

THE SYNTHESIS AND CHARACTERIZATION OF POLY(THIOARYLENE SULFONE)  
AND POLY(THIOARYLENE PHOSPHINE OXIDE) POLYMERIC MATERIALS

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**ABSTRACT**

New poly(thioarylene sulfone) (PTAS) and poly(thioarylene phosphine oxide) (PTAPO) homopolymer and copolymers were synthesized by the reaction of sodium sulfide and 4,4'-dichlorodiphenyl sulfone in the presence of NMP and water, and characterized. The reactions were conducted in a pressure reactor at about 100 PSI and 175-225°C. High molecular weights could be achieved as judged by GPC and intrinsic viscosity values. PTAS exhibits superior solvent resistance as compared to polyether sulfone. PTAS, PTAPO and PTAS-co-PTAPO exhibit high thermal stability. The copolymers show significant improvement in thermal stability over PTAS homopolymer.

# CERAMIC REINFORCED NYLON COMPOSITES PREPARED BY MECHANICAL ALLOYING

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## **ABSTRACT**

Mechanical alloying was used to process blends of silica and nylon 6,6 powder, which were pressed into composite sheets. The composition of the blends was varied between 0% and 10% silica, and milling time was varied between 0 and 5 hours. Two cooling rates were used when pressing the sheets to study the effects of different thermal treatments. The mechanical properties of the sheets were characterized using tensile testing, and crystallinity was measured using differential scanning calorimetry. Tensile test results show increasing strength and stiffness with greater silica content, and with greater crystalline phase content. Milling time and cooling rate had strong effects on both mechanical properties and crystallinity. Conclusions about the strengthening mechanism at work in particle reinforced semicrystalline polymer matrix composites were drawn based on relationships between mechanical properties, crystalline phase content, and composite composition.

## HYGROTHERMAL AGING OF VINYL ESTER COMPOSITES

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### **ABSTRACT**

The goals of this project were to study the effects of physical aging in Vinyl Ester/Carbon fiber composites with Phenoxyl and Polyvinylpyrrolidone (PVP), thermoplastic interphases. Both continuous and cyclic aging procedures were investigated. Continuous aging involved subjecting specimens to a constant humidity of 85% and a temperature of 52°C. Cyclic aging was achieved by subjecting the specimens to the same humidity and temperature interrupted by periodic vacuum oven drying. After the specimens were saturated, longitudinal and transverse shear tests were performed on the aged specimens and properties were compared to similar unaged specimens. An additional aim of this study was to investigate the "reverse thermal effect" (RTE) in Vinyl Ester composites. RTE is the phenomenon that occurs when a polymer matrix composite exposed to a constant humidity has been saturated at a relatively higher temperature will absorb more moisture upon cooling to a relatively lower temperature. This highly detrimental effect has been observed in Epoxy matrix composites [1,2,3], but was demonstrated for the first time in Vinyl Ester composites in this study. Mechanical testing of specimens demonstrating the reverse thermal effect showed that there is a strong correlation between moisture content and strength.

## RECYCLING OF TLCP REINFORCED POLYPROPYLENE

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### **ABSTRACT**

A mixture consisting of 75 wt% polypropylene (PP) and 25 wt% thermotropic liquid crystalline polymer (TLCP) was blended with an extrusion process in order to pregenerate the optimal TLCP reinforcement. This blend was then reprocessed five times by successive granulation and injection molding at temperatures below the melting point of the TLCP. The machine direction tensile modulus declines linearly with each reprocessing in a manner similar to glass reinforced composites. Differential scanning calorimetry (DSC), scanning electron micrographs (SEMs) and rheological tests were performed in order to help to determine the cause for the decline in mechanical properties. DSC scans indicated that there was no appreciable degradation of the polypropylene and this was supported by tests performed on pure polypropylene that had undergone a similar processing history. SEMs showed that as the material is processed repeatedly, the TLCP fibrils become twisted and broken which reduces the effective aspect ratio of the reinforcement. The decline in effective aspect ratio was verified experimentally by studying the transient rheological behavior of the PP/TLCP blends. The possibility of regenerating the TLCP fibrils in situ was considered by injection molding the blend at a temperature greater than the melting point of the TLCP.

# THE EFFECTS OF LONG TERM ANNEALING ON GAS SORPTION IN SEMICRYSTALLINE POLYMERS

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## **ABSTRACT**

The effects of long term annealing on the gas sorption behavior of isotactic poly(propylene) (it-PP) were studied. Void and crack free it-PP films containing solely alpha-phase crystals were prepared following a four step thermal treatment. In this treatment, it-PP was successively melted at 210°C for 8 minutes, quenched in ice water, annealed at 150°C for 24 hours, and finally quenched in liquid nitrogen. Samples so prepared were subsequently annealed at 35°C for various times ranging from 16.5 to 832.5 hours and studied by a number of techniques. Gas sorption studies were performed at 35°C during annealing. DSC was carried out to evaluate the change in crystallinity, and linear dilatometry was used to calculate the change in density at 35°C. A linear increase in crystallinity and in density with logarithm of annealing time was observed for times ranging from 16.5 to 832.5 hours. During that time the crystallinity increased by 0.7% and the density by 0.4%. Simultaneously the solubility was shown to decrease by 20%, which suggests that the amorphous density increased during annealing. This last result, although surprising, is tentatively explained in terms of a departure from equilibrium of the amorphous phase during secondary crystallization or cooling.

THE EFFECTS OF FIBER-SIZING AND MOISTURE ON THE BULK MECHANICAL  
PROPERTIES OF THERMOPLASTIC COMPOSITE SYSTEMS

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**ABSTRACT**

The effects of interphase morphology and moisture content on the bulk mechanical properties of two thermoplastic composite systems were studied. The composite systems were composed of nylon 66 matrices reinforced with either high modulus carbon fiber or E-glass fiber cloth weaves. These particular composite systems were used because of their propensity to form distinct transcrystalline regions at the fiber/matrix interface. Fiber-sizing, using poly(vinyl pyrrolidone) [PVP], was used to suppress transcrystallinity. Dynamic mechanical analysis (DMA) and Minimat off-axis tensile testing were used extensively to study the mechanical properties of the composite systems. Vibration testing was performed to compliment the DMA results. The damping properties were seen to increase in the samples which exhibited transcrystallinity. Microtensile testing showed that PVP-sizing strengthened and toughened both composite systems. Finally, the kinetics of moisture absorption and the effects of moisture on the aforementioned mechanical properties were analyzed in these thermoplastic composite systems. Water plasticized all composites studied; glass transitions shifted to lower temperatures, while ultimate stresses and storage moduli values decreased.

## VINYL ACETATE EMULSION POLYMERS FOR WOOD ADHESIVES

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### **ABSTRACT**

Polyvinyl Acetate (PVA) and Polyvinyl Acetate-N-Methylolacrylamide (PVA-NMA) were synthesized. The amount of NMA and the NMA addition procedure was varied for all the copolymers. Characterization of these polymers consisted of using the DSC to monitor the thermal behavior of the polymers, the viscometer to measure the viscosity of each polymer, and the SEM to observe the particle architecture and size distribution of the polymers. Since the particle architecture of the copolymers were different, the effects it had on the performance of the various copolymers were next explored. Therefore, Compression Block Shear tests were performed on the adhesives. The test revealed improved shear strength and moisture durability in the copolymers over the homopolymer. Also, the copolymer's performance and durability were a function of the synthetic method employed.

Surface Treatment of Ti-6Al-4V: Plasma-Sprayed Polyimide Coatings. Durability of Adhesively Bonded Samples.

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**ABSTRACT**

The durability of titanium adherends, plasma-sprayed with polymeric coatings, and bonded with a second plasma-sprayed polymeric coating or a polyimide adhesive film has been investigated. The titanium adherends were either grit-blasted with alumina or alumina/chromina particles. Durability was investigated using a wedge-type specimen by exposing the specimens to several different environments, including room temperature, boiling water, toluene, methyl ethyl ketone, jet fuel, and ethylene glycol. The system exhibiting durability comparable to that for adherends treated using standard solution methods included titanium adherends grit-blasted with alumina, plasma-sprayed with LaRC TPI-2000 and then LaRC PETI-5, and bonded directly without an adhesive film. For the samples that were grit-blasted with alumina and had two polyimide, plasma-sprayed layers, failure during exposure to room temperature and the solvents occurred in the adhesive, indicating a favorable adherend-plasma-sprayed coating interaction. The systems exhibiting poor durability, compared to that for adherends treated using standard solution methods, included titanium adherends grit-blasted with alumina/chromina particles, plasma-sprayed with LaRC TPI-2000, and bonded with a polyimide adhesive film, and titanium adherends grit-blasted with alumina/chromina particles, plasma-sprayed with LaRC TPI-2000 and PETI-5, and bonded directly with no adhesive film. The poor durability for the alumina/chromina grit-blasted systems occurred because of a lack of bonding interaction between the grit-blasted region and the plasma-sprayed polyimide, as indicated by failure occurring at the interface between these two regions.

## POST FAILURE ANALYSIS OF COMPOSITES AND ADHESIVES

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### **ABSTRACT**

The approach of fractography was used to study a smart composite that has a magnetic property. Samples were prepared from a structural member of both the control and tagged composite. Flexure and tension tests were performed, and the most significant finding was a decrease 26% in tensile strength. The reason for this difference was due to the weakened interfacial shear strength. Support for this argument was shown on both the macroscopic and microscopic levels. The goals of this project were to verify the changes in mechanical properties due to the tagging, hypothesize and support why there was a change.

Fractography was also used to analyze several Double Cantilever Beam (DCB) adhesive specimens. Four adhesives were compared in pre-failed DCB specimens. Photographs were taken of each adhesive and were labeled as having either a "cohesive" or "interfacial" crack. Predictions of the crack path propagation were also carried out using a governing equation. The goals of this project were to establish the mode to failure of the adhesives and to compare them to their mathematical predictions.

## USE OF DYNAMIC DSC TO STUDY GLASS TRANSITIONS IN POLYURETHANES

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### **ABSTRACT**

Temperature Modulated Dynamic Differential Scanning Calorimetry produces thermographic data of high sensitivity and accuracy. A Perkin-Elmer DSC-7 with a Dynamic attachment was used to examine the behavior of a polyurethane near its hard-segment glass transition temperature. A polyurethane with relatively high hard block content was selected and subjected to controlled thermal histories. The data from standard DSC implies that the hard segment of the polyurethane is amorphous. The DDSC data suggests previously unsuspected transition at 75°C.

Polyurethane Interphase Materials for Carbon Fiber/Vinyl Ester Composites

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**ABSTRACT**

Recent investigators have shown that the performance of polymer matrix composites can be significantly enhanced by using fibers sized with a thermoplastic polymer. As a continuation of this investigation, water dispersible polyurethane elastomer sizings have been synthesized and characterized. "Model" composites consisting of a sized carbon fiber embedded in a vinyl ester matrix were fabricated and characterized using the atomic force microscope (AFM). The AFM images clearly show that an interphase region was formed around the fiber.

# MODIFIED RELAXATION TIME DISTRIBUTIONS VIA GRADIENT CURED TOUGHENED THERMOSETS

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## **ABSTRACT**

Cyanate esters are useful in various industries due to their high temperature applications. Considering of the effects the cure process on these microphased separated, toughened thermosets helps in understanding their subsequent mechanical behavior. A plication of a thermal gradient cure regimen to these materials might provide unique and improved properties. Modeling the changing phase composition and time-dependent behavior of the gradient cured toughened thermoset was necessary to determine a cure profile to fit the application specifics. Transmission electron microscopy (TEM) confirmed that the toughener particle size was a function of cure temperature. Glass transition temperatures along the length of the gradient material were determined so t at the phase composition could be analyzed using the Gordon-Taylor equation. Phase composition varied with cure temperature. Stress relaxation results for time-dependent behavior were inconclusive. Implications from the behavior of the gradient's extr me ends suggest the gradient cured rubber toughened thermoset will have intermediate behavior.

# APPLICATIONS OF JAVA AND THE WORLD WIDE WEB: A THREE-DIMENSIONAL GRAPHING TUTORIAL

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## **ABSTRACT**

This three-dimensional graphing tutorial, which is part of a larger statistics tutorial called DIG Stats, uses text, sound, movies, analytical questions, and a Java Wapplet to create an interactive tool for students (upper level high school students and above) of all disciplines to explore three-dimensional graphs on the World Wide Web. The three-dimensional graphs explained in this tutorial all have three independent variables on the axes, and a dependent variable represented by color within axes.

## BIOTRIBOLOGY AND CARTILAGE WEAR

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### **ABSTRACT**

This research explores synovial joint lubrication using an in vitro apparatus simulating the in vitro conditions of the bovine shoulder and knee. Pre and post test differences in the cartilage and stainless steel disks were compared using profilometry, photomicrographs, scanning electron micrographs (SEM), and FTIR. A thin film was deposited on the stainless steel disk when buffered saline solution was used as a lubricant in a wear test. This film was absent in the presence of synovial fluid. The wear mechanism for the two lubricants was similar but not identical as observed by SEM. The mechanism, however, differed significantly for cartilage on cartilage tests.

# A DEVELOPMENT OF A CONSOLIDATION CYCLE FOR POLY(PHENYLENE SULFIDE) COMPOSITES

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## **ABSTRACT**

Due to the growing popularity of poly(phenylene sulfide), PPS, composites, it is important to develop a consolidation cycle which will produce consistently well consolidated composites. A designed experiment was completed to determine the optimal processing conditions for grade GR-01 PPS. In this experiment the consolidation temperature was held constant, while the consolidation pressure and time were varied. After processing was completed, short beam shear, SBS, tests were completed to obtain interlaminar shear strength data. SBS was chosen to quantitatively determine the strength of the panels. C-scans and optical microscopy were used as qualitative measures of consolidation to confirm the data obtained from the short beam shear tests.

# INFLUENCE OF MATERIAL ORTHOTROPY AND CROSS SECTIONAL GEOMETRY ON THE RESPONSE OF ELLIPTICAL CYLINDERS

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## **ABSTRACT**

In this study strains, curvatures, and force and moment resultants for composite cylinders were determined using a FORTRAN code and graphical output. Results for the circular cylinder provided a baseline for the elliptical cylinder results, allowing a comparison of the responses for different orthotropies (axially-stiff, hoop-stiff, and quasi-isotropic) and loadings (internal pressure and axial compression). This report shows a few of the responses and describes how the orthotropy and geometry affects the response of the cylinders under a load.

## SOME SELECTED FEATURES OF THE PHYSICAL AGING PROCESS FOR GLASSY POLYMERS

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### **ABSTRACT**

The effects of physical aging were examined in two separate studies: (1) The amorphous commercial polyimide Regulus® was subjected to physical aging and then tested thermally with differential scanning calorimetry. The enthalpic physical aging rate parameter  $\beta H$  increased, reached a maximum (0.69 J/g at  $T_g - 20^\circ\text{C}$ ), and then decreased as aging temperature approached  $T_g$  ( $239^\circ\text{C}$ ). After aging for 100h at  $T_g - 25^\circ\text{C}$ , tensile testing revealed that modulus increased 19%, stress at yield increased 16%, but strain at break decreased 47% compared to an unaged sample. The mechanical physical aging rate parameter was measured with creep testing. The largest value found was 0.81 at  $T_g - 35^\circ\text{C}$ . Thus, physical aging is expected to adversely affect impact toughness and strain at break of Regulus used as a composite matrix or structural adhesive. (2) Amorphous poly(ethylene terephthalate) and isotactic polystyrene were physically aged at about  $30^\circ\text{C}$  below their respective  $T_g$ s for 0, 10, and 100h. After cooling to room temperature, the samples were immediately brought to a crystallization temperature and held for varying amounts of time. Such treatment did not significantly affect either the crystallization rate or maximum percent crystallinity versus unaged samples. These results oppose a recent literature study of isotactic polystyrene.

# EFFECT OF MODE TOUGHNESS MIX ON THE FRACTURE OF Ti-6Al-4V/FM-5X BONDS

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## **ABSTRACT**

Using fracture tests, the strain energy release rate ( $G$ ) of a Ti-6Al-4V/FM-5X adhesive system was evaluated. Pure Mode I, Pure Mode II, and mixed mode (Mode I and Mode II) tests were conducted using double cantilever beam (DCB), end notch flexure (ENF), and mixed mode flexure (MMF) geometries. The adherend surfaces were pretreated using chromic acid anodization (CAA) prior to bonding. Interfacial type failures were induced using ENF and MMF specimens as a result of the Mode II loading inherent in these tests. Pure Mode I loading, as is the case with symmetric DCB specimens, resulted in cohesive failure and strain energies around  $2500 \text{ J/m}^2$ . The ENF specimens had strain energy values at about  $1300 \text{ J/m}^2$  while the MMF specimens had values close to  $1970 \text{ J/m}^2$ . From the tests conducted, a failure envelope was developed in order to predict failure energy and failure type for use in designing structural joints.

# COMPUTER MODELING OF THE MECHANICAL RESPONSE OF COMPOSITE STRUCTURAL BEAMS IN THE TOM'S CREEK BRIDGE

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## **ABSTRACT**

Computer modeling of the Tom's Creek Bridge in Blacksburg, Virginia was performed to determine the feasibility of using composite structural beams in a small traffic bridge. The software package Mathematica® was used to create two models: the perpendicular bridge model and the skew bridge model. These models determined the force acting on each of the bridge's 23 composite stringers caused by traffic on the bridge deck. Then the computer model results and the mechanical 3-point bend tests that were done on the beams were used to predict the bridge's safety. Both models produced similar results for the force distribution on the composite beams due to H-20 and HS-20 truck loading. The computer model results and the mechanical testing showed a factor of safety of at least 3 for the composite beams. Therefore these preliminary simulations indicate that the anticipated H-20 and HS-20 trucks can safely pass over the bridge.

# EFFECTS OF TOPOLOGICAL CONSTRAINTS ON THE THERMAL BEHAVIOR OF POLYMERS

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## **ABSTRACT**

In this study, differential scanning calorimetry was used to follow the effect of crosslinking on the thermal behavior of atactic poly(styrene). Samples were crosslinked either using an electron beam or through copolymerization with divinylbenzene. Where s the thermal behavior of samples crosslinked in the e-beam was independent of radiation dosage, that of samples crosslinked with various amounts of divinylbenzene was very much affected. In the latter series of samples, the glass transition temperature s elevated as crosslinking increased. While the glass transition temperature increased, the change in heat capacity decreased due to the decrease in mobility in the chain between the constraints. As expected, the molecular weight between constraints pl ys a very important role because the longer the chain, the larger the number of degrees of freedom and the lesser the effects of the constraints on the chain mobility.

# PHENYLETHYNYL TERMINATED POLY(ARYLENE ETHER SULFONE) COPOLYMERS

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## **ABSTRACT**

A series of poly(arylene ether) copolymers made by the step (condensation) nucleophilic substitution polymerization of 4,4'-dichlorodiphenylsulfone and various mole ratios of hydroquinone to 4,4'-biphenol in the presence of potassium carbonate and an aprotic dipolar solvent were investigated. Endcapping the oligomers with phenylethynylphenol produced tough, highly solvent resistant network materials after curing at 370°C. The Tg's of the oligomers ranged from 170-200°C and this value increased significantly after curing. Five copolymers were synthesized and characterized for molecular weight, Tg, and adhesive strength. Certain properties of these copolymers have been studied and will be compared to those of the homopolymers. In contrast to the homopolymers, the copolymers were either totally amorphous or only slightly crystalline which enhanced processability.

## EFFECTS OF CONDITIONING ON EPOXY RESIN COMPOSITES

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### **ABSTRACT**

Water-borne epoxy resins underwent mechanical testing after cure and after humidity and temperature conditioning. The resins tested were Shell Chemical Company's Epi-Rez® 3510 W-60 and Epi-Rez® 3540 WY-55, distinguished by lower and higher molecular weight respectively. Fitting a three-part exponential decay curve to the stress relaxation data gauged the level of plasticization. The 3510 was more comparable to the Epon 828 (a bisphenol-A derivative) cast from methyl ethyl ketone, while 354 had longer relaxation times than the Epon 828. Humidity conditioning at both room temperature and 100°C further plasticized all three resins. The 3540 also seemed to be slightly more susceptible to water gain and loss after curing than Epon 828 control; the 3510 showed mixed results.

## FORMATION OF A WOOD-BASED THERMOPLASTIC MATRIX COMPOSITE

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### **ABSTRACT**

The overall goal of this project is to make a complete thermoplastic matrix composite from wood-based sources. The wood-based source that was focused on was the steam-exploded fiber from wood chips of a yellow poplar tree. The method for formation of the composite is a suspension prepregging process. The thermoplastic matrix consisted of esterified steam-exploded fiber. Experiments were performed to see the effects of the catalyst sulfuric acid on the degree of degradation of the cellulose chains. Once the amount of catalyst needed for reaction was determined, different esters were synthesized, and then characterized to find a suitable ester for the suspension prepregging process. An ester was found to have desirable properties for this type of composite formation. Experiments were also performed that looked into the surfactant conditions, fiber type, and finally the particle size to determine parameters for the suspension prepregging process.

# DESIGN OF A COMPRESSION BENDING FIXTURE TO TEST OUT-OF-PLANE BEHAVIOR OF COMPOSITE MATERIALS AT ELEVATED TEMPERATURES

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## **ABSTRACT**

The study of cyclic compression bending and its effects on the behavior of composite materials is the next step in the study of these materials. To this end, a compression bending fatigue fixture was designed. This fixture was intended to establish the suitability of composite materials in off-shore applications, through the characterization of their behavior when subjected to cyclic compression bending at elevated temperatures. Of particular interest to this study was a unidirectional carbon fiber/PPS thermoplastic matrix composite. In a previous study, preliminary tensile and bending tests were conducted to establish room and elevated temperature tensile behavior as well as the effects of aging on material properties. This data was used to design the compression bending fatigue fixture. The fixture allows for multiple specimens to be tested simultaneously, in a corrosive environment such as sea water, at elevated temperatures. Due to large specimen displacements, a classical elastica analysis was performed to obtain bent geometry. No testing has yet been performed, but preliminary observations indicate that the compression bending fatigue fixture will provide reliable data for use in the design of flexible off-shore piping.

## Cure Reactions of Vinyl Ester/Styrene Matrix Resins

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### **ABSTRACT**

Vinyl ester resins have excellent physical, mechanical and handling properties and have been used as matrices in carbon fiber composites. During the cure reaction, a highly crosslinked network is formed by free-radical copolymerization of methacrylate and styrene. A detailed understanding of vinyl ester resin crosslinking reactions is of both fundamental and commercial interest. This research addresses the characterization of vinyl ester cure reactions. The cure reaction kinetics of vinyl ester resins (Derakane 441-400) are being studied by Fourier transform infrared analysis with emphasis on reactions at elevated curing temperatures. The gelation and curing behavior of vinyl ester networks is currently under investigation.

Infusion of Silver Into Polyimides By the Use of Supercritical Carbon Dioxide. Formation of Reflective Surfaces.

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**ABSTRACT**

Polyimides can be infused with silver complexes by the use of supercritical CO<sub>2</sub> in order to achieve superior optical properties. Highly reflective polyimide films were created by infusing (1,5-cyclooctadienehexafluoroacetylacetonato o)-silver(I) [Ag(COD)(HFA)] into a number of polyimides and then thermally curing those films at 300°C for time intervals varying from 30 minutes to 3 hours. Reflectivities of the films exhibited strong dependence on the infusion and cure condition as well as on the type of polyimide used. The highest reflectivity of 67.1% was achieved in the silvered films of BTDA/ODA, composed of 3,3',4,4'-benzophenone tetracarboxylic acid dianhydride (BTDA) and oxydianiline (ODA), infused at 5000 psi, 100°C for 30 minutes and cured for 1 hour. Reflectivities of silvered surfaces of other polyimides investigated in this project varied from 39% to 61%. A strong correlation between the presence of an unhindered double-bonded oxygen in the polyimide structure and the formation of mirror surfaces was detected. Discussion of this hypothesis as well as characterization of these films are presented.

# HYPERBRANCHED POLY(ARYL ESTER)S: SYNTHESIS, CHARACTERIZATION, AND FUNCTIONALIZATION

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## **ABSTRACT**

Hyperbranched poly(aryl ester)s of carboxylic acid and acetoxy functionality were synthesized according to techniques similar to those employed by Turner et al. [1,2] These polymers showed characteristics typical of hyperbranched systems and similar to those exhibited by dendritic polymers, making them highly satisfactory for the present work. The polymers were further modified to form hyperbranched polymers exhibiting a range of endgroup functionalities, such as cyanate, vinyl, phenylethynyl, and epox moieties. Additionally, these functionalized hyperbranched systems were characterized and prepared for testing as adhesive and crosslinking components of composites.

## Water Soluble Polymer Adsorption on Metal Oxides

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### **ABSTRACT**

The ceramic suspensions used in casting advanced ceramic substrates must be well dispersed and have a high solids volume fraction. For environmental and economic reasons, the solvent in this process needs to be water. However, the interparticle attractions are much greater in water than in organic solvents and increased stabilization is needed. Electrostatic stabilization is currently the only method able to stabilize ceramic particles in water, and this method suffers from serious drawbacks. The main problems are the sensitivity to pH and ions in solution, and the increased viscosity caused by using electric repulsion.

The problems of electrostatic stabilization can be overcome using steric stabilization. In homopolymer steric stabilization, parts of the polymer are attached to the surface of the particle, while other parts are extended into solution forming a steric hindrance to surface contact. In diblock steric stabilization, an anchor block which attaches to the particle surface is combined with a tail block which extends into solution to hinder contact. However, a working system using either concept has not yet been developed for aqueous ceramic suspensions.

The goal of this project was to test the characteristics of poly(2-ethyl-2-oxazoline), PEOX, for use as a homopolymer steric stabilizer, or as part of a diblock steric stabilizer. The adsorption behavior of poly(vinyl alcohol), PVOH, was also studied.

PEOX was found to adsorb on silica over a pH range of 2-9 and was observed to be insensitive to ionic impurities (NaCl) up to 0.1 M. PEOX was found not to adsorb on alumina or titanium dioxide under similar test conditions. The saturation concentration of  $M_w=29,400$  g/mol PEOX on silica is about 0.6 mg/m<sup>2</sup>, and the saturation concentration of  $M_w=194,300$  g/mol PEOX on silica is more than 1.1 mg/m<sup>2</sup>. The cloud point of  $M_w=29,400$  g/mol PEOX is 71°C, and the cloud point of  $M_w=194,300$  g/mol PEOX is 63.5°C.

PVOH adsorbed strongly on titanium dioxide, increasing with increasing pH. PVOH adsorbed strongly on silica under acidic conditions, pH less than 4, but weakly under basic conditions, pH greater than 9. PVOH adsorbed slightly on alumina in acid, decreasing to zero in base.

The absolute absorbances of  $M_w=334K$  poly(ethylene oxide), PEO, were not found, but trends were determined for these metal oxides. PEO adsorption on silica > titanium dioxide > alumina.

# PREPARATION OF POLYPHENYLENE SULFIDE (PPS) FOR AQUEOUS SUSPENSION PREPREGGING

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## **ABSTRACT**

Conditions necessary for the fabrication of Polyphenylene Sulfide (PPS) carbon fiber composites via aqueous suspension prepregging were studied. Two main issues studied were polymer particle size and polymer particle stabilization. Using a fluidized bed column as a separation device, the median size of raw PPS powder was reduced to approximately 50 microns. Stabilization of the PPS powder was analyzed using a Shimadzu particle analyzer and single tow dipping tests as a function of polyamic acid type, counterion base type, and polyamic acid concentration. These studies showed little change in stabilization as polyamic acid and counterion base were varied. Particle analysis also showed that a minimum concentration of polyamic acid to PPS of 10% by weight was needed to obtain proper stabilization for the prepregging process. All results indicate that the fabrication of PPS composites via suspension prepregging is a feasible process.

## DESIGN OF A COMPUTER INTERFACE TO STUDY MATERIAL PROPERTIES

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### ABSTRACT

A LabVIEW program was written to interface with the Dynastat material testing system to have a better control over existing hardware. The previous system was extremely "unfriendly" as far as system-user interaction was concerned. There were also obvious shortcomings with respect to the types of tests that could be conducted on the machine. In order to facilitate better control and have greater flexibility regarding the kind of tests that could be run on the machine, the timer, Dynalyzer, and Dynatherm were removed from the previous system. The machine in the present configuration is controlled by a Quadra 600 Macintosh using National Instruments' LabVIEW software. In addition to the program, two National Instruments data acquisition cards (NB-MIO-16 and a Counter card) were used to communicate and control the Dynastat. With the new interface, we have the ability to program the old test that the Dynastat could do, and it is now possible to run the following tests:

- physical aging with creep recovery and
- transient testing with frequency sweeps.

Currently, the system can run the above mentioned tests with the exception of the superimposition of the frequency sweeps. It is proposed that a switch be made to an IBM computer to get the desired frequency range for the testing, which may not be possible using Current Macintosh cards.