by WAXS that the platelets of the nanoclay were exfoliated in both nanocomposites, as no discernible sharp reflections were found in the X-ray diffractions patterns. The storage moduli (G') and loss moduli (G'') increased with nanoclay content, at low frequencies. The presence of nanoclay made these nanocomposites to behave as solids in the melt state, which can be explained in terms of the development of a percolated network structure. The mechanical properties of the blown films had an increase in the Young modulus for the nanocomposites in comparison to PA6. The optical properties of these blown films were considered satisfactory, without significant loss in bright and transparency.



plastic composite materials: a classification for designers' utility

Camplone Stefania ¹

¹ IDEA department - G.d'Annunzio University of Chieti - Pescara - Italy
stefania.camplone@unich.it

In the field of composite materials, designer often meets several difficulties in understanding the available information, which sometimes are very specialistic, as well as in finding "different" information, which are necessary in order to make easier their choice for a more conscious design act. On one side this is due to a more and more extreme and wide specialization of the field of composite materials: this fact, on the whole, doesn't help to identify the useful information for design choices. On the other side it is the expression of different educational paths, sensibility, fields of interest between the one who researches, classifies and informs on plastic innovative materials and the one who must use these information for products design. The consequences are the limits of traditional classifications of plastic composite materials, based mostly on mechanical, chemical and physical properties, which are sometimes also very complex and detailed: they don't consider at all those performances connected to sensorial qualities of surfaces, which are nearer to sensibility and interests of designers. We think that it is possible and necessary to suggest an alternative "vision" of plastic composite materials, which flows into a new hypothesis of classification, structured according to the prevalent choice criteria of designers. This report is related to the results of a research developed in the Faculty of Architecture of Pescara (Italy). Starting from a critical analysis of the most traditional classification systems and from a recognition on some classification systems regarded as the most promising to guide the designer in the composite materials choice, a project reference frame has been defined, which is enough comprehensive of the definition of a new classification system. The research flows into an hypothesis of "expressive-sensorial" data-base, linked also to the manufacturing processes of plastic composite materials.

S19-867

Influence of gamma irradiation on resistivity of recycled polyethylene composites

Kabisova Ludmila ¹, Gafurov Ulmas ¹

¹ Institute of Nuclear Physics - Composite Materials - Uzbekistan
ulmas3@mail.ccc.uz

The dose dependence of surface and volume resistivity of thermoplastic composites on γ -irradiated recycled high density polyethylene - HDPE bases has been investigated. The composite samples were γ -irradiated at different dose of the irradiation (γ - source Co60 with energy of 1.25 MeV). It was shown that the volume resistivity isn't change for composite sample without rubber - HDPER :EPDM (1) with low value the resistivity, while for other investigated polymer composites takes place the increasing ones with γ -irradiated dose raising after ~ 100 kGy. For plasticized composite HDPER :EPDM:GTR/plast-2(2/1) takes place the resistivity continuously increasing and showing down with dose raising. The resistivity behaviour was explained by radiation stimulated cross-links formation and oxidation processes. It is supported the measurements of the IR spectra of irradiated samples. The testing of electrical properties shows that the recycled polyethylene and thermoplastic TDV compositions on its bases have high radiation resistance and high electro-isolation dielectric properties. The work was supported by EC (STCU Project N° 3009).



Use of the EWF method to evaluate PBT/ABS blends toughness prepared at different extrusion conditions

RAZZINO CARLOS AMARAL ¹, FINOCCHIO HENRIQUE ¹, AMBROSIO JOSE DONATO ², LAROCCA NELSON MARCOS ³, PESSAN LUIZ ANTONIO ³, HAGE JR. ELIAS ³

¹ Graduate Program in Materials Science and Engineering UFSCar - Sao Carlos SP - Brazil, ² Center for Materials Characterization and Development CCDM UFSCar - Sao Carlos SP - Brazil, ³ Materials Engineering Department DEMA UFSCar - Sao Carlos SP - Brazil
CarlosRazzino@iris.ufscar.br

High rubber content acrylonitrile-butadiene-styrene terpolymer (ABS) has been used to tough poly (butylene terephthalate), PBT. Although PBT/ABS blends have shown to be compatible for some processing conditions, methyl methacrylate-glycidil methacrylate-ethyl acrylate copolymers (MGE) have been used as reactive compatibilizer to stabilize the PBT/ABS blend toughness obtained at higher processing temperatures. The evaluation of the fracture toughness of polymers is highly relevant, particularly because of the ongoing development of new polymeric blends, most of which are aimed at increasing the impact resistance for engineering plastics. The toughness evaluation method known as Essential Work of Fracture (EWF) is a relatively simple method useful for application with both brittle and ductile materials. PBT/ABS blends were prepared by twin screw extrusion using MGE copolymer as a reactive compatibilizer. The blend extrusion was done using different twin screw elements configuration, die geometry parameters, screw rotation and the feeding rate. The specimens of the DDENT (Double Deeply Notched Tensile specimens) geometry were machined from a narrow sheet obtained through a flat die and tensile-tested under low strain rate. As conclusion, EWF has been successfully applied to evaluate the toughness for PBT/ABS blends and it can be expressed that both screw profile, die dimensions and, mainly, the extrusion conditions may strongly affect the in situ compatibilized PBT/ABS blend EWF parameters. All the obtained results for the EWF parameters are in agreement with the PBT/ABS impact IZOD strength, as well as the influence of the studied processing conditions.

S19-992

MECHANICAL BEHAVIOR OF SISAL/POLYURETHANE BASED CASTOR OIL COMPOSITES

Milanese Andressa Cecília ¹, Cioffi Maria Odila Hilário ¹, Voorwald Herman Jacobus Cornelis ¹, Bittencourt Rosa Maria ¹

¹ UNESP - São Paulo - Brazil
pos06001@feg.unesp.br

The use of sisal fibers as reinforcement in polyurethane matrix is a subject of scientists and technologists for the past few years. These natural fibers present innumerable advantages such as biodegradability, renewable resource and low cost when compared with synthetic fibers. Castor oil, a vegetable triglyceride with hydroxyl groups, it was reacted with diphenylmethane 4,4'- diisocyanate (MDI) to produce the polyurethane matrix. Polyurethane composites reinforced with woven sisal fabric were processed by compression moulding at room temperature. Sisal fabrics were used untreated and thermal treated at 60°C for 72h and tensile strength of a laminate, polyurethane matrix and sisal fibers have been studied. Experimental results show an increase about six times on the ultimate tensile strength, to both conditions, when compared to the polyurethane. Tensile tests data show that the thermal treatment on the fibers promote a reduction about 23% on the laminate elongation when compared to the untreated fibers. In this research, sisal laminates were also characterized by scanning electron microscopic.



EFFECT OF POLYMER ADDITIVES ON THE PHYSICAL PROPERTIES OF BITUMEN BASED COMPOSITES

dogan mehmet ¹, Bayramlı Erdal ¹

¹ *Metu - Ankara - Turkey*
e140877@metu.edu.tr

Polymer modified bitumen is a binder obtained by the incorporation of various types of polymers in bitumen using mechanical mixing or chemical reactions. There are several factors affecting the properties of polymer modified bituminous composites such as; chemical composition of bitumen, kind of polymer and filler, compatibility of bitumen and polymer, amount of bitumen, polymer and filler, particle size of filler and process conditions. The main objective of this study is to determine the effects of polymer type and concentration on mechanical, thermal, properties and morphologies of bitumen based composites. It was also aimed to determine the effect of process temperature on mechanical and thermal properties of bituminous composites. Bituminous composites were prepared by using Brabender Plastic Coder, PLV 151. Mixing was made at two different temperatures (150 °C and 180 °C) at 60 rpm for 20 minutes. Three different kinds of polymer and four different polymer concentrations were used to understand the effect of polymer type and polymer concentration on bituminous composites properties. Low density polyethylene (LDPE), styrene-butadiene-styrene copolymer (SBS) and ethylene-vinyl-acetate (EVA) were chosen as polymer. The compositions were adjusted as the polymer volumes were equal to 5%, 10%, 20% and 50% of bitumen volume. According to the test results, addition of polymer increases the mechanical properties, reduces the melt flow index and thermal conductivity values of bituminous composites. Morphological analysis results show that, fibrillation occurs at tensile fractured surfaces of composites which contain LDPE and EVA when the polymer concentration reaches 20% of bitumen volume.

S19-1028

Rapid cytotoxicity characterization of high melt strength polypropylene films by neutral red uptake method.

Otaguro Harumi ¹, Rogero Sizue Ota ¹, Lima Luís Filipe Cardoso P. ¹, Parra Duclerc Fernandes ¹, Artel Beatriz W. Hutzler ¹, Lugão Ademar Benévolo ¹

¹ *IPEN-CNEN-SP - São paulo - Brazil*
hotaguro@ipen.br

High melt strength polypropylene (HMSPP) was developed by gamma irradiation (20 kGy) of polypropylene (PP) in the presence of different multifunctional monomers for the improvement of film and foam production as well as thermopressed products. HMSPP is designed to improve the processability of linear polypropylene (iPP) mainly for process such as film blowing or blow molding and probably oriented polypropylene film (OPP). PP with 1.5 of melt flow index, with and without antioxidant, were used. Four monomers have been utilized to modify these iPP samples such as, Ethyleneglycol dimethacrylate (EGDMA), Triallycyanurate (TAC), Triallyl isocyanurate (TAIC) and Trimethylolpropane trimethacrylate (TMPTMA), in a wide concentration range from 0- 5 mmol/100g of pure resin. This process can produce synthetic exogenous substance. To toxicity evaluation of HMSPP films was done in samples processed at high temperature in extruder and thermopressing in sequence to 300 µm thickness. A rapid cytotoxicity characterization of HMSPP films was performed. In the cytotoxicity test, extract of HMSPP samples were exposed in microplate cell culture with mouse connective tissue NCTC L929 cell line from ATCC and evaluated by neutral red uptake methodology. The results showed no toxic effect in all analyzed samples. Therefore, as the HMSPP samples present good properties under elongational flow for the production of biaxially oriented polypropylene film, these non-toxic samples can be adequate to manufacture packing plastic.



EFFECTS OF FILLERS ON MORPHOLOGICAL, MECHANICAL, FLOW AND THERMAL PROPERTIES OF BITUMINOUS COMPOSITES

Dogan Mehmet ¹, Bayramlı Erdal ¹, Tayfun Ümit ¹

¹ METU - Ankara - Turkey
e140877@metu.edu.tr

There are many different types of fillers used for bitumen modification such as; silica, limestone, basalt, mica, oyster shells. Filler gives rigidity, stiffness or hardness, regulates thermal expansion and shrinkage, improves heat resistance, and modifies rheological properties of bituminous composites. The main objective of this study was to determine the effect of filler type and ratio on mechanical, thermal properties and morphologies of bitumen based composites. It was also aimed to improve the heat resistivity of the bituminous composite to obtain a material with good mechanical and heat isolation properties. Bituminous composites were prepared by using Brabender Plastimeter, PLV 151. Mixing was made at 180 °C with 60 rpm for 15 minutes. Two grades of bitumen as 20/30 and 50/70 penetrations were used. CaCO₃, CaO, mica, baryte, kieselguhr and silanated kieselguhr were used as fillers in this study. Ethylene vinyl acetate copolymer, styrene-butadiene rubber, and styrene-butadiene-styrene block copolymer were used as polymers. According to the test results, using mica at low percentages had the effect of decreasing the viscosity of the bitumen due to its flow alignment property. Baryte gave high heat capacity and low heat conductivity to bituminous material. EVA containing samples showed the best combination on mechanical properties. The silanation process decreased the pore sizes as observed in mercury porosimetry experiments. A decreased amount of bitumen impregnation was obtained by the silanation process, clearly observed in SEM micrographs.

S19-1098

Fatigue behavior of NC2/RTM6 composites: statistical analysis by Weibull distribution

Voorwald Herman Jacobus Cornelis ¹, Volpiano Gustavo ¹, Cioffi Maria Odila Hilário ¹,
Rezende Mirabel Cerqueira ², Ortiz Edmundo ³

¹ UNESP - São Paulo - Brazil, ² IAE-CTA - São Paulo - Brazil, ³ ITA-CTA - São Paulo - Brazil
cioffi@feg.unesp.br

Aeronautic industries are continuously in researching for new possibilities to increase aircrafts efficiency sustaining the fly safe. The necessity of technological improvement according to the ambient international criteria, composite processing which uses unlocked molds should be avoided; then the RTM process, which uses closed mold equipments, is a safety process due to the volatiles are not spread around the room. Fatigue associated to constant and variable amplitude loading is responsible for damage and fracture in structures dynamically loaded. In the present research, NC2 multiaxial reinforcement/RTM6 monocomponent system composite has been successfully developed by using RTM process. Two types of panels, resulting from different process condition were studied in this work. The first one was produced using rigid tooling, which did not allow for CTE difference between the composite laminate and tooling, which means that compressive strain was applied during cooling. The second one was produced using soft tooling that allowed for CTE mismatch between the panel and tooling. Different from the former, no compressive strain was applied. To transmit a major confidence and security to the structural application design this work propose the statistic analysis by Weibull distribution using two parameters of fatigue behavior of NC2/RTM6 composites. Fatigue specimens of NC2 multiaxial reinforcement/RTM6 monocomponent system composite were produced according to the ASTM 3039 D. Axial fatigue tests were carried out according to ASTM D 3479 by an universal testing machine INSTRON 8800 and a sinusoidal load of 10 Hz frequency and load ratio R = 0.1 was applied. Weibull parameters acquisition permits a previous knowledge of fatigue behavior before the component application, an important feature regarding to the brittle materials.



Properties of Extruded Wood Plastic Composites Made from Pulp Fibers

Koubaa Ahmed ¹, Migneault Sébastien ², Soucy Joël ¹, Erchiqui Fouad ¹

¹ UQAT - Quebec - Canada, ² Université Laval - Quebec - Canada
ahmed.koubaa@uqat.ca

We investigated the potential of pulp fibers from three different pulping processes (Kraft, TMP, and CTMP) to produce wood plastic composites (WPC). Composites were obtained through two extrusion processes. In the first step, wood plastic pellets were made using a conical twin-screw extruder. In the second step, WPC pellets were then processed with a conical counter-rotative twin-screw extruder to produce rectangular samples of 4 cm width and 1 cm thick. The obtained composites were then evaluated for tensile, bending, and impact strength and dimensional stability. Results indicated that WPC made from the flexible kraft fibers led to the highest strength properties compared to the stiff thermo-mechanical pulp fibers. The WPC produced from the CTMP pulp fibers were in between in term of strength properties. The WPC made from Kraft pulps showed also the lowest water absorption and dimensional changes although they are lignin free compared to the WPC made from TMP and CTMP fibers. This was explained by the flexible nature of Kraft fibers which collapse during the process thus, reducing the void volume and consequently sites for water in the WPC. Fiber length and proportion also had significant effects on the physical and mechanical properties of the WPC. Length and proportion had much higher impact on the WPC physical and mechanical properties than lubricant and compatibility additives. At constant fiber diameter, increasing fiber length improved all mechanical properties of the extruded WPC. This could be explained mainly by better stress distribution along the fibers within the composite. The water absorption increased with increasing fiber length. This could be explained by slower water diffusion for composites made with short fibers.

S19-1107

Mechanical and morphological properties of cellulose acetate/organoclay nanocomposites

Romero Rafaelle Bonzanini ¹, Kaneko Manuela L.Q.A. ¹, Gonçalves Maria do Carmo ¹

¹ Institute of Chemistry, Universidade Estadual de Campinas - Sao Paulo, Campinas - Brazil
maria@iqm.unicamp.br

Bio-based polymer/layered silicate nanocomposites can be used to create new eco-friendly materials. The objective of this work was to investigate the structure, morphology and mechanical properties of cellulose acetate (CA) organoclay nanocomposites. Two different clays were used to prepare the CA nanocomposites: (1) a long chain quaternary alkyl ammonium salt chemically modified montmorillonite, V-OMT, commercially available as viscogel ED and (2) the methyl tallow bis-2-hydroxyethyl quaternary ammonium montmorillonite, Cloisite 30B, C-OMT. The melt processing via extrusion/injection was performed by using triethyl citrate, TEC, as a plastifier. The materials were prepared by direct melt compounding of CA, TEC and V-OMT or C-OMT in a co-rotating twin-screw extruder and then injected in an injection molding machine. The CA polymer and CA nanocomposites (CA/V-OMT and CA/C-OMT) were characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM) and tensile tests. The XRD results showed that there was a slightly increase of the clay gallery distance after the extrusion/injection molding process, for both nanocomposites. However, the TEM micrographs showed the presence partial exfoliated silicate platelets for both nanocomposites and indicated a higher content of individual clay platelets for the CA/C-OMT nanocomposite. Based on XRD and TEM results it can be suggested that the exfoliation of clay platelets can occur without polymer intercalation by controlling the processing conditions. The CA/V-OMT nanocomposite showed higher tensile strength and lower elongation at break compared to the CA/C-OMT nanocomposite. This behavior could be attributed to the different clay platelet arrangements of the two nanocomposites.



Consideration of different agents in Wax production in polymerization of ethylene in slurry phase.

Bayat Mohammad Hosein ¹, Abdouss Majid ¹, Javanbakht Mehran ¹

¹ Amir Kabir University Of Technology - Tehran - Iran
majidabdouss@yahoo.com

In coordinative polymerization of alpha-olefins via Ziegler-Natta catalysts, polyolefins produce with by-products such Wax. In industry wax defined as molecules with branch length between 18 to 70 atoms of carbon and a density of 0.930 to 0.950. After finishing of polymerization Wax removed from final product by a physical process. Wax molecules swells in the presence of suspending agents such hexane and heptane that are common suspending agents in slurry process. After swelling Wax density decreases to near suspending agent, therefore it can separate physically. In this article amount of produced Wax in polymerization of ethylene in slurry phase in laboratory reactor is measured. Utilized catalyst was third rate Ziegler- Natta with no internal and external electron donor consist of titanium chloride on magnesium chloride base. Way of Wax measuring in laboratory reactor and effect of different agents such temperature, pressure, concentration of molecular weight controlling agent (hydrogen) and cocatalyst, type of suspending agent and presence of electron donor compounds, has been considered.

S19-1269

Studies on effects of Grafting of Methyl Methacrylate onto commercial Acrylic Fibers on Thermal and Mechanical properties

Bagheri Amir Reza ¹, Abdouss Majid ¹, Javanbakht Mehran ¹

¹ Department of Chemistry, Amirkabir University of Technology, Tehran, Iran - Tehran - Iran
majidabdouss@yahoo.com

The graft copolymerization of methyl methacrylate (MMA) onto commercial acrylic fibers (PAN) has been studied using Azobis(isobutyro)nitrile (AIBN) as an initiator. MMA grafting initiated by radicals formed from thermal decomposition of AIBN. In this study, the effects of monomer and initiator concentration, time and temperature reaction on the grafting yield have been investigated. The optimum conditions for this grafting reaction were obtained with an MMA concentration of 0.7 M, an AIBN concentration of 0.0073 M, a reaction temperature of T=85°C and with reaction time of 60 minutes. The fiber structure has been investigated by different experimental techniques of characterization such as Fourier transform infrared spectroscopy (FT-IR), calorimetric analysis (DSC), thermogravimetric analysis (TGA), scanning electron microscopy (SEM), water absorption and also in this study has been investigated the mechanical properties. The thermal analysis data showed that by increasing in grafting yield, thermal stability of grafted fibers have less change and the thermal transitions of grafted fibers have approximately same behavior comparing with raw fibers sample. Grafting also affected slightly the fiber morphology. The experimental data of mechanical properties show clearly that by increasing of grafting yield, max extension will decreased but this change up to 13.5 % grafting yield is not so imperceptible. Grafting of poly MMA improved water absorption and moisture content of fiber. Keywords: Graft copolymerization; Acrylic fibers; Thermal analysis; Surface morphology; Mechanical properties.



Effect of a Polymeric Oxygen Scavenger on Functional and Barrier Properties of Coextruded Active PET Films

Incarnato Loredana ¹, Galdi Maria Rosaria ¹, Di Maio Luciano ¹, Attanasio Gerardina ¹

¹ *Department of Chemical and Food Engineering, University of Salerno - Fisciano - Italy
lincarnato@unisa.it*

The food packaging systems have generally the function to contain and protect the packaged products against physical and mechanical impacts, chemical reactions and biological contamination caused from the environment exposure. Recently, the need to extend food shelf life by preserving its organoleptic properties is becoming more and more connected to the development and design innovative and ecological packaging solutions. The scientific research is focused on different approaches: to apply biodegradable polymers as packaging materials, or to improve the common plastics through a proper functionalization. The functionalization of packaging materials by removing undesired gases with active scavengers is a very interesting solution to extend the shelf life of products and to preserve their characteristics and flavours. The oxygen, present in the environment, is one of the more critical gases since it is responsible of the main degradative phenomena which affect the food quality. One of the most promising approach in active technology is the incorporation of the oxygen scavengers into a polymeric matrix to produce active flexible films. Nevertheless, the design and the production of active films with traditional process technology can be difficult to realize because of the complexity of the system. The present work is focused on the production of multi-layer films by co-extrusion process containing layers of neat PET and active polyester at different concentrations of oxygen scavengers. The produced samples were characterized to evaluate their functional properties and their scavenging efficiency. In particular, tensile tests and haze measurements were carried out to investigate the effect of the scavenger on the mechanical properties and transparencies of the active samples. The scavenging efficiency was assessed both via oxygen absorption measurements on active samples and by verifying the effectiveness of the active films on sensitive food preservation.

S19-1298

Mechanical and barrier properties of copolyamide based nanocomposites by film blowing

Russo Giovanna Maria ¹, Garofalo Emilia ¹, Montesano Salvatore ¹, Incarnato Loredana ¹

¹ *Department of Chemical and Food Engineering, University of Salerno - Fisciano - Italy
gmrusso@unisa.it*

Polymer layered silicate nanocomposites represent nowadays a very interesting opportunity to enhance the properties of unmodified resin and produce high-performances plastics. With the adding of very low silicate contents not only structural properties but also functional properties are strongly improved. The field of packaging is one for which the application of nanocomposites is highly attractive, and improvements in mechanical and gas barrier properties could allow such materials to be employed as innovative solutions to satisfy the demanding requirements that a modern-day package must fulfill. This, coupled with the potential to process such materials with the conventional processing equipments, such as extrusion, can lead to a net improved performance/cost ratio. In this frame, great industrial and scientific attention is paid to polyamide-based nanocomposites prepared either because polyamides are inexpensive, available and widely used in packaging applications either because their hydrophilic nature is the base for a good compatibility with the silicate. Nevertheless, the difficulty in conveniently tuning materials and processing parameters to control the developed nanomorphology represents a great limit for the application of polyamide based nanocomposites on industrial scale. The present work focuses on the possibility to improve performance properties of polyamide layered silicate nanocomposite films by using, as alternative matrix, a statistical copolymer of the nylon 6 having a partially aromatic structure. Nanocomposites with different loadings of a nano-silicate (commercial organo-modified montmorillonite) were produced by film blowing imposing different drawing and blowing ratios. Oxygen barrier and mechanical properties were investigated on the nanocomposite films and correlated to their nanomorphology in order to establish the relationship between processing-structure-properties, crucial in predicting and optimizing the end performances.



Influence of curing conditions on morphologies of crosslinked PUs. Consequences on elastic properties and thermal compressive fatigue

Pichon Pascal G ¹, Méchin Françoise ¹, David Laurent ², Sautereau Henry ¹

¹ IMP LMM INSA de Lyon - Villeurbanne Cedex - France, ² IMP LMPB Université Claude Bernard Lyon 1 -
Villeurbanne Cedex - France
pascal.pichon@insa-lyon.fr

Different crosslinked polyurethanes were synthesized using different polyester crosslinked soft segments and 35 wt% hard segments, with polyether and aliphatic chain extenders. The materials were cast at low pressure, with moulds at 130 and 160°C and with different geometries. The exothermal crosslinking reaction implies that the real temperatures reached by the samples were strongly different and thus would give different morphologies. The Shore A hardnesses obtained were between 92 and 95. The glass transition temperature of the soft phase was around –40°C and the pseudo melting peaks of the hard domains were in the range 160-200°C. Morphologies observed by TEM, on samples stained by RuO₄, showed an isotropic lamellae organization of the hard domains in the soft matrix. SAXS experiments were performed at ESRF in Grenoble, France. The 1D correlation function obtained showed a correlation peak with a long period distance from 10 to 15 nm. Spin Diffusion experiments done by Solid-State NMR 1H permitted confirmation of the range of a lamella thickness. The rubbery behaviour was shown by a high recovery capacity after tensile testing. The stress softening after the first loading cycle may be due to the rupture of the shortest soft segments or due to the breaking-up of the hard domains. Both modulus and energy of the hysteresis loop were stabilized after 5 cycles. The same conclusions could be drawn with cyclic compression. Stress-controlled compression fatigue experiments were realized at high frequencies and loads, with a stress ratio of 0,1 on PU cylinders. In such conditions, an increase of temperature in the test specimen, especially in the centre, is observed, due to the dissipated energy in the hysteresis loop and to pseudo adiabatic conditions. The sample temperature can stabilize or not, depending on chemistry and processing, geometry, damping factor and aging. In case of stability, the equilibrium temperatures are in the range of 40 to 160°C.