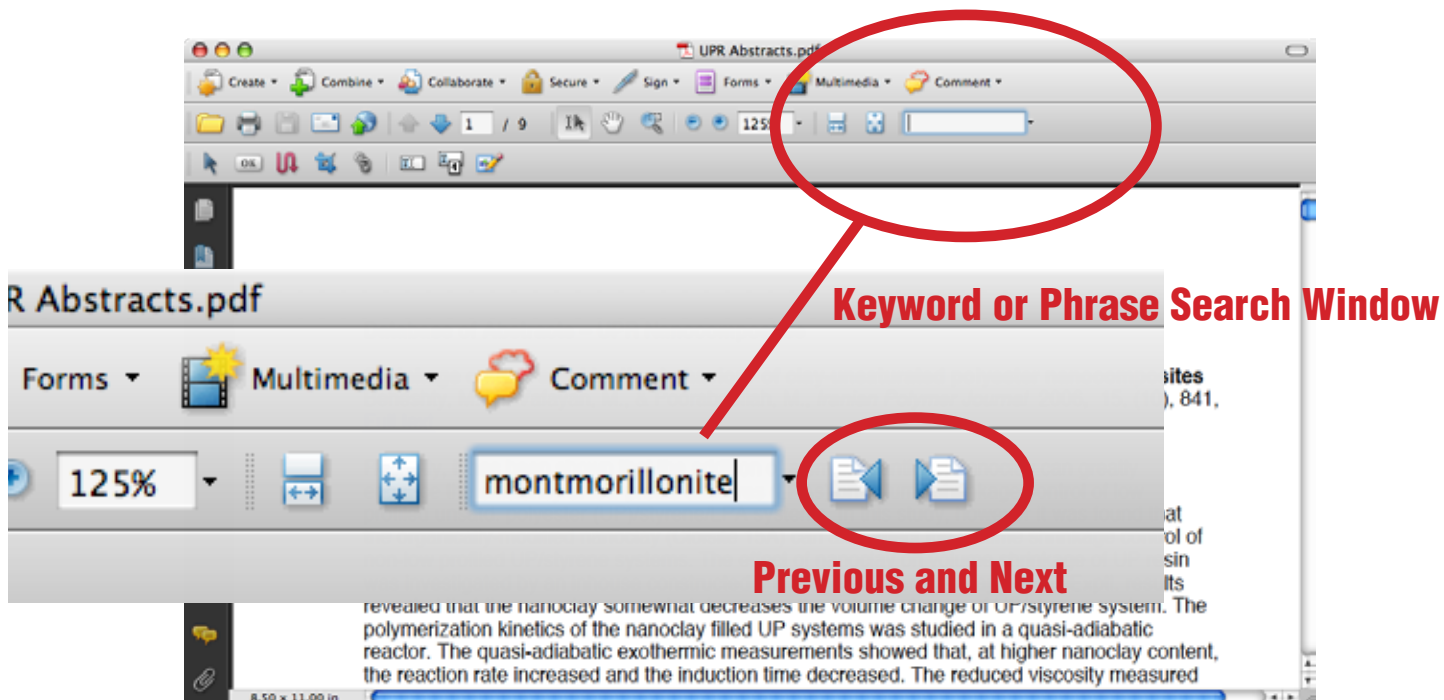
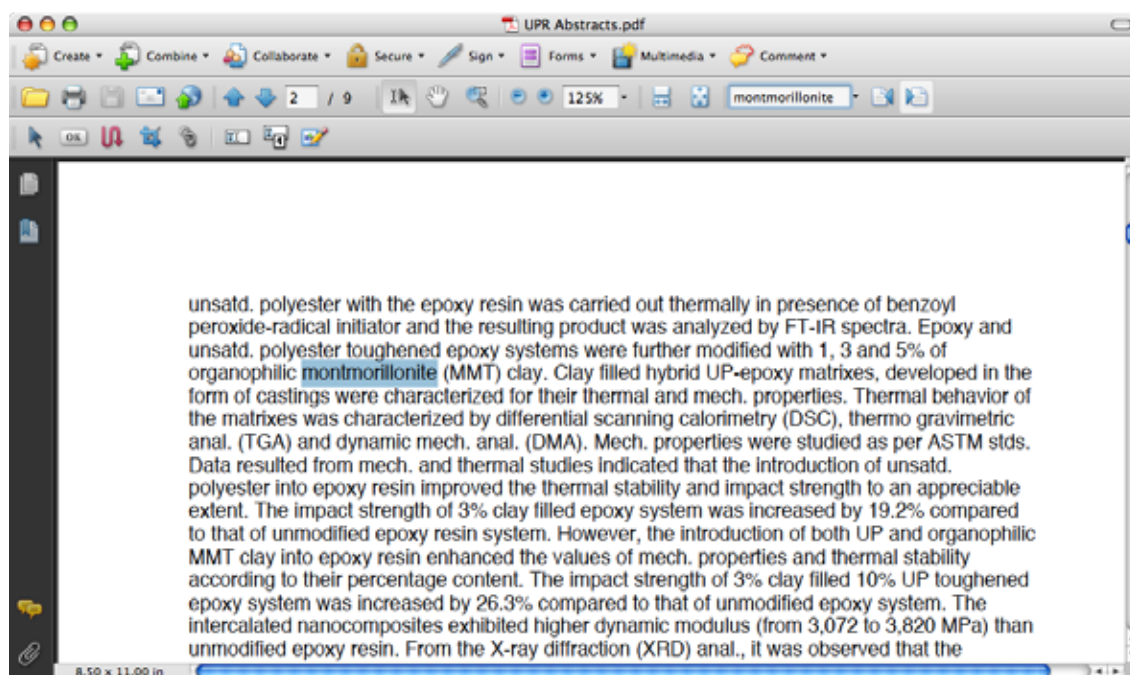


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Database of Abstracts – Bioplastic Nanocomposites

Relevance of polymer- and biopolymer-clay nanocomposites in electrochemical and electroanalytical applications

Aranda, P., Darder, M., Fernandez-Saavedra, R., Lopez-Blanco, M., & Ruiz-Hitzky, E., *Thin Solid Films*, 2005, Volume Date 2006, 495, (1-2), 104, [Full Text](#)

This paper introduces a general overview of polymer- and biopolymer-clay nanocomposites showing attractive properties for electrochem. and electroanal. applications, including the latest advances achieved in this field by our research group. A part of the paper is devoted to introducing the many advances carried out since our pioneering work on poly(ethylene oxide) (PEO)-smectite nanocomposites, including new approaches of synthesis and processing to improve the performance of these systems as solid electrolytes. Nanocomposites involving conducting polymers, e.g., polyaniline (PANI) and polypyrrole (PPy), as well as precursors of conducting materials, e.g., polyacrylonitrile (PAN), are currently tested as active phases of electrodes for different electrochem. devices. The combination of clays and biopolymers produces bio-nanocomposites that can be used as active phase of electrochem. sensors for the detection of ionic species.

An investigation of melt rheology and thermal stability of poly(lactic acid)/poly(butylene succinate) nanocomposites

Bhatia, A., Gupta, R. K., Bhattacharya, S. N., & Choi, H. J., *Journal of Applied Polymer Science*, 2009, 114, (5), 2837, [Full Text](#)

A systematic investigation of the rheol. and thermal properties of nanocomposites prepared with poly(lactic acid) (PLA), poly(butylene succinate) (PBS), and organically modified layered silicate was carried out. PLA/PBS/Cloisite 30B (organically modified MMT) clay nanocomposites were prepared by using simple melt extrusion process. Composition of PLA and PBS polymers were fixed at a ratio of 80 to 20 by wt % for all the nanocomposites. Rheol. investigations showed that high clay (> 3 wt %) contents strongly improved the viscoelastic behavior of the nanocomposites. Percolation threshold region was attained between 3 and 5 wt % of clay loadings. With the addition of clay content for these nanocomposites, liquid-like behavior of PLA/PBS blend gradually changed to solid-like behavior as shown by dynamic rheol. Steady shear showed that shear viscosity for the nanocomposites decreased with increasing shear rates, exhibiting shear-thinning non-Newtonian behavior. At higher clay concns., pseudo-plastic behavior was dominant, whereas pure blend showed almost Newtonian behavior. Thermogravimetric anal. revealed that both initial degradation temperature (at a 2% weight loss) and activation energy of thermal decomposition nanocomposite containing 3 wt % of C30B were superior to those of other nanocomposites as well as to those of PLA/PBS blend. Nanocomposite having 1 wt % of C30B did not achieve expected level of thermal stability due to the thermal instability of the surfactant present in the organoclay.

Nano-biocomposites: Biodegradable polyester/nanoclay systems

Bordes, P., Pollet, E., & Averous, L., *Progress in Polymer Science*, 2009, 34, (2), 125, [Full Text](#)

In the recent years, bio-based products have raised great interest since sustainable development policies tend to expand with the decreasing reserve of fossil fuel and the growing concern for the environment. Consequently, biopolymers, i.e., biodegradable polymers, have been the topic of many researches. They can be mainly classified as agro-polymers (starch, protein, etc.) and biodegradable polyesters (polyhydroxyalkanoates, poly(lactic acid), etc.). These latter, also called biopolyesters, can be synthesized from fossil resources but main productions are obtained from renewable resources. Unfortunately for certain applications, biopolyesters cannot be fully competitive with conventional thermoplastics since some of their properties are too weak. Therefore, to extend their applications, these biopolymers have been formulated and associated with nano-sized fillers, which could bring a large range of improved properties (stiffness, permeability, crystallinity, thermal stability). The resulting nano-biocomposites' have been the subject of many recent publications. This review is dedicated to this novel class of materials based on clays, which are nowadays the main nanofillers used in nanocomposites systems. This review highlights the main researches and developments in biopolyester/nanoclay systems during the last decade.

Design and preparation of bionanocomposites based on layered solids with functional and structural properties

Darder, M., Aranda, P., Ruiz, A. I., Fernandes, F. M., & Ruiz-Hitzky, E., *Materials Science and Technology*, 2008, 24, (9), 1100, [Full Text](#)

Biopolymers such as chitosan, pectin, alginate, carrageenan and gelatin, can be assembled to layered solids by direct intercalation via ion exchange in the case of smectites or a 'co-organized assembly' method in the case of layered double hydroxides (LDHs). Layered perovskites can be delaminated and combined with the biopolymers following a delamination/restacking procedure. The starting cationic exchange ability of smectites such as montmorillonite is turned into an anionic exchange capacity due to the intercalated chitosan excess, while an opposite effect is observed in the case of the LDHs after incorporation of alginate, pectin or carrageenan. This fact, combined with the good mech. properties of these bionanocomposites, allows their use as the sensing phase of potentiometric sensors applied to the recognition of cationic or anionic species in aqueous solution. Besides, perovskite-gelatin bionanocomposites can be processed as robust translucent films with highly oriented 2-dimensional particles exhibiting elevated dielec. permittivity values.

Bio-nanohybrids based on layered inorganic solids: gelatin nanocomposites

Darder, M., Ruiz, A. I., Aranda, P., Van Damme, H., & Ruiz-Hitzky, E., *Current Nanoscience*, 2006, 2, (3), 231, [Full Text](#)

An emerging group of hybrid materials is the so-called bio-nanocomposites, which are bio-hybrid nanostructured materials based on the combination of natural polymers (polysaccharides, proteins, enzymes, nucleic acids) and inorg. solids (clays, double layered hydroxides, phosphates, metal oxides, etc.). Bio-nanocomposites are interesting because, among other properties, the use of biopolymers provides biocompatibility, non-toxicity and biodegradability to the resulting nanohybrid materials. An example of this type of natural polymers is gelatin, a polypeptide derived from the structural protein collagen, that is able to form transparent, elastic and thermoreversible gels. This paper will review the role of inorg. solids, such as montmorillonite or perovskite, in combination

with gelatin, on the characteristics and final properties of different type of bio-nanocomposites based on this protein. With these examples, we will show the influence of the solids on the gelatin gel-transition temperature, film formation ability and rheol., mech. and dielec. properties.

Preparation and characterization of organoclay reinforced polylactic acid biocomposite films

Das, K., Ray, D., Bandyopadhyay, N. R., Sengupta, S., Sengupta, S. P., Mohanty, A. K., & Misra, M., *Advanced Materials Research*, 2009, 67(Nanomaterials and Devices), 289, [Full Text](#)

Poly(lactic acid) (PLA) based biocomposite films, reinforced with different loadings of organoclay, were prepared by solution casting method. Four different loadings of clay was done, 2, 5, 10 and 15 weight% with respect to the matrix. These biocomposite films were characterized by mech. characterization, SEM, and moisture diffusivity property at 93% RH. Both the mech. and the visco-elastic property of these films were measured by nano indentation technique. Mech. property by nano indentation anal. revealed an idea about the extent of clay dispersion in the matrix. The amount of clay loading and its dispersion significantly affected the mech. as well as the Visco-elastic behavior of the biocomposite films. The morphol. of the films were observed with the help of SEM.

Preparation and characterization of novel hybrid of chitosan-g-lactic acid and montmorillonite

Deban, D., Kumar, A. P., & Singh, R. P., *Journal of Biomedical Materials Research, Part A*, 2006, 78A, (2), 372, [Full Text](#)

The utilization of biopolymers and the development of org.-inorg. hybrids are ever increasing interest of material science researchers around the globe for various applications. The present attempt is intended to prepare nanocomposites of lactic acid grafted chitosan and layered silicates. Nanocomposites were prepared by dissolving chitosan and dispersing sodium montmorillonite in aqueous solution of L-lactic acid with subsequent heating and film casting. They were characterized by conventional techniques such as Fourier transform IR spectroscopy, x-ray diffractometry, thermogravimetric anal., energy dispersive x-ray spectroscopy, and elemental anal. The results from polar optical and transmission electron microscopic measurements are also discussed. Sorption behavior of samples has been followed by measuring swelling degree and contact angle. The films have shown enhanced hydrophilicity when compared with poly(lactic acid) (PLA). Issues on the interactions of polycationic chitosan with clay are also discussed. It is observed that nanocomposites are exhibiting better thermal and phys. properties than neat chitosan-g-LA and PLA.

Preparation and characterization of tapioca starch-poly(lactic acid)-Cloisite NA+ nanocomposite foams

Hanna, S.-Y. L. a. M. A., *Journal of Applied Polymer Science* **110**:4 (2008), pp. 2337–2344; 2008, [Full Text](#)

Tapioca starch, poly(lactic acid), and Cloisite NA+ nanocomposite foams, with four clay contents (1, 3, 5, 7, wt %), were prepared by melt-intercalation method. Selected

structural, thermal, physical, and mechanical properties were characterized using X-ray diffraction (XRD), scanning electron microscopy, differential scanning calorimetry, and an Instron universal testing machine, respectively. XRD results indicated that the 1 wt % nanocomposite foam did not show the characteristic basal reflection of the nanoclay. The 3, 5, and 7 wt % nanocomposite foams produced a mixture of intercalated and tactoid structures. The d_{001} -spacing of 3, 5, 7 wt % nanocomposite foams produced increases of 11.40, 11.15, and 10.67 Å, respectively, compared to that of the pristine clay. The morphological study showed that the nanocomposite foams exhibited a noticeably reduced cell size, more compact cells, and increased cell density. Increasing clay content caused a decrease in melting temperature (T_m). Bulk spring index and bulk compressibility were influenced ($P < 0.05$) significantly with the addition of different amounts of clay.

Poly(lactic-co-glycolic acid) and functional hydrogels for drug delivery applications

He, H., & Lee, L. J., *Annual Technical Conference - Society of Plastics Engineers*, 2004, 3, [Full Text](#)

Biodegradable polyesters like poly(lactide-co-glycolide) (PLGA) and pH-sensitive hydrogels have been used increasingly for various medical and biol. applications. The present work focused on the use of these functional polymers to design an assembled drug delivery system (DDS) that could integrate multiple functions in a single device and achieve different release patterns. For PLGA, the major concerns are the poor hydrophilicity, accumulated acidity during degradation, and bulk erosion characteristics. In this study, poly(ethylene oxide)/poly(propylene oxide)/poly(ethylene oxide) (PEO-PPO-PEO) tri-block copolymer and a nano-clay Cloisite 30B were utilized as modifiers to control the degradation behavior and hydrophilicity of PLGA. For comparison, a block copolymer, poly(lactic acid)/poly(ethylene glycol) (PLA-co-PEG) was synthesized. A pH-sensitive hydrogel together with a poly(hydroxyethyl methacrylate) (HEMA) was used as a gate to control drug release. By using this bilayered self-folding design, the drug protection and self-regulated oscillatory release were demonstrated.

Tapioca starch-poly(lactic acid)-Cloisite 30B nanocomposite foams

Lee, S. Y., & Hanna, M. A., *Polymer Composites*, 2009, 30, (5), 665, [Full Text](#)

Tapioca starch (TS), poly(lactic acid) (PLA), and Cloisite 30B nanocomposite foams, with four clay contents of 1, 3, 5, 7 wt%, were prepared by a melt-intercalation method. Selected structural, thermal, phys., and mech. properties were characterized using X-ray diffraction, SEM, DSC thermogravimetry analyses, and an Instron universal testing machine, resp. XRD results indicated that intercalation of TS/PLA into the nanoclay layers occurred in all four nanocomposite foams. At the same time, structures were observed in all nanocomposite foams but to a lesser extent with 1 and 3 wt% clay contents. Effect of clay content on melting temperature (T_m), onset degradation temperature, radial expansion ratio, unit d., bulk compressibility and bulk spring index of the nanocomposites were investigated. Among the four nanocomposites, 3 wt% clay content produced significantly different ($p < 0.05$) properties.

Processing techniques for bio-based unsaturated-polyester/clay nanocomposites: Tensile properties, efficiency, and limits

Mahmoodul Haq, R. B., Amar K. Mohanty and Manjusri Misra, *Composites Part A: Applied Science and Manufacturing*, 2009a, Volume 40, Issue 4, April 2009, Pages 394-403, [Full Text](#)

Bio-based clay/polymer nanocomposites using blends of styrene-based unsaturated polyester and epoxidized methyl soyate were manufactured using solvent-based processing techniques. Four methods were evaluated to assess limitations related to solvent removal and incorporation of high clay and bio-resin content. Nanocomposite characterization was performed using electron microscopy and tensile tests. Solvent type, bio-resin addition sequence, and sonication energy were the key parameters governing processing efficiency and composite quality. Processes with bio-resin added after solvent removal show promise for the incorporation of high bio-resin and nanoclay contents. Use of acetone as a solvent with bio-resin added after solvent removal led to nanocomposites with good nanoclay dispersion and exfoliation, and high tensile modulus. Direct sonication in the base resin diluted with styrene led to enhanced and balanced gains in stiffness and toughness.

Bio-based unsaturated polyester/layered silicate nanocomposites: Characterization and thermo-physical properties

Mahmoodul Haq, R. B., Amar K. Mohanty, and Manjusri Misra, *Composites Part A: Applied Science and Manufacturing*, 2009b, [Full Text](#)

Proper stiffness–toughness balance along with enhancement in other thermo-physical properties can be obtained by incorporating layered silicates (nanoclay) in bio-based resins, defined as blends of functionalized vegetable oils and petroleum-based resins. Bio-based polymer nanocomposites with varying clay concentration and varying bio-resin (epoxidized soy bean oil) content in unsaturated polyester resins were manufactured. Thermo-physical properties such as tensile modulus and strength, coefficient of thermal expansion, moisture absorption, toughness, and glass transition temperatures were studied. Fracture surface morphologies and characterization of nanocomposites were performed using electron microscopy. The resulting bio-blend nanocomposites exhibit promising results for use in structural applications.

Biodegradable polymer/layered silicate nanocomposites: A review

Okamoto, M., *Journal of Industrial and Engineering Chemistry*, 2004, 10(7), 1156, [Full Text](#)

A review on the prepn., characterization, materials properties, crystn. behavior, melt rheol., and processing of biodegradable polymer/ layered silicate nanocomposites, which are the most widely interest in materials science research today, is given in this article both in terms of academic and industrial aspects. Montmorillonite and hectorite are among the most commonly used smectites type layered silicates for the preparation of nanocomposites. In their pristine form they are hydrophilic in nature and this property makes them very difficult to dispersed into a polymer matrix. The most common way to remove this difficulty comprises replacing interlayer cations by some quaternized ammonium or phosphonium cations preferably with long alkyl chain. The whole range of biodegradable polymer matrixes is covered. This new family of composite materials

frequently exhibits remarkable improvements of material properties when compared with virgin polymers. Improvements can include high storage modulus both in solid and melt states, increased tensile and flexural properties, decrease in gas permeability, increased heat distortion temperature and thermal stability, and increase in rate of biodegradability.

Recent advances in biodegradable nanocomposites

Pandey, J. K., Kumar, A. P., Misra, M., Mohanty, A. K., Drzal, L. T., & Singh, R. P., *Journal of Nanoscience and Nanotechnology*, 2005, 5, (4), 497, [Full Text](#)

There is growing interest in developing bio-based products and innovative process technologies that can reduce the dependence on fossil fuel and move to a sustainable materials basis. Biodegradable bio-based nanocomposites are the next generation of materials for the future. Renewable resource-based biodegradable polymers including cellulosic plastic (plastic made from wood), corn-derived plastics, and polyhydroxyalkanoates (plastics made from bacterial sources) are some of the potential biopolymers which, in combination with nanoclay reinforcement, can produce nanocomposites for a variety of applications. Nanocomposites of this category are expected to possess improved strength and stiffness with little sacrifice of toughness, reduced gas/water vapor permeability, a lower coefficient of thermal expansion, and an increased heat deflection temperature, opening an opportunity for the use of new, high performance, lightwt. green nanocomposite materials to replace conventional petroleum-based composites. The present review addresses this green material, including its tech. difficulties and their solns.

Water resistance and mechanical properties of biopolymer (alginate and soy protein) coated paperboards

Rhim, J.W., Lee, J.H., & Hong, S.I., *LWT--Food Science and Technology*, 2006, 39, (7), 806, [Full Text](#)

The effect of biopolymer coating on the water barrier and mech. properties of paperboards used as corrugated fiberboard box liners was studied under several conditions. Paperboards were coated with selected biopolymers, such as alginate and soy protein isolate (SPI) and studied with or without further treatment, such as crosslinking through CaCl₂ or formaldehyde treatment and compositing with organically modified montmorillonite (OMMT). Biopolymer coating increased the thickness of paperboards from 9% to 16%, depending on the coating materials and treatment methods, and resulted in a smoother and more homogeneous surface. Though the tensile strength (TS) of the coated paperboards decreased from 12.5% to 37.5% of the uncoated paperboards by coating, ring crush strength was not decreased. Wetting properties, such as contact angle of water drop, dynamic change in contact angle, water vapor permeability (WVP), and water absorptivity were also affected by biopolymer coating, but the degree of change was dependent on the coating materials as well as treatment methods. For example, the rate of change in contact angle of water on paperboards decreased dramatically from 1.4 to 3.8 times depending on the coating materials as well as treatment methods. Generally, SPI-coated paperboards were more water-resistant than alginate coated ones. However, water resistance of the alginate-coated paperboards post-treated with the CaCl₂ solution was comparable to the SPI coated ones.

Interfacially compatibilized poly(lactic acid) and poly(lactic acid)/polycaprolactone/organoclay nanocomposites with improved biodegradability and barrier properties: effects of the compatibilizer structural parameters and feeding route

Sabet, S.S., & Katbab, A. A., *Journal of Applied Polymer Science*, 2009, 111, (4), p1954, [Full Text](#)

Nanocomposites with enhanced biodegradability and reduced oxygen permeability were fabricated via melt hybridization of organomodified clay and poly(lactic acid) (PLA) as well as a PLA/polycaprolactone (PCL) blend. The nanocomposite microstructure was engineered via interfacial compatibilization with maleated polypropylene (PP-g-MA). Effects of the compatibilizer structural parameters and feeding route on the dispersion state of the nanolayers and their partitioning between the PLA and PCL phases were evaluated with X-ray diffraction, transmission electron microscopy, and SEM. Although highly functionalized PP-g-MA with a low mol. weight was shown to be much more effective in the intercalation of PLA and the PLA/PCL blend into the clay gallery spaces, composite samples compatibilized by high-mol.-weight PP-g-MA with a lower degree of maleation exhibited lower oxygen permeability as well as a higher rate of biodegradn., which indicated the accelerating role of the dispersed nanolayers and their interfaces in the enzymic degradation of PLA and PLA/PCL matrixes. This evidenced a correlation between the nanocomposite structure and rate of biodegradn. The size of the PCL droplets in the PLA matrix was reduced by nanoclay incorporation, and this revealed that the nanolayers were preferentially wetted by PCL in the blend. However, PCL appeared as fine and elongated particles in the microstructure of the PLA/PCL/organoclay hybrids compatibilized by higher mol. weight and less functionalized PP-g-MA. All the PLA/organoclay and PLA/PCL/organoclay hybrids compatibilized with high-mol.-weight PP-g-MA displayed a higher dynamic melt viscosity with more pseudo solid-like melt rheol. responses, and this indicated the formation of a strong network structure by the dispersed clay layers.

Flexural, morphological and thermal properties of poly(lactic acid)/organo-montmorillonite nanocomposites

Shyang, C. W., & Kuen, L. S., *Polymers & Polymer Composites*, 2008, 16, (4), 263, [Full Text](#)

Poly(lactic acid) (PLA)/organo-montmorillonite (OMMT) nanocomposites were prepared by using solution intercalation and melt intercalation methods. For solution intercalation method, toluene was used as solvent. For melt intercalation method, PLA/OMMT composites were prepared by using single-screw extruder. The flexural properties of PLA/OMMT composites have been studied by using three point bending tests. Comparisons between the flexural properties of PLA/OMMT nanocomposites prepared by both methods have been carried out. The microstructures of the PLA/OMMT nanocomposites were assessed by Field Emission SEM (FESEM) and X-ray Diffraction (XRD) anal. The thermal properties of PLA/OMMT nanocomposites have been characterized by using Differential Scanning Calorimeter (DSC). The flexural modulus of PLA/OMMT nanocomposites prepared by both solution intercalation and melt intercalation methods increased significantly by the addition of OMMT. For both methods, it was found that the optimum flexural properties of the PLA nanocomposites was achieved at 1 weight% OMMT loading. The dispersion of OMMT in the PLA prepared by solution intercalation is better than that of melt intercalation method. This is attributed to

the ease of intercalation of PLA chain into the OMMT layered silicate during the solution intercalation process. XRD results revealed that intercalation of OMMT layered silicate occurred in the PLA matrix.

Preparation and characterization of tapioca starch-poly(lactic acid) nanocomposite foams by melt intercalation based on clay type

Siew Yoong Lee, H. C. a. M. A. H., *Industrial Crops and Products* **28** (2008), pp. 95-106, 2008, [Full Text](#)

Tapioca starch (TS), poly(lactic acid) (PLA), and four different organoclays (Cloisite 10A, Cloisite 25A, Cloisite 93A and Cloisite 15A) were used to produce nanocomposite foams by melt-intercalation. Structural, thermal, physical and mechanical properties were characterized using X-ray diffraction (XRD), scanning electron microscopy (SEM), differential scanning calorimetry (DSC), and an Instron universal testing machine, respectively. The first XRD peaks for all four nanocomposite foams, were observed to shift to lower angles, indicating that intercalation occurred. The extent of intercalation depended on the type of organoclay and was exhibited in the sequence of Cloisite 10A > 25A > 93A > 15A. Glass transition temperatures (T_g), melting temperatures (T_m), and transition enthalpies (ΔH) of the foams were investigated by DSC. Radial expansion ratio (RER), unit density, bulk spring index (BSI), bulk compressibility, Young's modulus (E), water absorption index (WAI), and water solubility index (WSI) were influenced ($p < 0.05$) significantly with the addition of different organoclays into the TS/PLA matrix.

Polylactide-Layered Silicate Nanocomposite: A Novel Biodegradable Material

Suprakas Sinha Ray, K. Y., Masami Okamoto, and Kazue Ueda, *Nano Letters*, 2002, 2 (10), pp 1093–1096, 2002, [Full Text](#)

This letter describes the preparation, characterization, material properties, and biodegradability of polylactide (PLA)-layered silicate nanocomposite. Montmorillonite modified with trimethyl octadecylammonium cation was used as an organically modified layered silicate (OMLS) for the nanocomposite preparation. WAXD and TEM analyses respectively confirmed that silicate layers of the montmorillonite were intercalated and nicely distributed in the PLA-matrix. The material properties of neat PLA improved remarkably after nanocomposite preparation. The biodegradability of the neat PLA and corresponding nanocomposite was studied under compost, and the rate of biodegradation of neat PLA increased significantly after nanocomposite preparation.

Preparation of poly(lactic acid)/poly(ethylene glycol)/organoclay nanocomposites by melt compounding

Tanoue, S., Hasook, A., Iemoto, Y., & Unryu, T., *Polymer Composites*, 2006, 27, (3), 256, [Full Text](#)

Poly(lactic acid) (PLA)/organoclay nanocomposites were prepared by melt compounding in a co-rotating twin screw extruder. Two types of commercialized organoclay (di-Me benzyl stearyl ammonium ion and di-Me distearyl ammonium ion intercalated between clay platelets named as Clay A and Clay B, resp.) and two grades of poly(ethylene glycol) (PEG) with different mol. weight ($M_w = 2,000$ and $300,000$ - $500,000$ named as PEG2k and PEG500k, resp.) were used in this study. The Young's modulus improved by

the addition of organoclay to PLA matrix. The Young's modulus decreased with the addition of PEG to PLA/organoclay nanocomposites. The tensile strength and elongation of PLA/Clay B nanocomposites increased with the addition of PEG2k. The effect of the addition of PEG on d-spacing of PLA/organoclay nanocomposites is dependent upon the kind of organoclay. The sizes of clay agglomeration in PLA/PEG/organoclay nanocomposites are larger than those of PLA/organoclay ones in the same organoclay. Addition of PEG to PLA/ organoclay nanocomposites during melt compounding will not be useful for the preparation of PLA/organoclay having fully exfoliated clay platelets. The shear thinning properties of the nanocomposites are independent of the addition of PEG. On the whole, PEG2k is good plasticizer for PLA/organoclay nanocomposites.

Mechanical properties of bioplastics and bioplastic-organoclay nanocomposites prepared from epoxidized soybean oil with different epoxide contents

Tanrattanakul, V., & Saithai, P., *Journal of Applied Polymer Science*, 2009, 114, (5), 3057, [Full Text](#)

The objectives of this study were to investigate the effect of epoxide content (24-88 mol %) on the mech. properties and characteristics of epoxidized soybean oil (ESO) and to compare the mech. properties of ESO-organoclay nanocomposites with different epoxide contents (40 and 100 mol %). ESO was synthesized by in situ epoxidn. with acetic acid and hydrogen peroxide. We prepared ESO bioplastic sheets from ESO by curing with methyltetrahydrophthalic anhydride and 1-methylimidazole. The tensile properties and tear resistance of the synthesized bioplastic (ESO40, where the number indicates the molar percentage of epoxidn.) were investigated and compared with ESO bioplastic sheets prepared from com. ESO with 100 mol % epoxidn. (ESO100). The tensile modulus, tensile strength, tensile toughness, and tear strength of the ESO bioplastics increased with increasing epoxide content, whereas the elongation at break of the ESO100 bioplastic was lowest. No trend was observed in the bioplastics prepared from ESO24-ESO88. Dynamic mech. thermal anal. showed increases in the storage modulus and glass-transition temperature as the epoxide content was increased. Thermal degradation also increased with increasing epoxide content. The crosslink d. and chain flexibility controlled the mech. properties and characteristics of the ESO bioplastics. ESO-organoclay nanocomposites were prepared by in situ intercalative polymerization. The addition of organoclay increased the mech. properties of the ESO bioplastics. The effect of organoclay content (1-8 wt %) on the mech. properties was similar to the effect of the epoxide content. The sESO100 nanocomposite showed a higher modulus but lower tensile strength and elongation at break than the ESO40 nanocomposite. Intercalation of the organoclay in the ESO nanocomposites was observed by transmission electron microscopy and X-ray diffractometry.

Melt intercalation of poly(lactic acid) nanocomposites: fabrication microstructure and performance

Ton-That, M.-T., Denault, J., Bloch, J., & Champagne, M., *Annual Technical Conference Society of Plastics Engineers*, 2006, 0272, [Full Text](#)

The prepn. of nanoclay-reinforced poly(lactic acid) (PLA) nanocomposites by means of melt processing has been investigated. In order to optimize the dispersion of the nanoclays and the nanoclay-matrix interface, strong interaction between the nanoclay and the polymer matrix is required, preferably at the atomic level. Different chemistries of

the organo-nanoclay have been carefully considered in order to optimize the chemical interaction between the organic and inorg. phases during processing. Various processing conditions have been examined with the aim of minimizing the degradation and oxidation of the materials, both the matrix and the organo-nanoclay, while at the same time maximizing clay dispersion and the interaction between the polymer matrix and the clay. X-ray diffraction, field emission gun SEM (FEGSEM), transmission electron microscopy (TEM), differential scanning calorimetry (DSC) and dynamic mech. thermal anal. (DMTA) were used to characterize the dispersion of the nanoclay, the crystalline structure and the mech. behavior of the PLA nanocomposites, resp. The relationship between formulation, structure, and performance is discussed.

Fabrication and characterization of biodegradable poly(lactic acid)/ layered silicate nanocomposites

Wu, T.-M., & Chiang, M.-F., *Polymer Engineering and Science*, 2005, 45, (12), 1615, [Full Text](#)

In this study biocompatible/biodegradable poly(lactic acid) (PLA)/ layered silicate nanocomposites (PLSNs) were successfully prepared by the intercalation of PLA polymer into organically modified layered silicate through the solution mixing process. Both X-ray diffraction data and transmission electron microscopy images of PLSNs indicate most of the swellable silicate layers were disorderedly intercalated into the PLA matrix. Mech. properties of the 0.1 wt% silicate-containing fabricated nanocomposites performed by dynamic mech. anal. have significant improvements in the storage modulus when compared to that of neat PLA matrix. Adding more layered silicates into PLA matrix induced a decrease in the mech. properties of PLSNs, probably due to the presence of a large dimension of porosity in the fabricated nanocomposites.

Biodegradable poly(lactic acid)/chitosan-modified montmorillonite nanocomposites: Preparation and characterization

Wu, T.-M., & Wu, C.-Y., *Polymer Degradation and Stability*, 2006, 91, (9), 2198, [Full Text](#)

In this study, the biodegradable poly(lactic acid) (PLA)/ montmorillonite (MMT) nanocomposites were successfully prepared by the solution mixing process of PLA polymer with organically-modified montmorillonite (m-MMT), which was first treated by n-hexadecyl trimethyl-ammonium bromide (CTAB) cations and then modified by biocompatible/biodegradable chitosan to improve the chemical similarity between the PLA and m-MMT. Both X-ray diffraction data and transmission electron microscopy images of PLA/m-MMT nanocomposites indicate that most of the swellable silicate layers were disorderedly intercalated into the PLA matrix. Mech. properties and thermal stability of the PLA/m-MMT nanocomposites performed by dynamic mech. anal. and thermogravimetric anal. have significant improvements in the storage modulus and 50% loss in temperature when compared to that of neat PLA matrix. The degradation rates of PLA/m-MMT nanocomposites are also discussed in this study.

Poly(lactic acid)/Organoclay Nanocomposites: Thermal, Rheological Properties and Foam Processing

YINGWEI DI, S. I., 1 ERNESTO DI MAIO,2 LUIGI NICOLAIS1,2, *Journal of Polymer Science, Part B: Polymer Physics* 43(6): 689-698, 2004, [Full Text](#)

In this study, polymer nanocomposites based on poly(lactic acid) (PLA) and organically modified layered silicates (organoclay) were prepared by melt mixing in an internal mixer. The exfoliation of organoclay could be attributed to the interaction between the organoclay and PLA molecules and shearing force during mixing. The exfoliated organoclay layers acted as nucleating agents at low content and as the organoclay content increased they became physical hindrance to the chain mobility of PLA. The thermal dynamic mechanical moduli of nanocomposites were also improved by the exfoliation of organoclay; however, the improvement was reduced at high organoclay content. The dynamic rheological studies show that the nanocomposites have higher viscosity and more pronounced elastic properties than pure PLA. Both storage and loss moduli increased with silicate loading at all frequencies and showed nonterminal behavior at low frequencies. The nanocomposites and PLA were then foamed by using the mixture of CO₂ and N₂ as blowing agent in a batch foaming process. Compared with PLA foam, the nanocomposite foams exhibited reduced cell size and increased cell density at very low organoclay content. With the increase of organoclay content, the cell size was decreased and both cell density and foam density were increased.

Polymer blends and composites from renewable resources

Yu, L., Dean, K., & Li, L., *Progress in Polymer Science*, 2006, 31, (6), 576, [Full Text](#)

This article reviews recent advances in polymer blends and composites from renewable resources, and introduces a number of potential applications for this material class. In order to overcome disadvantages such as poor mech. properties of polymers from renewable resources, or to offset the high price of synthetic biodegradable polymers, various blends and composites have been developed over the last decade. The progress of blends from three kinds of polymers from renewable resources-(1) natural polymers, such as starch, protein and cellulose; (2) synthetic polymers from natural monomers, such as polylactic acid; and (3) polymers from microbial fermentation, such as polyhydroxybutyrate-are described with an emphasis on potential applications. The hydrophilic character of natural polymers has contributed to the successful development of environmentally friendly composites, as most natural fibers and nanoclays are also hydrophilic in nature. Compatibilizers and the technol. of reactive extrusion are used to improve the interfacial adhesion between natural and synthetic polymers.

Emerging biodegradable materials: starch- and protein-based bio-nanocomposites

Zhao, R., Torley, P., & Halley, P. J., *Journal of Materials Science*, 2008, 43, (9), 3058, [Full Text](#)

This article provides a broad overview on the natural polymer-based bio-nanocomposite properties, processing and application. Bio-nanocomposites prepared with natural biopolymers, such as starch and protein, can be formed using a melt intercalation or a solvent intercalation method. Incorporation of layered silicates into the biopolymer matrixes results in improved mech. properties, water vapor barrier properties, and

thermal stability of the resulting bio-nanocomposites without sacrificing biodegradability due to their nanometer size dispersion. Consequently, even though natural polymer-based bio-nanocomposite is in its infancy, it has a huge potential in the future.

Nanofibers from polylactic acid nanocomposites: effect of nanoclays on molecular structures

Zhou, H., Kim, K.-W., Giannelis, E., & Joo, Y. L., *ACS Symposium Series*, 2006, 918, (Polymeric Nanofibers), 217, [Full Text](#)

Poly(Lactic) acid (PLA) and its nanocomposite nanofibers have been successfully obtained via electro spinning from both solution and melt. Our results show that mol. structures of electro spun nanofibers are significantly influenced by both electro spinning conditions and the presence of nanoclays. Highly oriented structures of PLA, which give rise to the formation of a fibrillar? crystal form, are observed in electro spun fibers, and the formation of beta crystal is enhanced by strongly aligned nanoclays. It is also found that due to rapid solidification, cold crystallization occurs between 100° and 130° and the degree of cold crystallization becomes more prominent in electro spun nanofibers from melt. Annealing effect on fiber structures is also investigated by DSC and XRD.

An adaptive neuro-fuzzy inference system for modeling mechanical properties of tapioca starch-poly(lactic acid) nanocomposite foams

Lee, S. Y., Hanna, M. A., & Jones, D. D., *Starch/Staerke*, 2008, 60, (3-4), 159, [Full Text](#)

Tapioca starch, poly(lactic acid) and Cloisite 30B nanocomposites foams, with clay contents of 1, 3, 5 and 7% (weight/weight), were prepared by a melt-intercalation method. Multiple inputs single output models were developed to predict radial expansion ratio, unit d., bulk compressibility and spring index of the nanocomposite foams. An individual ANFIS model was developed for each mech. property using clay content, temperature, pressure and torque as input parameters. All models preformed well with R2 values > 0.71. All models had very low root mean squared error values.