# Barrier properties of maleated natural rubber / clay nanocomposites developed by masterbatch technique

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In recent years, organic-inorganic nanocomposites have attracted great interest to researchers because they frequently exhibit unexpected hybrid properties synergistically from the two components. Polymer nanocomposites are a class of reinforced polymers with low quantities of nanometric-sized fillers which give them improved properties. Being highly unsaturated, natural rubber is easily attacked by heat, oxygen, ozone and chemicals leading to degradation of polymer chains and deterioration of properties.

In this study maleated natural rubber was modified with nanoclay to improve its barrier properties and strength. The ability of clay layers to improve the barrier properties and strength of MA-g-NR is examined as a function of clay content. The sorption properties of the nanocomposites were investigated using different solvents. Oil resistance of the samples was found using methods outlined in ASTM D 471:98.

The oil intake reduced by 52 % at 5 % nanoclay loading. The time for initiation of ozone cracking has increased from 3 to 4 hrs. Air permeability also significantly reduced on nanofiller modification. The swelling resistance is also enhanced by increasing the clay loading. The study shows that the barrier properties of natural rubber can be significantly improved by reinforcing with nanoclay.

**Key words:** nanocomposites, barrier properties, maleated NR, masterbatch, swelling behaviour

# Zinc powder filled coatings for corrosion protection

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Epoxy and polyamide based coatings were prepared with metallic zinc powder and the zinc content was varied from 50% to 80% wt/wt. Nanoclay was used as filler. The filler content was varied from 10 to 40 wt %. This coating was tried on mild steel substrates. The substrates were found to have superior corrosion protection over commercially available zinc rich coating as observed by chemical and electrochemical measurements of corrosion potential, galvanic current, limiting current, mass loss , water uptake and coating defects by salts spray in 3 wt % sodium chloride solution for different time duration etc. Mechanical properties of the coatings (100µm) were also evaluated by scratch hardness and cross hatch hardness tests and results indicated the enhanced mechanical properties of the coating.

**Key words:** zinc, nanoclay, epoxy, corrosion protection.

# Biodegradable polymers

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Plastics are being used all over the world. From drinking cups and disposable silverware to parts for automobiles and motorcycles, plastics are continuing to rise. Plastics have been an environmental trepidation because of the lack of degradation. Plastics make up about 20% by volume of waste per year. Plastics are extremely important to the job market as well as packaging throughout the world. Since plastics are vital to people's everyday lives, production of biodegradable plastics to make plastics more compatible with the environment is necessary. So biodegradable polymers are known as "REBIRTH OF PLASTIC". The two main reasons for using biodegradable materials are the growing problem of waste resulting in the shortage of landfill availability and the need for the environmentally responsible use of resources. Biodegradable plastics began being sparking interest during the oil crisis in the 1970's. As oil prices increased, so did the planning and creating of biodegradable Materials. The 1980's brought items such as biodegradable films, sheets, and moldforming materials. Green materials (or plant-based) have become increasingly more popular. This is due to the fact that they are a renewable resource that is much more economical than they were in the past.

This paper reviews biodegradable plastics focusing on their potential on starch based plastics, soya based plastics, bacteria based plastics, purpose and needs of biodegradable plastics, properties of biodegradable plastics, advantages and disadvantages of biodegradable plastics.

**Key words:** biodegradable plastics, starch based plastics, soya based plastics, bacteria based plastics

# Effect of amylase producing vibrios from the benthic environment on the biodegradation of low density polyethylene-starch blends

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Biodegradable polymers have recently attracted much public and industrial interest as a consequence of extensive discussions on better waste management strategies. Low-density polyethylene (LDPE) is currently one of the most commonly used thermoplastics for packaging applications. The resistance of polyethylene to biological attack is due to its hydrophobicity, high molecular weight, and lack of functional groups recognizable by microbial enzymatic systems. These properties limit the scope of LDPE in applications in which biodegradability is a desirable attribute. The blending of biodegradable polymers such as starch with inert polymers like polyethylene, has received considerable attention because of its possible applications in the waste disposal of plastics. The reasoning behind this approach is that if the biodegradable component is present in sufficient quantity, and if it is removed by microorganisms in the waste disposal environment, then the plastic or film containing the remaining inert components should disintegrate and disappear.

Starch is an abundant, inexpensive and natural raw material, which could be mixed with thermoplastics. The microbial consumption of starch in the starch mixed plastic products leads to increased porosity, void formation and loss of integrity of the plastic matrix.

LDPE was mixed with different grades of tapioca starch, namely, low-grade starch and high-grade starch. Various compositions were prepared and their mechanical and thermal studies have been carried out. Biodegradability of these samples was checked using culture medium with *Vibrios* isolated from marine benthic environment having the capability of producing amylase. The studies on biodegradability show that these blends are partially biodegradable.

**Key words:** biodegradable polymers, LDPE, starch

# Modification of epoxy by addition of thermoplastic polymers

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In civil engineering constructions, cement-bonded materials have a major contribution. Improvement in performance and durability of cement bonded materials has been sought continuously for long. Nevertheless, such structures deteriorate with time due to various reasons such as moisture, temperature, load, chemical attack, fatigue and many other factors. For repair and restoration of these structures, the requirement of properties of repair materials varies according to the properties of the base concrete and form of the repair. Fresh plain cement mortar or concrete may not meet the desired properties. Polymers are often used for most of the repair work to meet the required properties.

Currently latexes or emulsions of polymers are used either as monomer or as copolymer of various combinations like polyvinyl acetate, vinyl acetate-ethylene, styrene-butadiene, styrene-acrylic, and styrene butadiene rubber emulsions. However, in spite of several useful characteristics, these polymers have their limitations.

Multicomponent polymeric system (polymeric blend) is now one of the advanced domains in modern polymer science. Various physical properties of such polymer blends are of particular interest because the same are related to the composition, inter component interaction, phase structure as well as processing conditions.

In view of the above, studies have been carried out on modification of the epoxy polymer by blending thermoplastic polymers. Acrylic and styrene butadiene rubber (SBR) are used in different ratios to take advantage of strong points of both the polymers. Thermal, chemical and physico-mechanical properties of developed blends have been studied. It has been inferred from the work that the polymer blend improves the properties remarkably as compared to neat epoxy system. The developed polymer blend would be used for the formulation of different types of repair materials for building applications.

**Key words:** cement bonded materials, concrete repair materials, epoxy polymer, thermoplastic additives, polymer-cement composites

# Modification of carbon black filled natural rubber using novolac resins

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This work investigates the effect of addition of novolac resins of varying phenol: formaldehyde ratios into carbon black filled NR compounds. The cure characteristics and mechanical properties of the compounds were studied. Results indicate that the cure time increases with increasing resin content. Similarly the maximum torque and viscous torque exhibit an increasing trend. Novolac resins, in general, are seen to improve the tensile modulus and tear strength of the rubber but the tensile strength and elongation at break decrease slightly. There is, in addition, an improvement in oil resistance and thermal ageing resistance of carbon black filled NR by the incorporation of novolac resins. The resins for the study were synthesized in the laboratory at various P/F ratios. Extraction studies prove that the resin is inextractable from the rubber. Summing up, the presence of the resin has addressed to a considerable extent the limitations of NR, namely poor ageing and oil resistance.

**Key words:** NR, novolac resins, carbon black, ageing resistance, oil resistance

# Short nylon fiber – natural rubber composite prepared by latex masterbatching : cure characteristics and mechanical properties

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Short fiber filled rubber products are becoming popular owing to the possibility of obtaining anisotropic properties, ease of processing and economy. Fiber breakage and consequent reduction in performance properties is a major problem encountered during processing and product development of short fiber rubber composites. We have developed a novel method for the incorporation of short fibers into the rubber matrix which can overcome this problem. In this method short fibers chopped to approximately 6mm, are incorporated into the rubber latex. The amount of fiber was varied to get up to 30 phr of fiber content in the final composite. The short fiber-rubber masterbatches thus prepared were then coagulated and processed into sheets. The studies conducted in the Thermo Haake Rheocord showed higher energy input in lower cycle time compared to the conventional composites, where, fibers are incorporated in the dry rubber stage. Fiber breakage analysis showed a reduction in the fiber breakage during milling of the latex stage masterbatches compared to the conventional composites. The masterbatches were compounded on a two roll mixing mill and vulcanized by compression moulding. The cure characteristics and mechanical properties of the composites compounded with a dry bonding system based on hexamethylenetetramine, resorcinol and hydrated silica (HRH) were evaluated. The minimum torque and differential torque obtained from the Rubber Process Analyser increased with fiber content. Cure time increased with fiber content while the scorch time initially decreased and then remained almost constant. The new composites showed improved modulus, tensile strength and abrasion resistance compared to conventional composites. Tear strength, resilience and compression set were similar to the conventional composites.

**Key words:** short fiber–rubber composites, cycle time, fiber breakage, cure characteristics, mechanical properties

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# Melt Rheology of Polyethylene caco$_3$ Nanocomposites Using Brabender Torque Rheometer

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The present investigation is a study on the effect of nano filler ($CaCO_3$), on torque development in compounds of polyethylene (PE) using Brabender torque rheometer. Nano calcium carbonate was synthesized by *in situ* deposition technique and its size was confirmed by transmission electron microscopy (TEM). Particle size of calcium carbonate was obtained in the range of 35 – 60 nm. Composites of the fillers (nano and micro scale $CaCO_3$) in polyethylene (PE) matrix with different filler loading (1-5 wt. %) were prepared. The data obtained from a Brabender torque rheometer were evaluated to find out the melt viscosities at low shear rate during preparation of nano and micro scale composites. The concentrations as well as particle size of filler in composites influence the melt viscosity. The magnitude of melt viscosity of nano compounds showed lower values as compared with the corresponding microscale ones. The surface area of the filler enormously increases as the particle size is in the range of 35 – 60 nm, leading to a strong tendency of agglomeration and aggregation, which resulted in poor mixing of nano $CaCO_3$ particles in PE matrix.

**Keywords:** nanoparticles, polyethylene, *in situ* deposition technique, Brabender torque rheometer, melt viscosity.

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**Keywords:** nanoparticles, polyethylene, *in situ* deposition technique, Brabender torque rheometer, melt viscosity.

# Effect of low temperature prevulcanisation on the colloidal and mechanical properties of natural rubber latex

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Sulphur prevulcanisation of natural rubber latex(NRL) was conducted at low temperature(30$^0$C) using zinc butyl xanthate[Zn(bxt)$_2$] –zinc diethyl dithiocarbamate[ZDC] accelerator combination. Zn(bxt)$_2$ was prepared in the laboratory. The optimization of prevulcanisation time and the amount of accelerators used were done. The films were cast from this compounded latex and their crosslink density and tensile properties were determined. Effect of thermal ageing on mechanical properties of these latex films was investigated. After thermal ageing, tensile properties and crosslink density of low temperature prevulcanised latex films were improved. The morphology of the tensile fracture surface of these latex films before and after thermal ageing was monitored using scanning electron microscopy (SEM). The low temperature prevulcanised latex was stored for 30 days and the colloidal properties were measured at different storage intervals. These colloidal properties were compared with those of high temperature prevulcanised latex using ZDC alone. The mechanical stability time (MST) was increased during storage. Both mechanical and colloidal properties were found to be superior for low temperature prevulcanised latex.

**Key words:** low temperature prevulcanisation, colloidal properties, mechnical properties, NR latex, accelerator combination

# Effect of blend composition on the tensile behaviour of PS/HIPS blends

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The tensile behaviour of unnotched and notched polystyrene(PS) / high impact polystyrene(HIPS) blends was evaluated at slow speed. Both tensile modulus and maximum strain remain more or less constant upto about 40% HIPS and thereafter show a drastic change indicating changes in the morphology of the blend at this composition ( Fig.1 and2 ). The notched specimens also follow a comparable trend even though the notch sensitivity marginally increases with HIPS content. The figures suggest that PS / HIPS blends containing more than 40% of HIPS fail in a ductile mode.

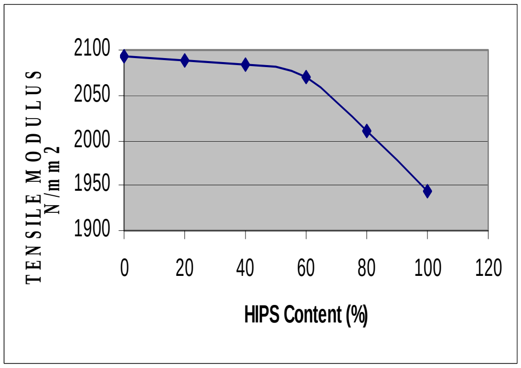

Fig: 1 The variation of tensile modulus with HIPS content.

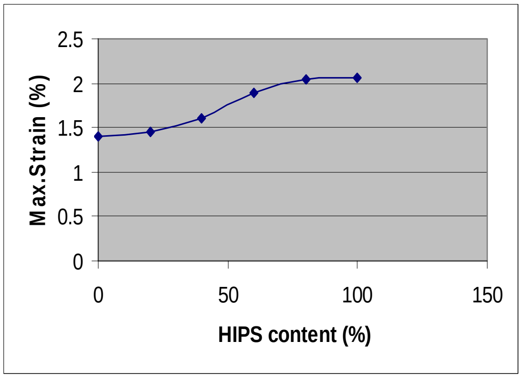

Fig: 2 The variation of max. strain with HIPS content.

**Key words:** PS/HIPS blends, tensile modulus, maximum strain, morphology

# Ultrasound-triggered release of Ibuprofen from a chitosan-mesoporous silica composite- a novel approach for controlled drug release

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In this work, an attempt was made to synthesize a novel chitosan-mesoporous silica (CS-MS) hybrid composite to design a drug delivery system based on ultrasound triggered stimuli-responsive smart release. The in-vitro drug release properties of both the mesoporous silica (MS) and chitosan (CS) hybrids were investigated. Ibuprofen (Ibu) was used as a model drug. The results from powder X-Ray diffraction (XRD) patterns exhibited that in the Ibu-loaded composites, MS can accommodate drug molecules in the lumen of the channels and pores, while CS works as biopolymer matrix. Control of drug release through the porous network was performed by measuring the uptake and release of Ibu. We studied the ultrasound (US) triggered release of Ibu from the pores of CS-MS composites in a simulated body fluid (pH 7.4) and simulated intestinal fluid (pH 1.4). The results exhibited that US can be used as a non-invasive technique for drug release from polymeric materials. It is suggested that the enhancing effect of ultrasound on drug release is due to the cavitation effect, without any significant destruction on the polymer morphology.

**Key words:** controlled drug release, Ibuprofen, chitosan-mesoporous silica composites, ultrasound triggered release, XRD

# Copper (II) ions and copper nanoparticles loaded chemically modified cotton cellulose fibres with fair antibacterial properties

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This work describes release of copper (II) ions from cellulose fibres which have been chemically modified by periodate induced oxidation of cellulose, followed by covalent attachment of biopolymer chitosan. The release of copper (II) ions has been investigated in physiological fluid (PF) and protein solution (PS) both at 37$^o$C. Fibres have demonstrated excellent antibacterial activity against *E.coli*. Finally, their borohydride-induced reduction has yielded copper nanoparticles loaded fibres, with average diameter of particles, nearly 35 nm. The formation of copper nanoparticles has been established by surface plasmon resonance, FTIR spectroscopy. These fibres also show fair biocidal action against *E.Coli*.

**Key words:** biocidal activity, modified cotton fibre, copper nanoparticles, surface plasmon resonance, FTIR, physiological fluid

# Synthesis, photopolymerization and characterization of linear alicyclic (meth)acrylates

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A number of parameters that govern the photo chemical performance of oligomeric macro monomers include the viscosity, refractive index and molecular mass. Refractive index is of prime importance in optic fiber coatings while viscosity is important to provide necessary thixotropy to the coating compositions. The photopolymerizable macromonomers normally have an average molecular mass ranging from 1000 to 20000. They are synthesized using three major constituents: (1) diepoxide or polyol with a molecular mass ranging from 200 to 3000, (2) aliphatic, alicyclic or aromatic diisocyanates or diacids and (3) vinyl or allyl terminated mono, di or triacrylate / methacrylate with at least one hydroxyl group or carboxylic acid group. This work describes the synthesis of linear polyurethane macro monomers with alicyclic moieties and (meth)acrylate end functionalities. Formulations made from one or more polymeric macro monomers, one or more photoinitiators along with additives such as radical scavengers were tested for photo curing performance using differential photocalorimetry.

The photocuring can be studied using differential photocalorimetry (DPC), which gives the cure characteristics at applied intensity and range of wavelengths. The heat flow against time is recorded under isothermal conditions and the rates of polymerization as well as the percentage conversion are estimated. Isothermal kinetics, throws light on parameters such as the induction time, time to attain peak maximum as well as the percentage of monomer reacted at peak. The synthesis as well as polymerization and characterization methods will be presented.

**Key words:** polyurethane macromonomers, photopolymerisation, differential photocolorimetry, isothermal kinetics, cure characteristics

# Studies on the mechanical properties and water absorption of siloxane modified epoxy resin

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Epoxy resins based on bisphenol A-epichlorohydrin (DGEBA) exhibit brittleness and low elongation after cure. This leads to low resistance to crack initiation and propagation. The most common approach to toughen thermosets is by dispersing a rubbery phase in the epoxy matrix. In the present work we were studying the modification of DGEBA with polydimethylsiloxane (PDMS). Organosiloxanes exhibit important characteristics such as very low glass transition temperature (-120$^0$C), moisture resistance, good electrical properties, low stress, high flexibility, and good thermal and oxidative stabilities. The PDMS was blended with commercial epoxy resin (DGEBA) at various ratios using polyamine as curing agent. Their thermal, tensile and impact properties were also determined. Water absorption of the various blends was studied. Water absorption of siloxane modified DGEBA at maximum uptake of water was also studied and compared it with that of neat DGEBA. Morphology of the fractured surfaces was studied using scanning electron microscopy. The results show that the impact strength, resilience energy, energy absorption and elongation at break increase with the concentration of PDMS without much deterioration in tensile properties. The blends show sufficient decrease in modulus indicating enhanced flexibility. The DGEBA/PDMS blends show substantial improvement in thermal stability as evident from TGA data. Siloxane modified epoxies show appreciable water resistance also.

**Key words:** epoxy resin, siloxane modification, mechanical properties, water absorption, thermal stability

# Surface modification of carbon nanofibres by high energy electron and gamma radiations

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Carbon nanofibres (CNFs) were surface treated with high energy electron beam and gamma radiations at varying doses. The neat and the modified CNFs were examined by scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), Raman spectroscopy, TGA and X-ray diffraction (XRD) to characterize the changes caused by modifications. After high energy irradiation, surface defects were introduced and fibre surface became rougher as evident from the SEM analysis. The generation of surface polar groups after high energy irradiation was investigated by XPS. Raman spectra revealed that there was an increase in degree of disorderliness and a decrease in crystallite size after high energy treatments. The results are corroborated from the XRD results. However, there was no significant change in d-spacing on high energy treatments.

**Key words:** carbon nanofibre, surface treatment, high energy irradiation, d-spacing, XRD

# Droplet orientation and its morphology in polymer dispersed ferroelectric liquid crystal composite films

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Composites materials based on liquid crystals (LCs) have attracted considerable attention over the last few years because of their unique dielectric, morphological and electro- optic performance in novel display applications. Typical examples are polymer dispersed liquid crystals, suspensions of nanotubes in ferroelectric LCs etc. The inclusions in known composite LC systems produce director distortions that extend over macroscopic scales. A new approach based on the idea of controlling the properties of the composites by adding a low concentration of nanotubes into a LC matrix is of great interest. The nanotubes are so small that they do not disturb the LC orientation and thus macroscopically homogeneous structures are obtained. At the same time, they are sufficiently large to maintain the intrinsic properties of the materials from which they are made and share these properties with the LC matrix due to anchoring with the LC. The inherent conductivity and spontaneous self alignment properties of CNTs make them an attractive alternative as an alignment layer. We found that embedding the carbon nanotubes in a LC results in changes of the dielectric spectra of the matrix, caused by the strong interaction between LC and carbon nanotubes.

In this paper, we report detailed investigations on morphological and dielectric behaviour of polymer dispersed liquid crystals (PDLC), dichroic PDLC and carbon nanotube dispersed ferroelectric liquid crystals. In all the cases, polymer induced phase separation (PIPS) technique has been used for preparing the materials. The polymer dispersion shows the flexible properties of the display whereas dichroic PDLC gave rise to colour display.multiwalled carbon nanotubes (MW-CNT) have been dispersed in a ferroelectric liquid crystal in the wt/wt of 0.05% and 0.1%. The morphological investigation was carried out which shows uniform distribution of the CNT in the FLC matrix after sonification. The transition temperature of FLC was slightly increased on dispersing CNT in it. The dielectric parameters (measured in the frequency range 50Hz to 1 MHz) increased for CNT dispersed FLC by ~ 27% from the pure FLC values. Polymer dispersed liquid crystal composite films consisting of different polymers and liquid crystal mixtures have been prepared using polymerization induced phase separation technique. These materials were characterized for optical, electro-optic and dielectric studies in detail.

Our results indicate that the external electric field strongly influences the liquid crystal droplet morphology in the composite films. Better polarization switching responses were observed in the films containing ferroelectric liquid crystal mixture over nematic systems.

**Key words:** liquid crystal composite films, polymer dispersed liquid crystals, dichroic PDLC, carbon nanotube dispersed liquid crystals, polarization switching

# Carbon Black Master Batch from Fresh Natural Rubber Latex

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Carbon black is used very widely to enhance the ultimate properties of natural rubber vulcanizates. The level of dispersion of carbon black in natural rubber matrix is an important parameter that determines the final properties of a large variety of rubber products. The conventional dry mixing of carbon black with rubber is highly energy intensive. Pollution arising from the flying of carbon black particles is hazardous to the people involved in the rubber compound production. This work is an effort to find a solution to these problems.

Carbon black as slurry was incorporated in fresh natural rubber latex followed by coagulation and drying to produce carbon black master batches. Though a high degree of dispersion of filler in rubber could be achieved, the time required for mixing and coagulation was very long.

It has been known that the coagulation time of natural rubber latex could be reduced by addition of surfactants. The effect of surfactant on the coagulation time of carbon black slurry - fresh natural rubber latex mixture was systematically investigated. A process for the production of carbon black - natural rubber masterbatch by quick coagulation of fresh natural rubber latex was established. The superiority of the new technique was established by comparing the coagulation behaviour of control carbon black slurry - fresh natural rubber latex mixture containing no surfactant.

Conventional compounds of the control and the surfactant incorporated masterbatches containing various loading of the filler were prepared and the mechanical properties of the vulcanizates evaluated. The effect of ageing on the mechanical properties is also discussed.

**Key words:** carbon black masterbatch, natural rubber latex, surfactant assisted coagulation, coagulation behaviour, mechanical properties

# Nucleation of polypropylene: synthesis and characterization of organo functionalized nanosilica particles

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The aim of the present work was to study the nucleation effect of Organo functionalized silica nanoparticles on Polypropylene matrix. To that end, monodisperse nanosilica particles were prepared by hydrolysis and condensation of tetraalkoxysilanes according to a method developed by Sto-ber, with tetraethoxy silane (TEOS), deionized water, and ammonia ($NH_4OH$) as a catalyst in the presence of ethanol ($C_2H_5OH$). Nanosilica particles having different particle size were prepared by changing the molar ratio of ammonia. The nanoparticles were organo functionalized with octadecyl trichlorosilane (OTS), octadecyl trimethoxysilane (OTDMS), aminopropyl trimethoxysilane (APTMS), mixture of OTS-APTMS (1:1), oleic acid (OA) and γ-methacrloxypropyl trimethoxysilane (KH-570). The nanoparticles were characterized using Fourier Transform Infrared spectroscopy (FTIR), Thermo Gravimetric Analysis (TGA) and SEM. The nucleating efficiency of these particles on PP was studied using optical microscopy and differential scanning microscopy.

# Preparation, properties and characterization of epoxidised natural rubber layered silicates nanocomposites

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Polymer/layered silicate nanocomposites exhibit remarkable improvement in mechanical and barrier properties compared with the virgin polymers or microcomposites. Nanoclay being organophilic are highly compatible with polymers especially with polar ones. Natural rubber being a non polar rubber has incompatibility problem and their nanocompostes are inferior to some of the engineering properties. Epoxidised natural rubber (ENR), a polar form of rubber is expected to have high affinity and better performance with nanomaterials.

Epoxidised natural rubber nanocomposites were prepared by melt compounding of ENR having an epoxy content of 50 mole % at ambient temperature. Two grades of organically modified montmorillonite having layer distances of 2.1 nm and 1.85nm were used in this study. Accelerated sulphur curing system was used for the vulcanization of the nanocomposites. For comparison commercial clay was included in this study. 10 phr loading were given for all the composites. The cure characteristics and mechanical properties were evaluated. The dispersion of the silicate in the matrix was studied by X-ray diffraction (XRD) and transmission electron microscopy (TEM). The addition of modified montmorillonite to the rubber reduced its cure time and scorch time. The maximum torque was higher for these composites. The montmorillonite filled composites showed better mechanical properties compared to the reference material. The enhancement in the properties is believed to be due to the partial exfoliation/ intercalation of the layered silicates in ENR. Among the two types of nanocomposites, the nanocomposite with montmorillonite having higher inter layer distance showed faster cure and better mechanical properties.

**Key words:** epoxidised natural rubber, nanocomposites, layered silicates, montmorillonite, XRD, TEM

# Effect of sealing on the diffraction efficiency of an acrylamide based photopolymer

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Photopolymer media has gained much importance in the field of holography, because of its high sensitivity, low cost, versatility, and ease of processing, compared to other holographic recording media like, dichromated gelatin, thermoplastics, photographic emulsions, inorganic refractive crystals etc. One of the most known polymer matrices for holographic recording is poly (vinyl alcohol), which is a water soluble polymer. Incorporation of organic dye, monomer and an electron donor to the PVA matrix makes it photosensitive and high diffraction efficiency in holographic recording is obtained. In this material, PVA acts as the host for the monomer, which is polymerized by free radical polymerization. Our photopolymer film consists of poly (vinyl alcohol) as the binder, acrylamide as the monomer, methylene blue as sensitizer and triethanolamine as the electron donor. The film was prepared by gravity settling method under ambient conditions and holographic gratings have been recorded on the dried film using He-Ne laser(632.8nm) and a maximum diffraction efficiency of ~ 75% was obtained at an angle of $60^0$ for the film with optimum dye concentration of $0.14*10^{-4}$ M. Eventhough good diffraction grating was obtained, the photopolymer was seriously affected by environmental conditions, especially by variations in humidity, because of this some cracking was observed on the surface of the film. In order to protect the film from environmental effect, the film was sandwiched between two glass plates using epoxy sealant. The sealed sample showed a maximum diffraction efficiency of 67% with the same recording parameters. Even though it showed an initial decrease in diffraction efficiency, it remained as such for a long time and no cracking was observed on these sealed films on storage.

**Key words:** holographic recording media, photopolymer film, epoxy sealing, diffraction efficiency, polyvinyl alcohol

# Nanosilica based nylon-6 short fibre-natural rubber composites

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Composite materials play a key role in aerospace industry, automobile industry and in other engineering applications as they exhibit outstanding strength-to-weight and modulus-to-weight ratios. Short-fibre-reinforced rubber composites have attracted much attention because of better processability, improved physical and mechanical properties and economic advantage. Short-fibre-reinforced rubber composites have been successfully used in the production of V-belts, hoses, tyre treads, seals and complex- shaped mechanical goods. In these composites, a dry bonding system based on hexamethylenetetramine, resorcinol and hydrated silica (HRH) is used to improve fibre-matrix interfacial adhesion which is very critical for efficient transfer of load to the reinforcing member of the composites. In this work we report the effect of substituting hydrated silica of the HRH bonding system with nanosilica on the properties of short nylon fibre reinforced NR composites. The silica was also used as an additional filler in the composite. Nanosilica was synthesized by acid hydrolysis of sodium silicate using dilute hydrochloric acid .The minimum torque, maximum torque and cure time of the hybrid composites increased with silica loading. Cure rate increased with fibre loading and decreased with silica content. Scorch time also decreased with fibre loading and silica content. Volume fraction of rubber in a solvent-swollen sample increased with nanosilica. Mechanical properties and thermal stabilities were improved by the use of the nanosilica based HRH bonding system. The tensile strength improved by 34 % in the case of 30 phr fibre loaded composites. The tear strength improved from 106 to118 N/mm in the presence of 6 phr of nanosilica. By the addition of 9 phr nanosilica, the modulus values increased by 55%, 33% and 28%, respectively for 10 phr, 20 phr and 30 phr fibre loaded samples. It indicates that nanosilica is very effective in improving the mechanical properties of the short nylon fibre/ NR composites.

Key words: short fibre composites, NR, nylon-6 short fibre, nanosilica, mechanical properties

# Pine apple leaf fibre (PALF) reinforced polypropylene nanocomposites

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Polypropylene nanocomposites reinforced with pine apple leaf fibre (PALF) were compounded using Haake Rheocord 9000. Variation in mechanical properties, crystallisation behaviour, water absorption and thermal stability with the addition of nanoclay in polypropylene/PALF composites were investigated. It was observed that the tensile, flexural and impact properties of polypropylene increases with the increase in fibre loading from 10-30 wt%. Composites prepared using 30wt% PALF and 5wt% MAPP exhibited optimum mechanical performance with an increase in tensile strength to 31%, flexural strength to 45% as compared with virgin polypropylene. Further incorporation of organically modified nancolay additionally increases the mechanical performance of the composites. An increase of 20% in tensile, 24.3% in flexural strength was observed in the case of PP/PALF/MAPP composites which are probably due to the intercalated morphology. However, addition of nanoclay decreased the impact strength of MAPP treated PP/PALF composites to about 7.5%. Dynamic mechanical analysis (DMA) data showed an increase in storage modulus (E') and damping factor (tanδ), presenting a strong influence between the fibre/nanoclay and coupling agent. DSC, TGA/DTG thermogram also displayed improved thermal properties as compared with virgin polypropylene. Morphological studies evaluated from SEM revealed improved interfacial adhesion between the fibres/nanoclay and PP matrix. Wide angle X-Ray diffraction studies indicate an increase in d-spacing from 22.4 $A^0$ in Cloisite 20A to 40.1 $A^0$ in PP/PALF nanocomposite due to improved intercalated morphology.

**Keywords:** polypropylene, nanocomposites, mechanical properties, thermal stability, SEM, TEM, X-Ray scattering

# Gas permeability properties of metallocene polyolefin/ethylene vinyl acetate copolymer blends intended for medical applications

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The advances in metallocene catalysis technology have enabled the properties of polyolefins to meet specific end-use needs of some of the medical products such as blood/platelet bags, intravenous fluid containers and medical tubings. Because of its narrow molecular weight distribution, the processability of these types of polymers becomes difficult even though it gives the benefit of low extractable from the product while in use. In order to improve the processability and functional properties, these polymers are being used in blends with other conventional polyolefins. Blends of metallocene based ethylene-α-olefin copolymer (m-PO) with ethylene vinyl acetate copolymers (EVA) have been studied, with the purpose of exploring their properties and potential in medical film packaging applications. As gas permeability is one of the prime parameter of blood/platelet storage containers, an attempt has been made in this study, to understand the permeability properties of the blends. Melt-mixing of m-PO with EVA having different vinyl acetate content (12, 18 and 28%) were carried out in a torque rheometer and melt viscosities of the materials were evaluated from their respective torque values. The oxygen ($O_2$) and carbon dioxide ($CO_2$) permeability of the thin sheets of these blended materials having 0.3mm thickness were studied at three different temperatures (10, 25 and 40$^{o}$C). The temperature dependence of the permeability of these gases was also evaluated. Gas permeability studies indicated that the permeability of both $O_2$ and $CO_2$ gases were less through m-PO compared to its blends with EVA. It could be seen that an increasing trend in gas permeability with the increase of vinyl acetate content in the blend for both $O_2$ and $CO_2$ gases. It was further observed that the permeability of carbon dioxide was higher than that of oxygen in all the cases. The temperature dependence of the gas permeability was found to be in accordance with the Arrhenius expression.

**Key words:** metallocene catalysis, ethylene vinyl acetate copolymers, gas permeability, blood/platelet storage containers

# Initiation of cationic polymerization using allyl phosphonium salts in presence of free radical initiators

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The aim of the present study was to examine the initiation efficiency of novel addition fragmentation agents, namely 2-(N, N-dimethylcaboxy-propenyl) triphenylphosponium hexafluoroantimonate (DMTPH) and 2-(morpholinocarboxy-propenyl) triphenyl phosponium hexafluoroantimonate (MTPH) in photopolymerization. Thus, the present study describes the synthesis of amide based allylic phosphonium salts (DMTPH and MTPH) with hexafluoroantimonate counter anion and examines their initiation activity as an addition fragmentation agent both in the presence and the absence of added radical (photo and thermal) initiator in cationic polymerization of cyclohexene oxide (CHO). The thermal and photo latent activity of these salts in accelerating the polymerization of CHO were investigated at 70 °C and $\lambda > 290$ nm, respectively. Apart from CHO, photo polymerization of other cationically polymerizable monomers (such as *n*-butyl vinyl ether, isobutyl vinyl ether, N-vinyl carbazole and glycidyl phenyl ether) using benzoin and DMTPH initiating system was also examined at $\lambda > 290$ nm.

**Key words:** cationic polymerization, initiation, allyl phosphonium salts, photopolymerization, initiation activity

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# Functionalized MWNTs in natural rubber matrix: mechanical properties and electrical conductivity

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Functionalized carbon nanotubes (CNTs) are easy to exfoliate in polymer matrices thereby achieving homogenous filler dispersion. Carboxyl groups improve the water affinity of CNTs and thus makes easy for the preparation of stable CNTs-NR latex suspensions. In the present work, natural rubber based nanocomposites have been prepared with carboxylated multiwalled carbon nanotubes (MWNT-COOH). MWNT surface has been functionalized by acid treatment and dispersed in water by ultrasonication to get stable aqueous dispersions. The as-prepared dispersions were mixed with the compounded NR latex, cast into sheets, dried and cured under optimized conditions to get nanocomposite films with MWNT concentrations ranging from 0.05 to 1.0 phr. Better solubility (600 mg/L) of MWNT-COOH in water provided visual indication for the functionalization of carbon nanotubes. FTIR analysis confirmed the presence of carboxyl moiety on the CNTs. Significant mass loss in TGA of MWNT-COOH compared to pristine MWNT indicated significant functionalization. Investigations on the mechanical properties of the nanocomposites showed 66 % increase in tensile strength, 54 % increase in modulus and 58 % increase in tear strength of the composite film containing the carboxylated nanotubes as low as 0.1 phr. Conductivity measurements revealed that surface functionalized MWNTs can effectively impart electrical conductivity to the NR matrix. The conductivity reaches a value of the order of $10^{-5}$ $Scm^{-1}$ at 1.0 phr concentration. From the improved mechanical properties, it has been concluded that the carboxyl groups on the MWNT surface favour to improve the interfacial bonding between the nanotubes and the rubber matrix. Significant improvement in conductivity indicates that exfoliated carbon nanotubes are well dispersed in the NR matrix. The results for NR-MWNT-COOH were found to be better as compared with that of NR-MWNT matrix.

**Key words:** functionalized carbon nanotube, NR, mechanical properties, electrical conductivity, interfacial bonding

# Weld line behaviour of PP, HDPE and PP/HDPE blend composites

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Short fibre composites are often manufactured through injection moulding process.The injection moulding of large and complex parts requires the use of multi-gated moulds which results in the formation of weld lines.A sudden change in wall thickness can also cause weld line formation. These structurally weak points in the moulded parts cause serious difficulties in design and long term durability of the processed polymer composites. Incorporation of glass fibres in commodity plastics like PP and HDPE enhances the mechanical properties of polymers but it weakens the moulded part at weld lines. The objective of the study is to find the extent of weld line weakness in PP, HDPE and PP/HDPE blend composites and to find optimum fibre length at maximum mechanical strength. Moreover for composites of PP, the effect of varying compositions of glass fibre on the tensile strength was also studied.

Short fibre composites of PP, HDPE and their blends were prepared by mixing glass fibres of varying lengths (viz., 2,4,6,8 and 10mm) and corresponding polymer matrix in an internal mixer, Brabender Plasticorder, at a rotor speed of 52 rpm. Then dumbbell shaped specimens with and without weld lines were moulded using semi-automated injection moulding machine and were tested on 50kN Shimadzu Universal Testing Machine at $28^0$C.

The studies have shown that the fibre length at which mechanical strength is maximum varies considerably with the composites and is found to be a function of matrix and the reinforcement. The optimum fibre length for PP, HDPE and PP/HDPE blend composites were found to be 6mm, 4mm, 4mm for specimens with weld lines and 8mm, 8mm, 4mm for specimens without weld lines respectively. The studies on varying compositions of glass fibre on the tensile strength of PP composites reveal that in the absence of weld line, tensile strength is found to increase linearly with increasing wt% of glass fibre up to 30% and a decreasing trend is noticed for weld line specimens. The maximum weld line strength is obtained at 10% glass fibre at an optimum fibre length of 6mm for PP composites. Thus in products where weld lines cannot be avoided methods of improving the mechanical strength at the weld lines are of great significance.

**Key words:** weld line behaviour, short fibre composites, glass fibre, PP, HDPE

# Modification of resol phenolic resin by unsaturated polyester for improved mechanical properties

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Cured phenol formaldehyde resol resin is a brittle material due to an extensive three dimensional structure. Formation of microvoids in the cured structure results in inferior mechanical properties. In this study, unsaturated polyester (UP) is used as a modifier for phenolic resol resin. The tensile and impact strengths of the modified resin are compared with that of the neat resin. The SEM pictures of the fractured surface are used to investigate the morphological changes on modification. The modified resin has fewer voids after crosslinking and possesses superior mechanical properties, especially impact strength.

Key words: phenolic resol resin, microvoids, modifier, mechanical properties

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# Kinetic studies on nanosilica production from sodium silicate in poly(vinyl alcohol) medium

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Kinetic studies on the production of silica in nanoscale using poly(vinyl alcohol) (PVA) as surfactant was carried out in a batch reactor taking sodium silicate as raw material. The study included the effect of different process variables like sodium silicate, hydrochloric acid (HCl) and PVA concentrations, pH and drying time. All these factors have a significant effect on the nature and size of silica produced. It was found that the initial sodium silicate concentration of 15% (w/v) was the most favourable concentration producing highest yield of silica. Both acidic and basic catalysts were used in the synthesis and provided good results. A pH of 8 was found to be the most favourable. The concentration of HCl was found to be playing a critical role in the synthesis reaction and is used to determine the parameters like rate constant ‘k’ and reaction order ‘n’. The value of the rate constant k is determined both by theoretical and experimental methods.

**Key words:** kinetic studies, nanosilica, poly(vinyl alcohol), rate constant, reaction order

# Polymer blends, alloys and their application

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The unbelievable advances in science and technologies have resulted in the emergence of new products and processes which have in turn accelerated the pace of industrialization. One such group of products is polymeric system. The system when converted into solid state are called plastics. Plastics are the products of twentieth century and can be expected to perform a major role as materials of next century.

Many new materials were introduced into the family of plastics during the last forty years, but the direction of polymer research and development has been changing gradually in the recent years. In the last decade, the pace of introduction of new polymers has slowed down due to huge expenses involved in the development and testing of totally new polymers. Therefore, now the trend is to fulfill the gaps in the existing array of plastic materials by modifying them through blending, reinforcing, grafting and other methods such as polymer alloys/ interpenetrating polymer systems which can improve the properties and/ or appearance.

Much attention is currently being diverted to the simplest route for combining outstanding properties of different existing polymers that is the formation of polymer blends. In the formation of blends many useful properties of single phase, may be preserved while other properties may be averaged according to the blend composition. Proper control of overall blend morphology and good adhesion between phases are required in order to achieve good mechanical properties. Example of a few blends such as rubber-phenolic blend, epoxy / liquid polysulphide blend, interpenetrating type network have been highlighted in this paper alongwith their properties.

**Key words:** polymer blends, alloys, blend morphology, interfacial adhesion

# Studies on the conductivity and tensile properties of polyaniline blended natural rubber latex

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In an effort to study the conductivity and tensile properties of polyaniline(PANI) blended natural rubber latex (NRL) system, films were prepared under different conditions. Perchloric acid (HCl $O_4$) dopped PANI was prepared at low temperature in the laboratory. PANI dispersions were prepared in water and in vulcastab –VL. NRL was compounded using both the PANI dispersions. In each case, incorporation of PANI dispersion into the latex mixes was done in two ways- before prevulcanisation and after prevulcanisation. The films were cast and dried at room temperature and in oven at $70^0$C for different times. D.C conductivity, swell index, crosslink density and tensile properties of these films were measured. The films show conductivity of the order $10^{-9}$ S/m. Incorporation of PANI dispersions to the latex mixes before prevulcanisation gave films of higher tensile strength than that incorporated after prevulcanisation. Tensile strength was found to be higher for films cast from compounded NRL using PANI dispersion in vulcastab-VL than that of PANI dispersions in water.

**Key words:** PANI/NR latex blend, conductivity, tensile properties, prevulcanisation, perchloric acid dopping

# Conducting short fibre/elastomer composites

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Polyaniline (PANI) is a very important conducting additive and is also considered as a potential candidate for the development of conducting blends because of its high conductivity, stability, ease of synthesis and low-cost reagents. There are a few examples of conducting elastomer blends based on polyaniline and unsaturated elastomers. Even though these PANI/elastomer composites exhibited excellent conducting properties, the main concern with them was the lack of sufficient mechanical properties. This drawback of the PANI-rubber composites can be overcome by using short fibres grafted/coated with PANI. This will impart the elastomer, the conductivity of PANI and reinforcement of short fibres. This work describes the preparation of a conducting composite based on natural rubber (NR), PANI and PANI coated short nylon-6 fibre. PANI was synthesized by chemical oxidative polymerization of aniline in the presence of hydrochloric acid. PANI coated short nyon-6 fibres (PANI-N6) was prepared by *in situ* polymerization of aniline in the presence of short nylon-6 fibre. The conducting composites were prepared by mechanical mixing on a two-roll mill. The cure characteristics, mechanical properties, electrical conductivity and thermal analysis of the composites were evaluated. The amount of fibre in the composite was varied from 40 to 120 phr and the amount of PANI used was in the range 40-140 phr. The composite showed higher tensile strength, tear strength and modulus values and lower elongation at break. The DC electrical conductivity and the thermal stability of the composites increased with PANI and PANI-N6 concentration. The highest conductivity obtained was $1.99 \times 10^{-6}$ S/cm.

Key words: short fibre-elastomer composites, conductivity, PANI, cure characteristics, mechanical properties

# Formulating acoustically transparent composites with carbon nanotube reinforcements for underwater sonar applications

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Structural materials used for underwater sonar applications need to be acoustically transparent for efficient transmission of sonar signals. Acoustical transparency in water is achieved by matching the impedance of the material to water. Acoustic impedance of any material or medium is the product of density and wave speed. In this work, an epoxy copolymer consisting of aromatic and aliphatic backbones was blended with CTBN to formulate the base polymer. Thermoset microspheres were added to the polymer to adjust the density of the material. Silica and carbon nanotube were added as reinforcing fillers. Carbon nanotube was also expected to dampen the shear modes in the material for any given geometry. The acoustical performance of the material was characterized in terms of sound transmission loss. This paper presents the formulation and performance properties of an acoustically transparent polymer composite.

**Key words:** acoustically transparent composites, carbon nanotube, underwater sonar application, epoxy copolymer, thermoset microspheres

# Effect of nanosilica on the mechanical properties of HDPE-nylon fibre composite

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Short fibre reinforced polymers enjoy the advantage of providing stiffness levels achievable with continuous fibres while at the same time being moldable into complex shapes. The effect of nanosilica on the mechanical properties of HDPE-nylon fibre composite at different loading levels of nylon fibre and nanosilica is the topic of this paper. The use of two types of fillers leads to synergic effect on the mechanical properties of fibre composite. Addition of nano silica along with nylon fibre produced good filler dispersion. 1% silica loading with 30wt.% nylon fibre-HDPE composite improves the tensile strength, tensile modulus, flexural strength and flexural modulus while 1% silica loading with 20wt.% nylon fibre-HDPE composite improves the impact strength.

**Key words:** short fibre reinforced polymers, nanosilica, HDPE-nylon fibre composite, mechanical properties

# Studies on adhesive properties of vinyl acetate-butyl acrylate copolymer for coating applications

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The coating must adhere to the surface that has been coated because to decorate or protect any surface, the coating must remain in position. This study investigated the adhesive properties of vinyl acetate (VAc)-butyl acrylate (BuA) copolymer latex on metal substrates for coating application. The metal substrate studied was mild steel. Vinyl acetate (VAc)-butyl acrylate (BuA) comonomer mixtures with different composition and solid content were polymerized by semicontinuous emulsion polymerization process. The shear and peel strength of the resulting copolymers were investigated at different temperatures to evaluate its adhesion property. A high shear strength of the order of 1.9 MPa was obtained for 85/15 wt.% VAc-BuA copolymer with 45% solid content. A peel strength of the order of 0.67 N/mm was obtained for 85/15 wt.% VAc-BuA copolymer with 45% solid content. The result was interpreted in terms of different composition, solid content and temperature.

**Keywords:** shear strength, peel strength, metal-to-metal bonding

# Surface energy and water uptake behavior of PVA/SSA proton conducting membranes

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The surface and interfacial properties of proton-conducting ion exchange membranes are important in their application as solid polymer electrolytes in fuel cells. Poly(vinyl alcohol)(PVA)/ sulfosuccinic acid (SSA) membranes of different crosslink densities were prepared by varying the SSA content (0-30 wt.%) and the drying temperature. These membranes were characterized for their surface energy and wetting characteristics using the contact angle method under dry and wet conditions. Contact angles were measured using the sessile drop method. The total surface energies of the membranes varied as a function of the membrane condition (wet and dry) and the degree of crosslinking. For varying SSA content, the proton conductivity and water uptake of these membranes were measured. Wetting and surface energy of these membranes were found to vary with crosslinking time and SSA content. Wetting characteristics of these membranes affect the proton conductivity, water uptake and ion exchange capacity. For comparison purposes commercial Nafion 117 membranes were also analyzed.

**Keywords:** Surface energy, Proton conductivity, PVA/SSA membranes

# Miscibility studies of HPMC/PEG blends in water by viscosity, density, refractive index and ultrasonic velocity method

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Hydroxy propyl methyl cellulose (HPMC) / Polyethylene glycol (PEG) blends are edible polymer films used for food packing and directly in foodstuffs. However they are water-soluble in ordinary temperature and have good mechanical properties. The miscibility of HPMC/PEG blend in water was studied by viscosity, ultrasonic velocity, density and refractive index techniques at 30 and 50º C. Using viscosity data, the interaction parameters μ and α were calculated. These values revealed that HPMC/PEG blend is miscible when the HPMC content is more than 60 wt-% in the blend at 30 and 50º C, below which is immiscible. Further the result was also confirmed by ultrasonic velocity, density, refractive index measurements, which also revealed that the change in temperature has no significant effect on the miscibility of HPMC/PEG polymer blend.

**Keywords:** blend, density, hydroxy propyl methylcellulose, miscibility, poly(ethylene glycol), refractive index, ultrasonic velocity, viscosity.

# Polymer blends and thermoplastic elastomer

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We all know that elastomers are wonderful. Crosslinking makes this all possible. But crosslinked polymers can not be recycled very easily. So in the interests of keeping the earth from becoming a giant landfill, we have come up with a new approach, the thermoplastic elastomer. The idea behind thermoplastic elastomers is the notion of a *reversible crosslink*. Normal crosslinked polymers cannot be recycled because they do not melt. They do not melt because the crosslinks tie all the polymer chains together, making it impossible for the material to flow. This is where the reversible crosslink comes in. Normal crosslinks are covalent, chemically bonding the polymer chains together into one molecule. The reversible crosslink uses noncovalent or secondary interactions between the polymer chains to bind them together. These interactions include hydrogen bonding and ionic bonding. The beauty of using noncovalent interactions to form crosslinks is that when the material is heated, the crosslinks are broken. This allows the material to be processed, and most importantly, recycled. When it cools again, the crosslinks reform.

The formal definition of a thermoplastic rubber or elastomer - TPE - is “a polymer blend or compound which, above its melt temperature, exhibits a thermoplastic character that enables it to be shaped into a fabricated article and which, within its design temperature range, possesses elastomeric behaviour without crosslinking during fabrication. This process is reversible and the products can be reprocessed and remoulded.”

In this paper we are going to deal with the different grades that are available as thermoplastic elastomers, their properties and application in wire, cables, pen grips and air bag covers.

**Key words:** thermoplastic elastomers, polymer blends, reversible crosslinks

# Miscibility and phase structure of the blends and copolymers of nylon 4,6/nylon 12

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In the present study blends of nylon 4,6/ nylon 12 were prepared by melt blending. Thermal and crystallization behaviour of the blends indicates that the components crystallize individually and phase separate due to crystallization. It seems the presence of nylon 12 increases the crystallizability of nylon 4,6. In the case of nylon 12, the crystallization is inhibited by nylon 4,6 which is already in the solidified form. These results indicate partial miscibility of nylon 12 and nylon 4,6 in the melt state. The melting and crystallization behaviour of these blends in the presence of TPP, which can catalyze the amide exchange reaction between polyamides and form random copolymer, indicates that the wide difference in polyamide polarity of nylon 4,6 and nylon 12 makes the exchange reaction difficult to happen. On the other hand the copolymer prepared by condensation of monomer resulted in the formation of a random copolymer as evident from the single peak nature of the crystallization and melting thermograms as well as the depression of the melting and crystallization temperatures. The phase structure of the copolymers and blends was studied using WAXD and FTIR.

**Keywords:** phase structure, miscibility, crystallizability, nylon 4,6, nylon 12

# Breathing in-breathing out approach to prepare nanosilver loaded hydrogels: highly efficient antibacterial nanocomposites

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The key objective of developing novel materials for hygienic living conditions is to lower the risk of transmitting diseases and bio-foul. Among inorganic antibacterial agents, silver has been identified as an extensively studied material since ancient time to fight infections and control spoilage. With this aim**,** a number of silver-hydrogel nanocomposite systems are being developed. In this study, we put forward a unique strategy to prepare silver nanoparticles loaded poly (acrylamide-*co*-*N*-vinyl-2-pyrollidone) hydrogel composites. The hydrogel networks provide excellent stability for silver nanoparticles and can be stored at room temperature and hydrogels are highly biocompatible in nature. In order to load nanosilver particles into such non-ionic hydrogel, a novel **"breathing in - breathing out" (BI-BO)** approach was employed. As the number of BI-BO cycle increases the amount of silver nanoparticles getting loaded into these hydrogels also increases. This behavior is obvious and confirmed by UV-vis spectral and thermal analysis. Further, the formed hydrogel-silver nanoparticle composites are confirmed by FTIR spectroscopy and transmission electron microscopy (TEM). The average diameter from the size distribution curve came out to be 11.5nm. The antibacterial studies of these hydrogel silver nanocomposites showed excellent results on Escherichia coli (*E.coli*). The antibacterial activity increases with the number of BI-BO cycles and the sample, undergone three BI-BO cycles, showed optimal bactericidal activity. The degree of crosslinking and the amount of silver content have great influence on the antibacterial efficacy.

# Mechanical properties and transport behaviour of chitin whiskers (CW) reinforced carboxylated styrene butadiene rubber latex (XSBR) nanocomposites

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Nanocomposites were successfully prepared using a colloidal suspension of chitin whiskers (CW) as reinforcement in carboxylated styrene butadiene rubber latex (XSBR) by water evaporation method. The chitin whiskers were prepared from commercial crab shell chitin powder by acid hydrolysis. Atomic force microscopy (AFM) was carried out to see the size and structure of chitin nanowhiskers and scanning electron microscopy (SEM) and atomic force microscopy (AFM) were used to study the nanocomposite morphology. The mechanical properties of nanocomposites like tensile strength, tear strength, tensile modulus and elongation at break were measured. Transport parameters such as diffusion coefficient, sorption coefficient and permeation coefficient were also calculated from water diffusion studies and all of them showed a decrease with filler loading. The result indicates that there exist a strong interaction between chitin whiskers and XSBR latex by the hydrogen bonding. The properties of the nanocomposites were strongly affected by the concentration of chitin whiskers in the rubber matrix. This has been explained on basis of the network formation of chitin whisker in XSBR latex.

**Key words:** nanochitin whisker, nanocomposites, tensile properties, diffusion, morphology