

## Synthesis of Molecularly Imprinted Targeting Polymer Quercetin by the Precipitation Polymerization

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In this study, synthesis of molecularly imprinted polymer by precipitation polymerization for using as quercetin adsorbent is reported. Quercetin molecular imprinted polymer (MIP) was synthesized with one-pot reaction method by mixing of these reagents, 1 mmol of quercetin, 6 mmol of monomer, acrylamide (AA), 30 mmol of crosslinker, ethylene glycol (EDMA) and benzoyl peroxide (BOP) as the initiator in the porogen tetrahydrofuran (THF). Non-molecularly imprinted polymer (NIP) as a control experiment was synthesized following as the same procedure but excluding quercetin. Morphological of MIP and NIP was characterized by scanning electron microscopy and infrared spectroscopy. In addition, MIP and NIP were evaluated for adsorption kinetics with the maximized value of 47.8  $\mu\text{mol/g}$  and 40  $\mu\text{mol/g}$  as well as adsorption equilibrium were calculated as 144  $\mu\text{mol/g}$  and 130  $\mu\text{mol/g}$ , respectively.

**Keywords** Molecularly-imprinted polymer; Quercetin; Adsorption kinetics; Adsorption equilibrium

## Aliphatic Isocyanate – Based Polyurethane Foam for Biomedical Application

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For many decades, polyurethane foam is the useful material for various applications such as construction, design furniture, packaging, and insulating; however, many researches have been focused on the use of polyurethane for medical field as the biomaterials. This research synthesized polyurethane foam based on polycaprolactonediol(PCL), and polypropylene glycol (PPG). PCL is the hydrophobic material generally used for polyurethane synthesis while PPG is the hydrophilic material added to improve water absorption of polyurethane foam. Distilled water, dibutyltindilaurate (DBTL) was used as blowing agent and catalyst respectively. In addition, aliphatic isocyanate: butane diisocyanate (BDI) and lysine triisocyanate (LTI) were used as isocyanate to avoid the toxicity from aromatic group. This research aim to study the effect of polyols molar ratio and types of isocyanate on mechanical and thermal properties of polyurethane foam. Degradability and toxicity of products will also be investigated to ensure these products are suitable for human body. From the results, FTIR spectra show peak of urethane linkage and disappearance of isocyanate, it demonstrated that these products are without toxicity from excess isocyanate group. These products are the flexible polymer confirmed by glass transition temperature ( $T_g$ ), about  $-70^{\circ}\text{C}$  from DSC. From SEM images, it found that increasing of PPG affect the morphology of PUF, for instance, pore size, pore size distribution, and cell structure. Additionally, polyurethane foam synthesized from LTI show the greater morphology than BDI. The influence of isocyanate on toxicity was also investigated.

**Keywords** Aliphatic isocyanate; Biocompatible; Mechanical properties; Polyurethane foam; Toxicity

## Synthesis, Characterization and Photophysical Properties of Iridium(III) Complex Polymer for PLED

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A series of  $\pi$ -conjugated chelating polymers with charged iridium complex units based on 1,10-phenanthroline in the backbones of polyfluorene were synthesized by Suzuki polycondensation. 1,10-Phenanthroline (phen) was served as the N<sup>^</sup>N ligand to form a charged iridium(III) complex monomer where the 2-phenylpyridine (ppy) was the C<sup>^</sup>N ligand. The feed ratios of iridium complex monomer in the polycondensation were 0.01, 0.03, 0.05, 0.07 and 0.10 % and the corresponding polymers were denoted as PFir01, PFir03, PFir05, PFir07 and PFir10, respectively. The polymers were characterized by <sup>1</sup>H NMR and their photophysical, thermal and electrochemical properties were investigated. All chelating polymers displayed a good thermal stability and film-forming properties. The result shows that the polymers could be a good candidate for PLED device.

**Keywords** PLED; Iridium; Suzuki polycondensation

## Preparation and Properties of Maleated Natural Rubber Glove Grafted with Cassava Starch

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The objective of the present work was to study the preparation and properties of the maleated natural rubber gloves (MNRG) grafted with cassava starch (CSt). The experimental was carried out in toluene-aqueous solution mixture at 70°C. Firstly, MNRG was made from natural rubber glove (NRG) and maleic anhydride (MA) in toluene. The chemical structure of the MNRG was confirmed by FTIR. The evidence for formation of a graft copolymer was found at 1770 cm<sup>-1</sup> resulting from the chemical reaction between NRG and MA. With an increase in the MA content, the swelling ratio of the MNRG decreased in toluene due to the change in the chemical composition of the MNRG. Then, MNRG was continued to graft with CSt by using K<sub>2</sub>S<sub>2</sub>O<sub>8</sub> as an initiator. The FTIR band of the MNRG-g-CSt appears at 1090 cm<sup>-1</sup> referred to the presence of ester group from grafting between MNRG and CSt. The swelling ratio of the MNRG-g-CSt in water increased with increasing CSt while the swelling ratio in toluene of the MNRG-g-CSt decreased with increasing CSt. The highest tensile strength of the MNRG-g-CSt was found at 30 phr CSt.

**Keywords** Biodegradation; Blend; Chemical modification; Green process

# Surface Modification of Crosslinked Poly(styrene-*co*-divinyl benzene-*co*-vinylbenzyl chloride) by Click Chemistry: Preparation, Characterization, and Adsorption Properties

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Chelating copolymer beads in micron-size range were prepared by suspension polymerization and click reaction. The click chemistry was used as a tool for tuning the surface functionality of poly(styrene-*co*-divinyl benzene-*co*-vinylbenzyl chloride), PVBC. In order to obtain the PVBC-click copolymer, the PVBC was covalently attached with propargyl alcohol via triazole formation. After click-coupling reaction, the change in surface morphology and chemical functionality were confirmed by SEM-EDX and FT-IR, respectively. Adsorption characteristics for heavy metal were investigated by batch adsorption in aqueous systems under different experimental conditions. The adsorption process was time, pH and concentration dependent. The adsorption capacities for Zn(II), Ni(II) and Cu(II) in 500 ppm solutions were found to be 0.936, 0.733 and 0.696 mmol/g, respectively. Adsorption of Cu(II) ion, the model heavy metal ion, on the PVBC-click resin was well fitted to Langmuir isotherm model. The results of this work indicated that surface functionalization of the copolymer by click reaction could be a simple and suitable method and the PVBC-click prepared in this work could be used for the effective removal of metal ions from aqueous solution.

**Keywords** Click chemistry; Vinylbenzyl chloride; Adsorption; Propargyl alcohol; Azide

## Development of Biodegradable Polyurethane Foam: The Effect of Chain Extenders on Properties

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Polyurethane foams (PUF) have been widely used in many modern industries such as structural, cushioning, insulating, electrical and packaging. These foams can be synthesized by diisocyanate, multipolyols and chain extender. Recently, in many research, the properties of PUF was developed by varying raw material. The purpose of this study not only synthesized biodegradable polyurethane foams by varying chain extender length to improve properties but also investigated the accelerative degradation after disposed into environment. So, in this study, the type of chain extender was varied. Polycaprolactone diol (PCL), hydrophobic material, was often used as a main block of soft segment. Inexpensive polypropylene glycol (PPG), hydrophilic material, was used to increase the PUF degradation. In addition, aromatic methylenediphenyl diisocyanate (MDI) were mainly material to build hard segment block of PUF. This work is focus on the use of easily and cheap accessible diols, ethylene glycol (EG), 1,4 butanediol (BDO) and 1,6 hexanediol (HDO) are used as the chain extender for commercial biodegradable polyurethane foam synthesis. The Fourier Transforms Infrared Spectroscopy (FT-IR) was used to characterize urethane linkage and other functional group in PUF. The result revealed that the peak of urethane linkage took place in the foam and the isocyanate peak disappears. The morphology of PUF was characterized by scanning electron microscope (SEM). The results showed that number of cell foam and pore characteristic depended on the type of the chain extender. The PUF with HDO chain extender shown the greater pores than other chain extender with equal both polyols content. Also the density of PUF was investigated

**Keywords** Biodegradable polyurethane foam; Chain extender; polypropylene glycol.

## **Effect of Sulfur on Crosslink Density of Poly(lactic acid)/ Pre-vulcanized Natural Rubber Latex Blown Films**

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Due to brittleness of poly(lactic acid) (PLA) blown films, natural rubber (NR) was blended to improve their mechanical properties. In previous work, the PLA blended with natural rubber latex (NRL) exhibited transparent and smooth film.; however, this PLA/NRL blown film still has low mechanical properties that is not suitable to use in packaging application. To improve the mechanical properties of PLA/NRL blown film, dynamic or in-situ vulcanization of rubber while blowing film was chosen. There are two typical vulcanization systems, i.e., peroxide and sulfur systems. Peroxide system is used to crosslink all types of rubber while sulfur system is usually used to crosslink rubber whose molecules contains double bond. In this work, vulcanization only NR domain is preferred because PLA matrix is still able to be molten. Therefore, sulfur system was used to prepare pre-vulcanized natural rubber latex (PNRL). The aim of this work is to measure crosslink density and relate it to mechanical properties of PLA/PNRL blown film by varying the amount of sulfur. Zinc diethylthiocarbamate (ZDEC) and zinc oxide (ZnO) were used as an accelerator and activator, respectively. The crosslink density of PLA/PNRL blown films was measured using toluene as solvent in swelling method, and mechanical tests (tensile and impact) were also performed.

**Keywords** Polylactic acid; Pre-vulcanized natural rubber latex; Sulfur; Crosslink density

## Effects of BR Grades on Dynamic Properties of NR/BR Blends for Automotive Suspension Parts

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Dynamic properties are very crucial for suspension parts in automotive industries. Objective of this research work was focused on studying dynamic properties of NR/BR rubber parts using different grades of BR with different structures, such as, linear branching (BR1220 and BR150L) and medium branching with high vinyl contents (VCR412 and VCR617). In the first part, STR5L NR and each grade of BR were controlled at the blend ratio of 70/30 (%wt) with 60 phr of carbon black filler (N330 and N550). Rubber compounds were prepared by mixing rubbers with additives using a laboratory kneader-type internal mixer and two-roll mill. Rubber samples were shaped by a compression molding machine using a cure cycle of  $t_{(c90)} + 3$  min at 150 °C. It was found that the blends using BR with high syndiotactic 1,2-polybutadiene (SPB) resin content (VCR412 and VCR617) yielded higher hardness and better crack growth resistance. The blends with BR150L showed that the best overall properties, such as, elongation at break, rebound resilience, heat built up, and dynamic mechanical thermal analysis (DMTA properties at 30 °C to 100 °C). However, tensile modulus (M100 and M300), tensile strength, tear resistance and compression set of the blends were insignificantly different. Nevertheless, more works are needed to justify the effects of BR grades in NR/BR blends as their best dynamic performance in automotive suspension applications.

**Keywords** Butadiene rubber; NR/BR blends; Automotive parts; Syndiotactic 1, 2-Polybutadiene (SPB) resin

# Synthesis and Characterization of Poly(AM-co-HEMA)/Poly (Vinyl Alcohol) Semi-IPN Hydrogel Films at Low HEMA Content

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The purpose of this work was to synthesize the semi-interpenetrating polymer network (semi-IPN) hydrogels of poly (acrylamide-co-2-hydroxyethyl methacrylate)/polyvinyl alcohol (P(AM-co-HEMA)/PVA)[1], [2], [3] at low HEMA contents (<10%wt). The P(AM-co-HEMA)/PVA semi-IPN hydrogels were prepared by a free-radical polymerization using ammonium persulfate (APS) as an initiator and ethylene glycol dimethacrylate (EGDMA) and glutaraldehyde (GA) as crosslinkers. In the first step, P(AM-co-HEMA) network was synthesized in aqueous solution at 50 °C for 24 h. The second step, PVA aqueous solution and glutaraldehyde crosslinking reagent were following added to form semi-IPN structure for 1 h. FT-IR results showed the bands of C-H stretching on the polymer backbone at 2940 cm<sup>-1</sup>. The broad adsorption band at 3330 cm<sup>-1</sup> can be attributed to the overlapping vibration of O-H and N-H stretching. The adsorption peaks at 1730 cm<sup>-1</sup> and 1089 cm<sup>-1</sup> were assigned to the stretching vibration of C=O and C-O group, respectively. The successfully synthesized semi-IPN hydrogels were then characterized using various techniques such as scanning electron microscopy (SEM), differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA) as well as swelling ratio.

**Keywords** Semi-IPN; Hydrogel; Novel polymer blends; HEMA; PVA

## Hydrogenation of Palmitic Acid to Bio-hydrogenated Diesel over Sulfided NiMo/Al<sub>2</sub>O<sub>3</sub>-TiO<sub>2</sub> Catalysts: Effect of Al<sub>2</sub>O<sub>3</sub>-TiO<sub>2</sub> Ratio on Activity and Selectivity

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Bio-hydrogenated diesel (BHD) has always been an interesting alternative for renewable fuel. The hydrogenation of oils seems to be a very promising method in term of production of future fuels. The major advantage of this process is the formation of hydrocarbon products at the conventional fuel range with less sulfur containing. In this study, a series of NiMo/Al<sub>2</sub>O<sub>3</sub>-TiO<sub>2</sub> catalysts were prepared and tested in hydrogenation of palmitic acid (for used as the palm oil model compound) using different Ni loaded with Ni/(Ni+Mo) weight ratios of 0.2, 0.3 and 0.4, respectively. The effects of Al<sub>2</sub>O<sub>3</sub>-TiO<sub>2</sub> ratio were investigated on Al<sub>2</sub>O<sub>3</sub>, TiO<sub>2</sub> and mixed Al<sub>2</sub>O<sub>3</sub>-TiO<sub>2</sub> (the ratio 8:2, 5:5 and 2:8) catalysts. Then, sol-gel and NiMo complex co-impregnation procedure were prepared and being processed. All catalysts were characterized by BET and H<sub>2</sub>-TPR techniques. The catalyst reactivity was investigated in a stirred batch autoclave at a temperature of 240-320 °C for 1 hour with the support of 10 bars of H<sub>2</sub>. The liquid parts of the products were then analyzed by gas chromatography–mass spectrometry (GC-MS) and gas chromatography–flame ionization detector (GC-FID). The change in the hydrogenation activity of catalyst and the effect of temperature (240-320°C) on the yield and compositions of products were also carefully investigated. Finally, the best catalyst was chosen based on the effect of Al<sub>2</sub>O<sub>3</sub>-TiO<sub>2</sub> ratio via the hydrogenation reaction under optimum conditions.

**Keywords** Sulfided NiMo catalysts; hydrogenation; Palm oil

## One-pot Synthesis of Graft and Chlorinated Natural Rubber from Latex as Oil-resistant Material

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Natural rubber is one of the renewable resources used for a variety of applications due to its excellent properties including flexibility and fatigue resistance. However, natural rubber is hydrophobic, and therefore it is not suitable for oil-related applications. In this work, a one-pot synthesis of graft and chlorinated natural rubber as oil-resistant material is described. Graft copolymerization of methyl methacrylate and chlorination were chosen as means to improve the hydrophilicity of natural rubber. Grafting of methyl methacrylate onto natural rubber latex was carried out using emulsion polymerization in the presence of cumenehydroperoxide/tetraethylene pentamine mixture as initiator whereas chlorination of the natural rubber was performed using common chlorinating agents. It was found that grafting efficiency of methyl methacrylate and chlorination onto natural rubber reaches 37% and 84%, respectively. The thermal properties and oil-swelling resistance graft, chlorinated natural rubber were characterized. These results show that the one-pot method developed in this work is a simple, versatile means for improving the hydrophilicity of the natural rubber. This work is also a proof-of-concept for other combinations of reactions or other polymers.

**Keywords** Natural Rubber; Chlorination; Grafting

## Synthesis of Alkoxy Unsaturated Fatty Acid Ester as Branched Pour Point Depressants

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Biodiesel is a replacement of diesel fuel since it is produced from renewable resources. Although biodiesel has many advantages over diesel fuel, a major drawback limiting its applications is poor flow properties at low temperature. Chemical additives is one of the methods that was used to improved cold flow properties of biodiesel. This research aimed to synthesize pour point depressants as chemical additives to improved flow properties of palm biodiesel. The major component of unsaturation in palm biodiesel was oleic acid; therefore, it was selected as a starting material to synthesize pour point depressants. Oleic acid was reacted with isopropanol *via* esterification. Then, isopropyl oleate was epoxidized with peroxyacetic acid and alkoxyated with ethanol, 1-butanol, 1-hexanol and 1-octanol for attachment of alkoxy side chains. The synthesized pour point depressants were characterized by <sup>1</sup>H-NMR technique. The results showed that at 8 wt% of octyloxy isopropyl oleate, the cloud point and the pour point of palm biodiesel were reduced by 3.2 °C and 0.6 °C, respectively.

**Keywords** Biodiesel; Alkoxylation; Cloud point; Pour point

## Tensile Properties of Glycerol Plasticized Corn Husk Cellulose Ester Films

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The purpose of this research is to study the effect of glycerol as a plasticizers on tensile properties of corn husk cellulose laurate films. Corn husk cellulose extraction was performed by delignification, bleaching and hydrolysis, respectively. After that, the esterification of corn husk cellulose was carried out under optimum conditions (80 °C for 12 hours) by using lauroyl chloride as an esterifying agent, toluene and pyridine as a solvent and a catalyst, respectively. Chemical structure, morphology and solubility of modified cellulose were examined. After modification, the plasticized cellulose laurate film was prepared by casting method with chloroform solvent. Glycerol was used as plasticizer at concentration of 1% to 10% w/w of dry cellulose ester. Tensile properties such as tensile strength and % elongation at break of plasticized and unplasticized cellulose laurate film were measured.

**Keywords** Cellulose; Corn husk; Plasticizer; Esterification; Cellulose ester

## Ring-Opening Polymerization of Cyclic Ester Monomers for the Synthesis of Biodegradable Polyesters

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Biodegradable polymers are versatile materials with a wide range of applications including surgical sutures, scaffolds, matrix materials for tissue-engineering and regenerative medicine, biodegradable packaging and agriculture. The ring-opening polymerization of cyclic ester monomers such as L-lactide and  $\epsilon$ -caprolactone has been studied using novel organotin compounds as coordination-insertion initiators. In this research, a novel initiator was synthesized via the reaction between tin(II) octoate and diethylene glycol monoethyl ether at 130 °C under vacuum. After purification, it was obtained as a colourless liquid. The poly(L-lactide) and poly( $\epsilon$ -caprolactone) products were characterized by a combination of analytical techniques such as fourier-transform infrared spectroscopy (FT-IR), thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). The organotin initiators were used in concentrations of 0.10, 0.20, 0.50 and 1.0 mol% in the bulk ROP of  $\epsilon$ -caprolactone at 130 °C and their efficiencies compared. The molecular weights of the poly( $\epsilon$ -caprolactone) products were determined by dilute-solution viscometer. The results showed that an initiator concentration of 0.10 mol% gave the highest viscosity-average molecular weights  $2.13 \times 10^4$ .

**Keywords** Biodegradable polyesters; Ring-opening polymerization; Poly(L-lactide); Poly( $\epsilon$ -caprolactone)

## Release Characteristics of Starch-Alginate Beads Containing Carbendazim for Agricultural Application

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Agrochemicals are normally added to soil to release nutrients for plants. However, the leaching losses from agrochemicals have problems such as environmental pollution and health hazard. Thus, controlled release of agrochemicals is used to solve these problems. Moreover, the controlled release of agrochemicals is used to increase the water used holding capacity of soil and extend the activity of agrochemicals. Carbendazim is a fungicide used to control the growth of fungal diseases in various crops. In this study, the starch-alginate beads were prepared by varying the amount of starch (i.e., 2.5, 5, and 10 %w/v) and crosslinking with 0.1 M calcium chloride (CaCl<sub>2</sub>) solution. The 10 %w/v carbendazim was incorporated into the starch-alginate beads. The morphology of these beads was characterized by Scanning Electron Microscopy (SEM). From the SEM images, an increase in the amount of starch improved the shape of the beads and they became more spherical. The water swelling and weight loss behaviors of the beads were carried out in aqueous medium. For the release study, increasing the starch amount caused the released carbendazim from beads in aqueous medium to decrease, while, in case of the soil column study, a much lower amount of carbendazim was released.

**Keywords** Starch; Alginate; Beads; Carbendazim; Drug delivery system

# **Influence of Composition of Chitosan (CS) and Poly (vinyl alcohol) (PVA) on Properties of the CS/PVA Blend-Hydrogel Films**

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The aim of this research was to investigate the effect of compositions of chitosan (CS) and poly(vinyl alcohol) (PVA) on the properties of CS/PVA blend hydrogel films. The blend hydrogel films were synthesized by free-radical polymerization using N,N', methylenebisacrylamide (MBA) as a chemical crosslinker and NaOH as an initiator. The prepared hydrogels were characterized by FT-IR, SEM, DSC and TGA. The mechanical properties of hydrogel were also carried out by tensile testing. FT-IR results showed that the hydrogel films of CS/PVA blend were successfully prepared. The surface morphology of hydrogels exhibited rough surface with some rectangular crystal forms. From DSC thermograms, the glass transition temperature ( $T_g$ ) and melting temperature ( $T_m$ ) of CS/PVA blend films was in the range of 70-90 and 220-250 °C, respectively, depending on CS/PVA composition. Moreover, the study of mechanical properties showed that tensile strength and Young's Modulus of CS/PVA blend films were in the range of 200-4000 MPa and 20-130 MPa, respectively. The best composition of CS and PVA was 1:3 weight ratio yielding the highest tensile strength and modulus of 90 MPa and 4074 MPa, respectively. This indicates that prepared CS/ PVA hydrogels have high strengths and good mechanical properties which could be used for wider application range.

**Keywords** Chitosan; Poly (vinyl alcohol); The blends hydrogel films; Thermal properties

# Filter Paper Grafted with PNA-containing Copolymer Brushes for Colorimetric DNA Sequence Determination

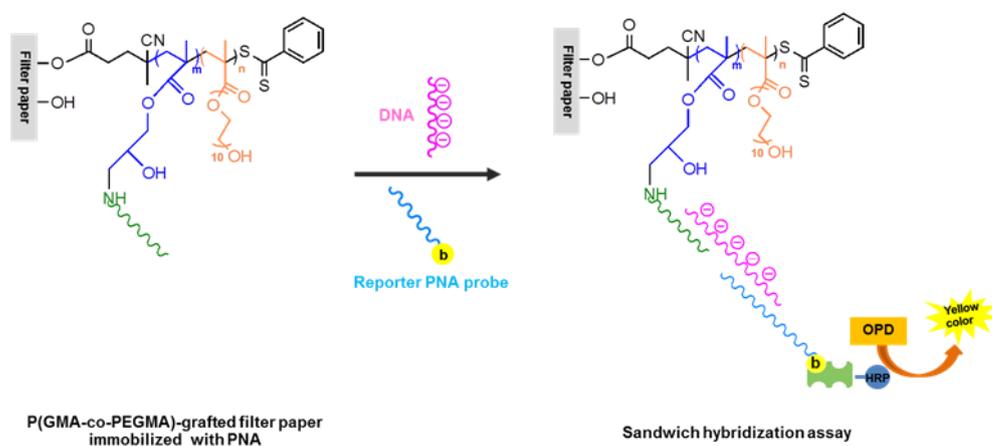
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This work aims to develop a filter paper-based platform for colorimetric DNA detection employing peptide nucleic acid (PNA) probe. Filter paper functionalized with poly(glycidyl methacrylate-co-poly(ethylene glycol)methacrylate)(P(GMA-co-PEGMA)) with GMA:PEGMA ratio of 30:70, 50:50, and 70:30 was first prepared via surface-initiated reversible addition-fragmentation chain transfer (RAFT) polymerization. PNA probes (Ac-GGAACCTGCGCG-LysNH<sub>2</sub>) were then immobilized on P(GMA-co-PEGMA) through ring-opening of epoxide groups in the GMA repeat units by amino groups in the PNA's structure. The success of P(GMA-co-PEGMA) grafting on filter paper and subsequent PNA immobilization was confirmed by Fourier transform-infrared spectroscopy and x-ray photoelectron spectroscopy. Signal amplification relies on sandwich-hybridization assay employing biotinylated PNA probe (b-PNA) having a sequence of b-o-o-AACACACAGACT-SerOHas reporter probe together with horseradish peroxidase-labeled streptavidin (SA-HRP). The sensing platform based on GMA:PEGMA ratio of 30:70 showed the best performance in preventing non-specific adsorption from the non-complementary DNA and discriminating between complementary and non-complementary targets which can be visualized by naked eye.



**Keywords** Filter paper; Peptide nucleic acid; Polymer brushes; Sandwich hybridization; DNA biosensor

## Effect of Thermal Initiators on Methyl Methacrylate Polymerization in Natural Rubber Latex

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A graft copolymer of methyl methacrylate (MMA) on natural rubber (NR) was prepared by emulsion polymerization initiated by two different thermal initiators: potassium persulfate (PPS) and benzoyl peroxide (BPO). The effects of the initiator type, initiator concentration, reaction temperature and time on the grafting properties were investigated. The results revealed that %graft copolymer, %ungraft NR, and %ungraft poly(methyl methacrylate) (PMMA) were influenced by the studied factors. The structures of the copolymers were characterized by Fourier transform infrared (FTIR) spectroscopy and <sup>1</sup>H nuclear magnetic resonance (<sup>1</sup>H-NMR) spectroscopy. Moreover, the molecular weight of the ungrafted PMMA was determined by gel permeation chromatography (GPC). The chemically modified graft copolymer prepared in this work will be useful for improving the miscibility of NR blended with other polymer system.

**Keywords** Methyl methacrylate; Graft natural rubber; Potassium persulfate; Benzoyl peroxide

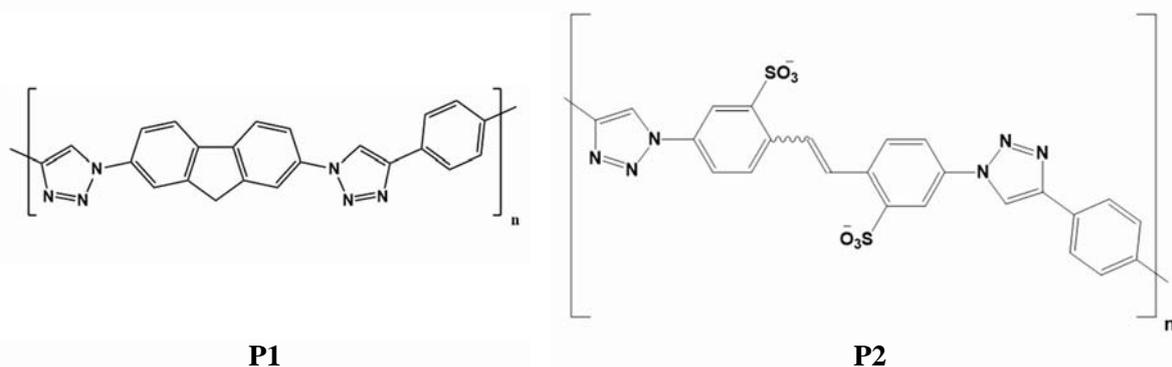
# Synthesis of Triazole-Containing Conjugated Polymers through Click Polymerization

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Click polymerizations were carried out to efficiently achieve syntheses of two novel triazole-containing conjugated polymers. The 2,7-diazidofluorene precursor was synthesized from a series of double reduction, diazotization and azidation of the corresponding dinitro derivative in 71% yield. The precursor was reacted with 1,4-diethynylbenzene under Click polymerization condition catalyzed by copper (I) ion to obtain polymer P1 as brown solid in quantitative yield. Water-soluble polymer P2 was similarly prepared from 4,4'-diazido-2,2'-stilbenedisulfonate and 1,4-diethynylbenzene through click polymerization in 91% yield. The characterizations of both polymers P1 and P2 by  $^1\text{H-NMR}$  spectroscopy indicated the presence of the singlet signals of the newly formed triazole protons appearing approximately at 9.4 and 9.5 ppm, respectively. Solid UV-Vis spectra also showed the relatively bathochromic shift of the absorption maxima at 747 and 540 nm, for polymers P1 and P2 respectively, supporting the extended  $\pi$ -conjugated nature of these polymers.



**Keywords** Click reaction; Triazole; Conducting polymer

## Preparation and Characterization of Silk Sericin–Silk Fibroin/Collagen Scaffolds for Skin Cell Culture

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A polymeric scaffold is a temporary structure for the cell growth to create a 3-dimensional structure of skin. Silk proteins are natural polymers composed of two types of proteins which are silk fibroin (SF) and silk sericin (SS). SF and SS were used as a scaffold for artificial tissue because they have suitable properties such as water and oxygen permeability, lower inflammatory, good cell adhesion, non-toxicity, biocompatibility, and biodegradability. Collagen (Col) is the main structural protein of the various connective tissues in animals. Its properties are non-toxicity, biocompatibility, and biodegradability, thus it could be used as a scaffold. In this study, the aim was to develop scaffolds for use in skin cell culture. The raw materials used to prepare scaffolds were SF, SS, and Col. Various blending ratios of SF and Col (i.e. 100/0, 70/30, 50/50, 30/70, and 0/100) were used to prepare the SF/Col scaffolds. The 0.1% w/v SS was added to the SF/Col scaffolds to prepare the SS-SF/Col scaffolds. These scaffolds were then characterized for their morphological appearance, water swelling, weight loss, and mechanical properties. The results showed that interconnected porous structures of scaffolds were obtained. Increasing immersion time increased the water swelling and weight loss.

**Keywords** Scaffold; Fibroin; Sericin; Collagen; Freeze-drying; Skin substitute

# Thermal and Mechanical Properties of Polybenzoxazines Modified with Adipic Acid

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In this study, the toughness of polybenzoxazine (PBA-a) was enhanced by applying adipic acid (AA) as plasticizer in order to remove the drawback of this novel thermosetting polymer. The content of AA was varied from 0 to 30 phr. The thermal properties were determined by Differential Scanning Calorimeter (DSC) and Thermogravimetric Analyzer (TGA), while the mechanical properties were analysed by Universal Testing Machine (UTM). The chemical interactions were determined by Fourier Transform Infrared Spectroscopy (FTIR). The results reveal that the glass transition temperature of the PBA-a was decreased with increasing the amount of AA. The FTIR spectra present the formation of ester linkage generated from the interaction between hydroxyl group of PBA-a and the carbonyl group in the adipic acid. Moreover, it was found that the flexural modulus was decreased and the elongation at break was increased with AA content, indicating that the toughness of the modified polymer was improved.

**Keywords** Toughness enhancement; Polybenzoxazine; Thermal and mechanical properties

## The Effect of Luffa Fiber and Kaolin on the Properties of Wheat Gluten Composites

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Effects of filler type, *i.e.* luffa fiber and kaolin (0, 5, 10 15 and 20 wt%), on water absorption, tensile and thermal properties of wheat gluten composites were investigated. The composites were prepared by using compression molding and glycerol was used as a plasticizer. The results revealed that water absorption of the wheat gluten matrix was significantly decreased by the addition of luffa fiber and kaolin. Moreover, the results from the thermal gravimetric analysis (TGA) confirmed that the thermal stability of the wheat gluten matrix was improved with the addition of luffa fiber and kaolin as well. Scanning electron microscopy (SEM) was used to characterize fractured surface of the composite. The SEM micrographs exhibited that luffa fiber well dispersed and embedded in the wheat gluten matrix. Contrastingly, kaolin poorly dispersed and formed aggregates in the composite as examined by SEM. These results correlated to the tensile properties of the composites, where the maximum tensile strength of wheat gluten/luffa fiber composite was 3.17 MPa, which was greater than that of wheat gluten/kaolin composite (2.40 MPa).

**Keywords** Filler; Thermal stability; Compression molding; Water absorption

## Synthesis for Composite Materials of Low-Density Polyethylene and Phosphate Compounds

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Phosphate compound were synthesized by a simple precipitation by using of two initial compounds ,  $\text{MnCl}_2 \cdot 4\text{H}_2\text{O}$  and  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$  . It was found that percent yields of both phosphate compounds were 98.01 and 98.68 , respectively. They were no significant difference. There compounds were further characterized , FTIR revealed the fundamental vibrations of  $\text{PO}_4^{3-}$  anion and  $\text{H}_2\text{O}$  in compound structures. XRD showed that indicated that there were orthorhombic phase. SEM indicated that there were clearly different in shapes and particle sizes depending on raw materials. The phosphate compounds were further mixed with LDPE and passed through blown film process. The mechanical properties were decreased as compared to LDPE.

**Keywords** Phosphate compound; Low-density polyethylene; Morphology; Simple precipitation

## Synthesis and Encapsulation of Curcumin in beta-Cyclodextrin Citric Acid Cross-Linked Polymer

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A water-soluble cyclodextrin polymer cross-linked by citric acid (pbCD) was synthesized by using sodium dihydrogen phosphate ( $\text{NaH}_2\text{PO}_4$ ) as catalyst. The dried mixture was treated at 140 °C for 30 min without solvent. The synthesized polymer was characterized by gel permeation chromatography (GPC), <sup>1</sup>H-NMR and FTIR spectroscopy. The inclusion complex with curcumin was prepared by dissolving pbcd and curcumin in water with sufficiently stirring for 24 h at room temperature. The aqueous solution was separated and dried. The curcumin-pbCD complex was characterized by UV-Vis spectroscopy and DSC. The UV absorption of water soluble curcumin-pbCD inclusion complexes was greatly increased. The photostability of curcumin in water was also investigated. In the formation of inclusion complexes, pbCD was able to be used as a solubilizer for hydrophobic molecules in cosmetic and pharmaceutical applications.

**Keywords** Cyclodextrin polymer; Curcumin; Encapsulation; Citric acid

# Property Improvement of Linear Low Density Polyethylene/Barium Sulfate Composites for Sea Fishery Application

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This research studied on properties of barium sulfate (BaSO<sub>4</sub>) - filled linear low density polyethylene (LLDPE) composites for sea fishery application. Both uncoated and stearic acid (SA) coated grades of BaSO<sub>4</sub> were used. Maleic anhydride grafted polyethylene (PE-g-MA) was used as a compatibilizer. BaSO<sub>4</sub> contents were varied at 5, 10, 15, 20 and 25% by weight and PE-g-MA was used at 1% by weight of BaSO<sub>4</sub>. All compounds were prepared using an internal mixer and the composite samples were shaped using an injection molding process. Morphology of the samples revealed that the difficulty of BaSO<sub>4</sub> dispersion in the LLDPE matrix increased with increasing BaSO<sub>4</sub> contents. Thermal properties of sample showed that the crystalline melting temperature, recrystallization temperature and %crystallinity of LLDPE in all samples were similar. From mechanical properties, the results indicated that the elongation at break and impact strength of LLDPE/BaSO<sub>4</sub> decreased with an increase of BaSO<sub>4</sub> contents but Young's modulus and hardness were increased. The incorporation of PE-g-MA resulted in the decrease of elongation at break and impact strength of LLDPE/BaSO<sub>4</sub>. It is indicated that a strong interfacial adhesion is not favorable for toughness, especially under high strain rate, because the bonding-cavitation process may be delayed and the plastic deformation of matrix may be restrained. On the other hand, the incorporation of SA had no effect on mechanical properties. Surprisingly, tensile strength of LLDPE/BaSO<sub>4</sub> composites was not significantly influenced by the presence of BaSO<sub>4</sub>, PE-g-MA, or SA. In addition, environmental stress cracking resistance (ESCR) of LLDPE/BaSO<sub>4</sub> composites was affected by BaSO<sub>4</sub> loading.

**Keywords** PE; BaSO<sub>4</sub>; Composites; Sea fishery application

## **Study of Vegetable Tanned Leather Flour as Bio-filler for NR: Effects of Wax Treatment**

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Each year, a large amount of waste generated from cutting and grinding processes in leather industries has been waiting to resolve. In this study, waste of vegetable-tanned leather flour was used as bio-filler in natural rubber (NR). Comparative study of untreated, polyethylene glycol (PEG) and PE-wax treated leather flour was carried out. First, loading of <35 mesh leather flour was controlled at 30 phr. STR-5L NR, leather flour, and other additives were compounded by using a two-roll mill and shaped into sheet samples by compression molding technique. It was found that NR with treated leather flour seemed to have higher Mooney viscosity and faster cure time. Flour treatment of PEG yielded the fastest cure time and improvement in mechanical properties, such as, tensile strength, tear strength and hardness. PE-wax improved interfacial adhesion between the filler and rubber matrix, filler dispersion, and defect reduction in samples. Moreover, the leather flour treatment prevented accelerator and activator absorption at the leather surfaces.

**Keywords** Leather; PEG; PE-wax; Natural rubber; Filler treatment

## **Development of Water-based Ink for Silk Screen Printing from Modified Poly(vinyl alcohol) and Natural Rubber**

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Water-based screen inks were developed consisting of PVA, modified PVA (P\*) and natural rubber latex (NR) as the main components. The modified PVA was achieved by esterification reaction of PVA with various amounts of oleic acid at 1, 3, 5 and 10 pph. The result was confirmed by FTIR technique. The weight ratio of PVA or P\*: NR as ingredient in the screen ink was controlled at 80:20. The viscosities of achieved water-based inks were measured. The viscosity of PVA and their modified PVA was at about 7000-10000 cP. The water-based inks were screened on the 100% cotton sheets and subjected to heat at 135-145 °C for 10 sec. After that, the screened sheets were tested for durability of the water-based inks by comparing the results before and after washing with detergent. The durability tests were investigated i.e., adhesion of the water-based inks on the sheet and pattern sharpness using optical microscope and color tone measuring according to ASTM D-1925. It was proved that the water-based inks still tightly stayed on the screened sheets after durability test with good quality of pattern sharpness and color tone. The results showed that the modified PVA with 5 pph of oleic acid (P\*5) showed the least difference in the shade-fading.

**Keywords** Water-based screen ink; Poly(vinyl alcohol); Natural rubber latex; Oleic acid

# Electrospun Polybutylene Succinate Nanofiber: Effect of Polymer Concentration, Voltage and Electrospinning Distance on Fiber Morphology

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This research was studied the electrospinning process of polybutylene succinate (PBS). The PBS solution was prepared by dissolved in a mixed solvent between dichloromethane (DCM) and dimethylformamide (DMF) with ratio 3/1. Effect of polymer concentration, voltage and electrospinning distance on morphology of the fiber were studied. The suitable electrospinning conditions were polymer concentration was 17 wt%, the applied voltage was 16 kV and the distance between needle orifice and collector was 18 cm. The characteristics of the nanofiber showed smooth round fibers. The average nanofiber diameter at 280-650 nm. Thermal properties and tensile strength of the PBS electrospun were also investigated.

**Keywords** Electrospinning; Polybutylene succinate; Nanofiber

## **Nanocomposite Films from Polybutylene Succinate and Bagasse-derived Cellulose Microfibrils**

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This research studied the properties of nanocomposite films prepared from polybutylene succinate (PBS) mixed with bagasse-derived cellulose microfibrils (CMF). An average diameter of as prepared CMF was approximately 10 nm. Nanocomposite films of PBS/CMF was prepared by solvent casting method at room temperature with various content of CMF at 0-5% (w/w). It was found that nanocomposite films were more opaque and porous by increasing CMF content. The results from FT-IR analysis showed only peaks of PBS corresponding to XRD analysis. These results indicated that there was no effect of CMF addition on PBS structure. Regarding the thermal properties, it was observed that the incorporation of CMF increasing the Tg and Tc of PBS without affecting the degree of crystallinity of the composite. The best tensile properties of PBS/CMF nanocomposite films were achieved at CMF content of 2% in this study, which showed an increase of tensile strength and Young's modulus compared to those of pure PBS film.

**Keywords** Nanocomposite; Film; Cellulose microfibril; Polybutylene succinate

## Preparation and Characterization of Banana Flour/Polyvinyl Alcohol Blend Film Crosslinked with 1, 3-dimethyl Urea

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The objective of this research was to study the preparation and characterization of packing films prepared from polyvinyl alcohol (PVA) / banana flour / 1,3-dimethylurea (DMU). The optimum conditions of these three elements were determined in order to obtain good physical and mechanical properties for the blend film. Banana flour was produced by peeled raw bananas, then drying at 50 °C for 24 hours, and finally grinding to obtain the an off-white fine powder. The chemical structure was characterised by Fourier transform infrared spectroscopy (FT-IR) and Scanning electron microscopy (SEM). The effect of plasticizer (glycerol) on mechanical properties of blend film was also studied. Banana flour solution (5% wt.) and glycerol (0 - 60 % wt. of banana flour) were used to prepare the film by cast molding (15\*15 cm). The mechanical, thermal and water absorption properties of films were investigated. It was found that using glycerol as plasticizer increased flexibility of the blended polymer film. The films ratio were optimized by mixing with PVA, banana flour + glycerol and DMU (0-5 %wt.) in hot water which was used as a solvent. DMU (crosslinking agent) increased the miscibility of films. This was confirmed by tensile testing, thermal analysis, water absorption and SEM images.

**Keywords** blend film; Banana flour; Polyvinyl alcohol; 1, 3-dimethyl urea

## Property Modification of Thermoplastic Cassava Starch using Pectin Particles

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This research aimed to study the preparation and properties of thermoplastic cassava starch (TPCS) polymer modified by pectin particles. Properties of the TPCS polymer were modified by different contents of pectin particles, i.e. 0%, 5%, 10%, 15% and 20%. Different TPCS polymers were mixed and shaped using an internal mixer and a compression molding machine, respectively. It was found that stress at maximum load and Young's modulus of 20% pectin modified TPCS polymer increased significantly for approximately 180% and 800%, respectively. Morphology from SEM technique revealed the good phase compatibility between the pectin and TPCS polymer. Moreover, IR peak shift was also found for pectin-modified TPCS polymer, indicating of new hydrogen bond formation. In addition, water uptake of different pectin-modified TPCS polymers increased slightly when the contents of pectin particles increased.

**Keywords** Cassava starch; Pectin; Thermoplastic starch; Compression molding

## **Properties of Composite Foam based on Natural Rubber Latex/Polyvinyl Alcohol/Tapioca Starch/Waste Silk Cocoon**

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The aim of this work is to study the features of composite foams that are prepared by mixing four components natural rubber latex, polyvinyl alcohol, tapioca starch and the fibroin fibres from the waste of silkworm cocoons. A baking process was employed to produce the foam samples. The foaming process of the composite foams was varied in this work and the two blowing agents used were sodium bicarbonate and ammonium, these were in order to produce foams with low density and good mechanical properties. It was found that the foam produced by sodium bicarbonate has a large part of closed cells and a large section of larger cells (characterized by SEM). The increasing of blowing agent in foaming process was found to increase the water absorption and also decreased the density of the foams produced. This research also studied the effect of fibroin fibres as filler on the physical and mechanical properties of the composite foam. It was found that fibroin fibres helped to create more cells, decrease density and improve tensile strength.

**Keywords** Composite foams; Natural rubber latex; Tapioca starch; Silkworm cocoons waste

## Properties of Cassava Starch Film Cross Linked by Citric Acid

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Increasing awareness of environmental damage has led to development of environmental friendly plastic film. This research focused on preparation and properties of cassava starch film modified by citric acid. Different casted films were modified using different contents of citric acid, i.e. 0%, 1%, 2%, 5%, 10% and 20%. It was observed that deflection and strain at maximum load of the citric acid-modified cassava starch films increased significantly. Furthermore, IR spectra of the citric acid-modified cassava starch films showed the new peak approximately  $1730\text{ cm}^{-1}$  assigned for the carboxyl and ester carbonyl bands resulting from crosslinking reaction. From morphological structure from SEM technique, the citric acid-modified cassava starch films were homogeneous without pores or cracks. Moreover, water absorption of cassava starch films clearly decreased with increasing citric acid concentration.

**Keywords** Biodegradable film; Citric acid; Starch

# Properties of Transparent DGEBA-Based Epoxy Coatings Modified with Epoxidized Rice Bran oil and Their Nanocomposites

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In this work, the effects of epoxidized rice bran oil (ERBO) on the curing behavior, mechanical properties and UV stability of cationic UV cured epoxy coatings were studied. ERBO was synthesized by the epoxidation reaction of the rice bran oil with H<sub>2</sub>O<sub>2</sub> using H<sub>2</sub>SO<sub>4</sub> as a catalyst at 60°C for different reaction time. Based on the highest epoxy value, the ERBO at the reaction time of 3 hours was selected to use as a reactive diluent for diglycidyl ether of bis-phenol A (DGEBA) - based epoxy resin. To prepare the coatings, the various amounts of ERBO (5, 10, and 15 % wt.) were mixed with DGEBA, and 3% wt of cationic photoinitiator. The mixtures were applied on the Pb and Al sheets by a bar coater. The wet coatings obtained were then cured in a homemade UV-A (254 nm, 300 watts) curing oven. It was found that the conversion of the DGEBA epoxy modified with 5% ERBO was enhanced as compared to the pristine DGEBA epoxy. The optimum cure time was found at 15 minutes for all compositions. After curing, the scratch resistance, the chemical resistance, the flexibility, and the UV stability of the coatings were investigated. The results indicated that the addition of 5% ERBO could improve the scratch resistance and UV stability of the epoxy coating. Moreover, the nanocomposites of the modified epoxy and TiO<sub>2</sub> were prepared and tested. The UV stability of the epoxy-coating modified with 15% ERBO was further enhanced by formation of the composites with 0.03% of nano-TiO<sub>2</sub> particles.

**Keywords** Epoxy coatings; Epoxidized rice bran oil; Nanocomposites

## Preparation and Characterization of Starch-graft-p(MAH-co-MMA) and PLA Blends

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This research is focused on the preparation and characterization of starch-graft-p(MAH-co-MMA) and poly(lactic acid) (PLA) blends. The starch-graft-p(MAH-co-MMA) was synthesized from cassava starch, maleic anhydride (MAH) and methyl methacrylate (MMA) in dimethyl sulfoxide at 120°C for 8 hours using benzoyl peroxide and p-Toluene sulfonic acid as an initiator and catalyst respectively. A synthesized starch was confirmed structure by proton-nuclear magnetic resonance and fourier transform infrared spectroscopy. To prepare the blends, starch-graft-p(MAH-co-MMA) and PLA were mixed together by melt blending and fabricated into thin sheets by film casting method. Thermal properties of the samples were characterized by Thermal gravimetric analysis and differential scanning calorimetry. It was found that the glass transition temperature and percent crystallinity decreased as increasing amounts of starch-graft-p(MAH-co-MMA). In addition, their mechanical properties were also investigated. The results show that the tensile stress and strain decreased as increasing the starch-graft-p(MAH-co-MMA). However, the flexibility was improved interestingly by blending with starch-graft-p(MAH-co-MMA). It can be concluded that the prepared samples have a potential to be the candidates for use as bioplastics.

**Keywords** Cassava starch; Copolymer; Poly(lactic acid); Blend

## Natural Rubber Latex Collecting Bio-Cup

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Most of commercial collecting cups for natural rubber latex are made of polymers and ceramics. However, when these cups are broken, they are not able to naturally degrade. In this research, the bio-cup were prepared from the bio-clay. This clay was prepared from biological materials such as corn flour, glutinous rice flour, and tapioca flour. Then, it was uniaxial compressed to form a natural rubber latex collecting cup. Furthermore, carbon black and talcum were added as additives. The effect of the amounts and ratio of additives on physical, mechanical and chemical properties were investigated. It was found that carbon black was a promising additive to improve the physical and mechanical properties. Moreover, these bio-cups can be used under the acidic condition.

**Keywords** Collecting bio-cup; Natural rubber latex; Carbon black