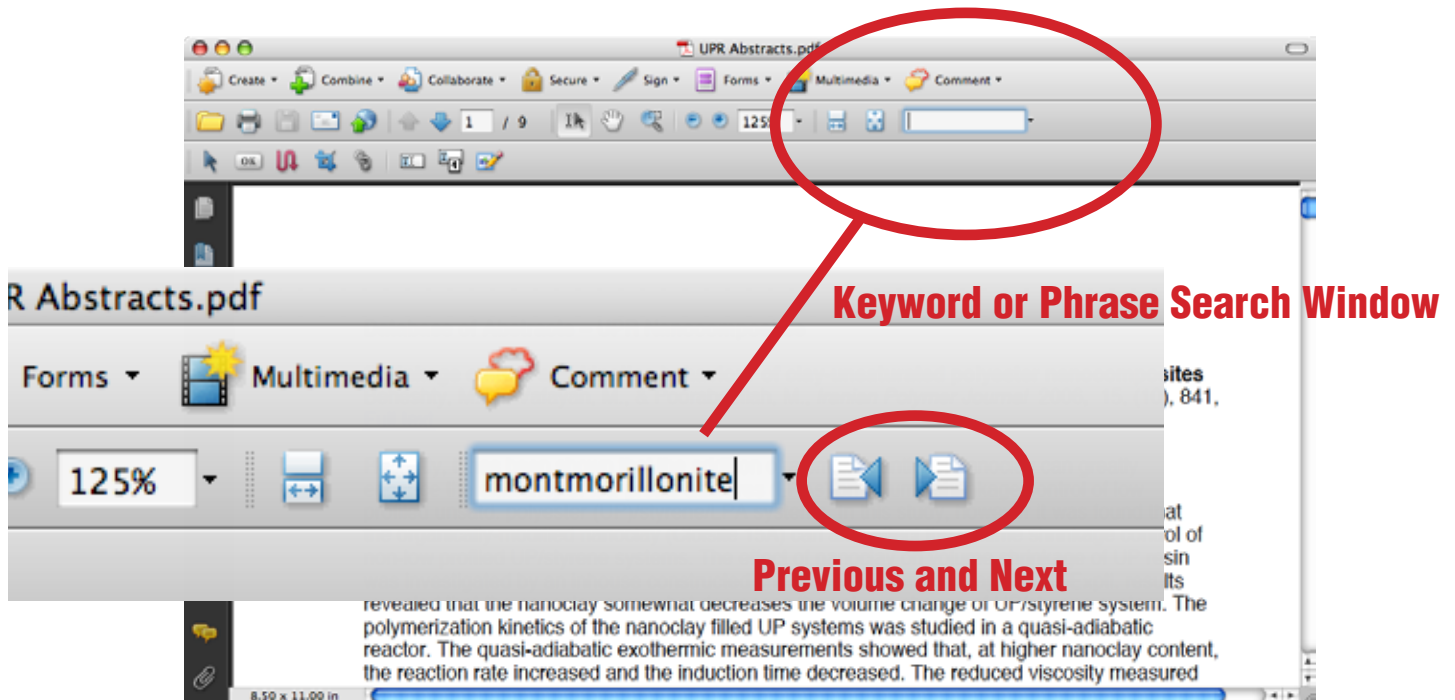
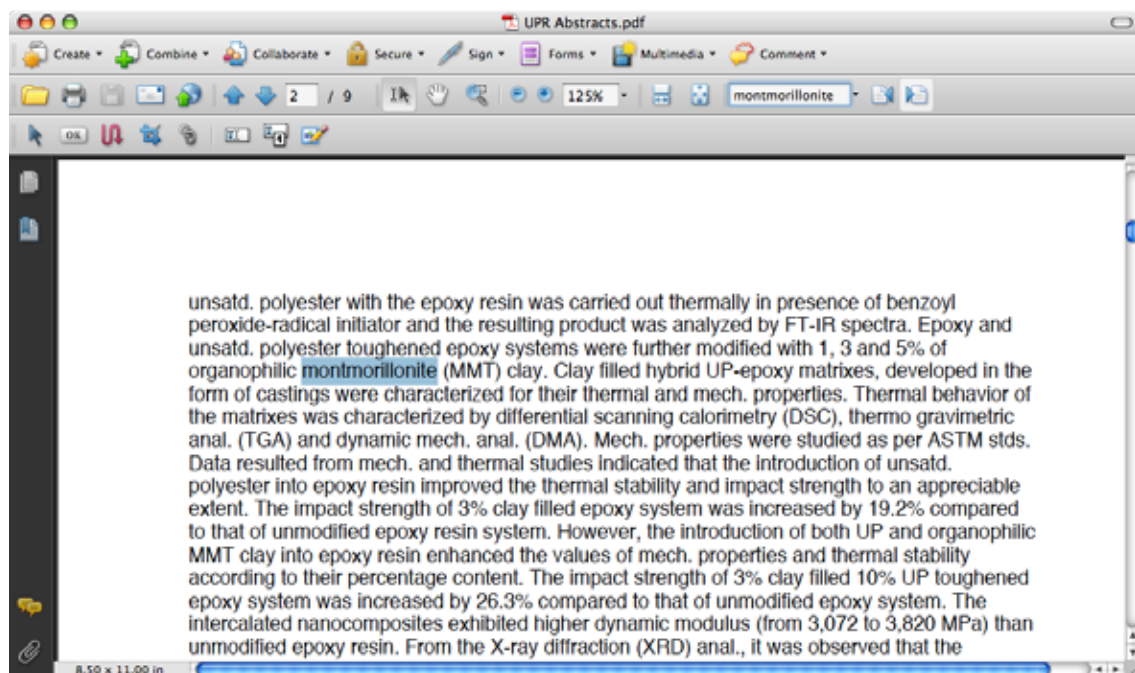


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## Database of Abstracts – UPR Nanocomposites

### **Shrinkage control and kinetics behaviour of clay-unsaturated polyester nanocomposites**

Beheshty, M. H., Vafayan, M., & Poorabdollah, M., *Iranian Polymer Journal* 2006, 15, (10), 841, [Full text](#)

Recently, it has been shown that the addition of a small quantity of nanoclay can greatly enhance the efficiency of low profile additives (LPAs) on volume shrinkage control of low profiled unsatd. polyester (UP)/styrene/LPA systems. In this study, however it was found that the organically-modified nanoclay (Cloisite 15A) can also affect the volume shrinkage control of non-low profiled UP/styrene systems. The effect of nanoclay on volume shrinkage of UP resin was investigated by an inhouse constructed shrinkage measurement apparatus. Exptl. results revealed that the nanoclay somewhat decreases the volume change of UP/styrene system. The polymerization kinetics of the nanoclay filled UP systems was studied in a quasi-adiabatic reactor. The quasi-adiabatic exothermic measurements showed that, at higher nanoclay content, the reaction rate increased and the induction time decreased. The reduced viscosity measured by a rheometric dynamic analyzer. The gel time calculated by both quasi-adiabatic reactor and rheometric dynamic analyzer data. Results have showed that adding nanoclay into the UP/styrene mixture makes the onset of the viscosity rise happen much earlier which leads to a higher reaction rate, faster viscosity rise, and earlier gelation. It is clearly observed that measuring the gel time at different level of Cloisite 15A is similar to using rheometry and exothermic expts.

### **Low profile unsaturated polyester resin-clay nanocomposite properties**

*Polymer Composites* 2009, 30, (5), 629, [Full text](#)

Unsatd. polyester (UP)/organically modified clay (OMC) nanocomposites were prepared by multistep simultaneous mixing of UP oligomer chain, styrene (St) monomer, and OMC. X-ray diffraction, transmission electron microscopy, dynamic mech. thermal anal., and SEM data were in support of the formation of a partially intercalated nanocomposite. The glass transition temps. of the nanocomposites revealed that the crosslinking reaction occurred homogeneously inside and outside of the OMC galleries. Adding 3 wt% OMC improved the flexural and storage modulus of UP by 31.5% and 30.2%, resp. The Izod impact strength of UP was also improved by 51.7% at 1 wt% of OMC loading. Similar results were obtained for low-profile UP/St/OMC nanocomposites. Resin shrinkage data measured by inhouse constructed apparatus showed that, at an OMC content of 3 wt%, the UP/St/OMC/low profile additive (LPA) system cannot provide superior volume shrinkage control. But, it is found that the use of nanoscale reinforcement in the UP systems is able to restore flexural and storage moduli loss when using LPAs.

### **Thermo mechanical behavior of unsaturated polyester toughened epoxy-clay hybrid nanocomposites**

Chozhan, C. K., Alagar, M., Sharmila, R. J., & Gnanasundaram, P., *Journal of Polymer Research* 2007, 14, (4), 319, [Full text](#)

The intercrosslinked networks of unsatd. polyester (UP) toughened epoxy-clay hybrid nanocomposites have been developed. Epoxy resin (DGEBA) was toughened with 5, 10 and 15% (by wt) of unsatd. polyester using benzoyl peroxide as radical initiator and 4,4'-diaminodiphenylmethane as a curing agent at appropriate conditions. The chemical reaction of

unsatd. polyester with the epoxy resin was carried out thermally in presence of benzoyl peroxide-radical initiator and the resulting product was analyzed by FT-IR spectra. Epoxy and unsatd. polyester toughened epoxy systems were further modified with 1, 3 and 5% of organophilic montmorillonite (MMT) clay. Clay filled hybrid UP-epoxy matrixes, developed in the form of castings were characterized for their thermal and mech. properties. Thermal behavior of the matrixes was characterized by differential scanning calorimetry (DSC), thermo gravimetric anal. (TGA) and dynamic mech. anal. (DMA). Mech. properties were studied as per ASTM stds. Data resulted from mech. and thermal studies indicated that the introduction of unsatd. polyester into epoxy resin improved the thermal stability and impact strength to an appreciable extent. The impact strength of 3% clay filled epoxy system was increased by 19.2% compared to that of unmodified epoxy resin system. However, the introduction of both UP and organophilic MMT clay into epoxy resin enhanced the values of mech. properties and thermal stability according to their percentage content. The impact strength of 3% clay filled 10% UP toughened epoxy system was increased by 26.3% compared to that of unmodified epoxy system. The intercalated nanocomposites exhibited higher dynamic modulus (from 3,072 to 3,820 MPa) than unmodified epoxy resin. From the X-ray diffraction (XRD) anal., it was observed that the presence of d 001 reflections of the organophilic MMT clay in the cured product indicated the development of intercalated clay structure which in turn confirmed the formation of intercalated nanocomposites. The homogeneous morphologies of the UP toughened epoxy and UP toughened epoxy-clay hybrid systems were ascertained from scanning electron microscope (SEM).

#### **Nanoindentation behaviour of layered silicate reinforced unsaturated polyester nanocomposites**

H.N. Dhakal, Z. Y. Z., M.O.W Richardson, *Polymer Testing* 25 (2006) 846–852, 2006, [Full text](#)

The effect of various loading levels of nanoclay reinforcement on the nanomechanical properties of layered silicate nanoclay reinforced unsaturated polyester (UPE) nanocomposites were investigated by a nano-indentation test method. The clay was dispersed into a UPE matrix via blending using a mechanical stirrer. Structural studies were carried out using a wide angle X-ray diffraction (WAXD) method and correlated with the nanoindentation results. This shows that nanoindentation behaviour is strongly influenced by clay reinforcement and the degree of clay dispersion in the polymer matrix. The experimental results show that there is a strong correlation between nanomechanical properties and inter layer d-spacing of clay particles in the nanocomposite system. Incorporation of 1%, 3% and 5% by weight nanoclay into the polyester resin results in an improvement in hardness of 29%, 24% and 14%, respectively. The elastic modulus increased from 5393MPa for unreinforced polyester to 6646MPa (23% increase) with the introduction of 5% by weight nanoclay.

#### **Volume shrinkage characteristics for unsaturated polyester- montmorillonite nanocomposites**

Abstracts of Papers, 230th ACS National Meeting, Washington, DC, United States, Aug. 28-Sept. 1, 2005 (2005), PMSE-501 Publisher: American Chemical Society, Washington, D. C. CODEN: 69HFCL, [Full-text](#)

The effects of UP resin types, and the amt. of MMT added on the vol. shrinkage characteristics for unsatd. polyester (UP)-montmorillonite (MMT) nanocomposites prepd. by in-situ intercalative cure of styrene (St)/UP/silane-treated MMT ternary systems at 110oC have been investigated. X-ray diffraction and TEM results have supported the formation of a nanocomposite,

characterized by a random dispersion of intercalated/exfoliated aggregates of clay sheets in the polymer matrix. For St/UP/silane-treated MMT systems, adding a higher content of MMT may generally result in a lower vol. shrinkage after the cure. It is due to the intermol. reaction between UP and the silane-treated MMT during the cure, causing a decrease of intrinsic polymn. shrinkage. At a fixed silane-treated MMT content, employing the MA-PG type of UP, with a smaller prepolymer size and a higher C=C unsatn. in its backbone than the MA-PA-PG type of UP, may generally lead to a lower vol. shrinkage after the cure. It is inferred that the formation of local phase domains with an exfoliated nanocomposite structure during cure is more favorable for the MA-PG system.

### **Synthesis and mechanical properties of unsaturated polyester based nanocomposites**

Inceoglu, A. B., & Yilmazer, U., *Polymer Engineering and Science* 2003, 43, (3), 661, [Full text](#)

Two classes of nanocomposites were synthesized using an unsatd. polyester resin as the matrix and sodium montmorillonite as well as an organically modified montmorillonite as the reinforcing agents. X-ray diffraction pattern of the composites showed that the interlayer spacing of the modified montmorillonite expanded from 1.25 nm to 4.5 nm, indicating intercalation. Glass transition values of these composites increased from 72°C, in the unfilled unsatd. polyester, to 86°C in the composite with 10% organically modified montmorillonite. From SEM, it is seen that the degree of intercalation/exfoliation of the modified montmorillonite is higher than in the unmodified one. The mech. properties also supported these findings, since in general, the tensile modulus, tensile strength, flexural modulus, flexural strength and impact strength of the composites with modified montmorillonite were higher than the corresponding properties of the composites with unmodified montmorillonite. The tensile modulus, tensile strength, flexural modulus and flexural strength values showed a maximum, whereas the impact strength exhibited a min. at approx. 3-5 wt% modified montmorillonite content. These results imply that the level of exfoliation may also exhibit a maximum with respect to the modified montmorillonite content. The level of improvement in the mech. properties was substantial. Adding only 3 wt% organically modified clay improved the flexural modulus of unsatd. polyester by 35%. The tensile modulus of unsatd. polyester was also improved by 17% at 5 wt% of organically modified clay loading.

### **Study of the thermal decomposition of flame-retarded unsaturated polyester resins by thermogravimetric analysis and Py-GC/MS**

Kandare, E., Kandola, B. K., Price, D., Nazare, S., & Horrocks, R. A., *Polymer Degradation and Stability* 2008, 93, (11), 1996, [Full text](#)

The thermal degradation behavior of flame-retarded unsatd. polyester resin formulations containing ammonium polyphosphate (APP), Cloisite 25A nanoclay and zinc-based smoke suppressants were studied using thermogravimetric anal. (TGA) combined with IR anal. of the evolved gases (EGA) and pyrolysis/gas chromatog.-mass spectrometry (GC/MS). In TGA-EGA expts., the mass loss as a function of temperature was correlated with the evolution of CO and CO<sub>2</sub> and O consumption as measured by an oxygen analyzer. The effect of APP, Cloisite 25A and the smoke suppressants on the evolution of CO and CO<sub>2</sub> was examined. The decomposition behavior of flame-retarded polyester resins under isothermal pyrolytic conditions was investigated and the evolved gaseous products were collected and qual. and semi-quant. analyzed via GC/MS. The addition of APP does not yield many new gaseous products relative to the unmodified polyester resin neither does the presence of zinc borate and zinc stannate

together with APP. Possible chemical interactions are discussed in an attempt to explain the observed results.

### **Unsaturated polyester/montmorillonite nanocomposites prepared by in situ intercalative copolyaddition**

Kedzierski, M., & Penczek, P., *Polimery* 2004, 49(11/12), 801, [Full text](#)

New approach to the synthesis of unsatd. polyester/clay nanocomposites is described. Various forms of organically-modified montmorillonite (OMMT) were introduced in situ during the copolyaddn. of epichlorohydrin, maleic anhydride and phthalic anhydride. The catalytic effect of OMMT containing quaternary ammonium ions was observed. The introduction of clay increases softening temperature, as well as melt or solution viscosity of unsatd. polyester. Cured unsatd. polyester/clay compns. exhibit increased hardness and heat resistance and, in some cases, decreased flammability. The best properties, including limiting O index (LOI) values at 27-29%, were obtained for the compns. with OMMT functionalized with hydroxyl group. In that case, covalent bonds between clay surface and unsatd. polyester probably are formed. The dispersion of OMMT in the polyester matrix as exfoliated nanocomposite was indicated by x-ray diffraction study.

### **Effect of reactive diluents on properties of unsaturated polyester/montmorillonite nanocomposites**

Kim, H.-G. O., Dae-Hee; Lee, Hun-Bong; Min, Kyung-Eun, *Journal of Applied Polymer Science* 2004, 92, (1), 238, [Full text](#)

Unsatd. polyester (UP)/montmorillonite (MMT) nanocomposite was prepd. by using hydroxypropylacrylate (HPA) as a reactive diluent instead of conventional styrene monomer and the effect of polarity of reactive diluent on properties of nanocomposite was investigated. X-ray and mech. test data indicated that mixing for an extended period of time is essential to enhance the phys. properties of nanocomposites in the UP/Cloisite 6A system. This was attributed to the high polarity of HPA that may disturb the preintercalation of UP resin into the galleries of MMT.

### **Nanocomposites based on montmorillonite and unsaturated polyester**

Kornmann, X., Berglund, L. A., Skerte, J., & Giannelis, E. P., *Polymer Engineering and Science* 1998, 38, (8), 1351, [Full text](#)

The concept of nanoscale reinforcement provides opportunity for synthesis of new polymer materials with unique properties. Montmorillonite (MMT) was derived from bentonite, purified, activated by sodium ions and mixed with reacting unsatd. polyester (UP). X-ray and transmission electron microscopy data were in support of the formation of a partially delaminated nanocomposite material. At an MMT content of only 1.5 vo.%, the fracture energy, GQ, of the nanocomposite was doubled, 138 J/m<sup>2</sup> as compared with 60 J/m<sup>2</sup> for the pure UP.

### **Kinetic analysis and mechanical properties of nanoclay reinforced unsaturated polyester (UP) resins cured at low temperatures**

Lee, J. L. L., Xu, *POLYM. ENG. SCI.*, 45:496-509, 2005 2005, [Full text](#)

The reaction between unsaturated polyester (UP) resin and styrene (St) is a heterogeneous free-radical chain-growth cross-linking copolymerization. Curing of the UP/St system in the presence of organically-modified nanoclay was studied by differential scanning calorimetry (DSC) and Fourier transform infrared (FTIR) spectroscopy. A mechanistic kinetic model based on the free radical copolymerization mechanism was developed to simulate the reaction rate and conversion profiles of UP/St resin mixtures with various nanoclay contents cured at low temperatures. The model parameters were determined from several DSC experiments under isothermal conditions. The model, in conjunction with heat transfer analysis, was able to successfully predict the temperature and conversion profiles during curing in two vacuum-infusion liquid composite molding (e.g., the Seemann composite resin infusion molding process [SCRIMP]) experiments. The presence of nanoclay particles enhanced the tensile modulus, but reduced the tensile strength of the UP nanocomposites. The fracture toughness parameter KIC was improved by 30% with the addition of 5 wt% nanoclay. The system with mixed nanoclay and calcium carbonate was found to possess the highest KIC without sacrificing the tensile strength.

### **Effect of nanoclay on shrinkage control of low profile unsaturated polyester (UP) resin cured at room temperature**

Liqun Xu, L. J. L., *Polymer* 45 (2004) 7325–7334 2004, [Full text](#)

The addition of a small amount of nanoclay (1-3 wt%) can provide excellent volume shrinkage control of unsaturated polyester (UP)/styrene (St)/poly(vinyl acetate) (PVAc) systems cured at room temperature. PVAc serves as the low profile additive (LPA). In this study, both temperature-induced phase separation of the uncured resin mixture and transmission electron microscopy (TEM) of the cured sample revealed that nanoclay resided in the LPA-rich phase, leading to a higher reaction rate and earlier onset of micro-cracking in the LPA-rich phase or at the interface of the LPA-rich and UP-rich phases. Consequently, an earlier volume expansion during curing was observed in reactive dilatometry, resulting in better shrinkage control. On-line measurement of the composite thickness change during vacuum-infusion liquid composite molding [e.g. the Seemann Composite Resin Infusion Molding Process (SCRIMP)] further proved excellent volume shrinkage control of nanoclay filled systems, leading to a smoother composite surface.

### **Experimental research on preparation of sepiolite clay/unsaturated polyester composite materials**

Liu, K., & Zhou, J., *Feijinshukuang* 2003, 26, (4), 22, [Full-text](#)

Sepiolite clay/unsatd. polyester composite materials were prepd. by treating with surface treating agents and enforcing with short cutting glass fiber. The effects of the types of surface treating agents, short cutting glass fiber, mixing time, preheating time, forming temperature and pressure, and holding pressure time on the properties of the composite materials were studied. The optimal technol. condition was obtained.

### **Unsaturated polyester/organo-clay nanocomposites: a fundamental approach**

Mironi-Harpaz, I., Narkis, M., & Siegmann, A., *PMSE Preprints* 2005, 92, 64, [Full-text](#)

A methodol. approach which provides a basis for understanding the structuring processes involving the formation of unsatd.-polyester (UP)/clay nanocomposites and establishing materials-processing-structure interrelations is employed. UP resins are bi-component systems comprising an UP alkyd, usually dissolved in styrene monomer. This gives rise to numerous possible approaches in synthesizing UP nanocomposites. UP-resin/organo-clay nanocomposites were synthesized, and the effects of various mixing processes, using several organically modified clay types, were investigated. Incorporation of these organo-clays resulted in an intercalated structure, the extent of which depended on the clays' org. treatment. The second approach is the synthesis of UP-alkyd/organo-clay nanocomposites. Several processing parameters were studied. Inducing high shear levels for prolonged durations promoted the intercalation and exfoliation of the silicate layers, resulting in a better dispersion of clay particles. The high shear levels effects were achieved by vigorous mech. mixing and were intensified by using large amts. of clay and optimized matrix viscosity.

### **Nanocomposite systems based on unsaturated polyester and organo-clay**

Mironi-Harpaz, I. N., M.; Siegmann, A., *Polymer Engineering and Science* 2005, 45, (2), 174, [Full text](#)

Unsatd. polyester (UP) systems give rise to numerous possible approaches in synthesizing nanocomposites. A simultaneous mixing method was used to synthesize UP-resin/organo-clay nanocomposites. The effects of various mixing processes, using several organically-modified clay types, were investigated. The incorporation of these organo-clays resulted in an intercalated structure, the extent of which depended mainly on the type of the clay organic treatment. Organo-clays that exhibited the highest intercalation levels were further studied using a sequential mixing method. The UP-alkyd (without styrene) was mixed with different organo-clays. Processing parameters such as mixing modes, applied shearing levels, clay contents, and mixing-temps. were investigated. Prolonged high shear levels promoted the intercalation and exfoliation of the silicate layers, resulting in a better dispersion of clay particles. The high shear levels effects were achieved by vigorous mech. mixing and were intensified by using large amts. of clay and optimized matrix viscosity. Rheol. studies of the nanocomposites were found complementary and in correlation with morphol. and thermal characterization. This methodol. approach provides a basis for understanding the structuring processes involving the formation of the UP/clay nanocomposites and establishing materials-processing-structure interrelations.

### **Characterization and thermophysical properties of unsaturated polyester layered silicate nanocomposites**

Miyagawa, H., Mohanty, A. K., Burgueno, R., Drzal, L. T., & Misra, M., *Journal of Nanoscience and Nanotechnology* 2006, 6, (2), 464, [Full text](#)

The thermophys. properties of unsatd. polyester (UPE) nanocomposites reinforced by organo-montmorillonite clay nanoplatelets are reported. The organo-clay nanoplatelets were sonicated in acetone for 2 h to be dispersed in the UPE matrix. Vacuum extraction removed not only the acetone but also the styrene present in the UPE solution. The same mech. and thermophys. properties of UPE were regained after adding the lost amount of styrene to the UPE solution. Both delaminated and intercalated clay morphologies were observed by transmission electron microscopy. It was found that the sonication process was effective to delaminate clay nanoplatelets for more homogeneous dispersion, dependent on organic chemical modifications for clay nanoplatelets. A higher storage modulus enhancement was obtained when the organo-clay nanoplatelets were delaminated and more homogeneously dispersed. The reinforcing

effect of both delaminated and intercalated clay nanoplatelets was theor. evaluated with the Halpin-Tsai equations. It was evaluated that the aspect ratio of delaminated clay nanoplatelets was approx. 150. The increase of the storage modulus below and above the glass transition temperature was achieved without reducing glass transition temperature and Izod impact strength with increasing clay content.

### **Smoke, CO, and CO<sub>2</sub> measurements and evaluation using different fire testing techniques for flame retardant unsaturated polyester resin formulations**

Nazare, S., Kandola, B. K., & Horrocks, A. R., *Journal of Fire Sciences* 2008, 26, (3), 215, [Full text](#)

Smoke is considered to be the main fire hazard but its production depends on major variables, principally the chemical character and the burning rate of the polymer plus the availability of oxygen and hence ventilation. The main aim of this work is to study the effect of smoke suppressants on flammability and smoke production of flame retarded unsatd. polyester resin-nanocomposites using four different testing regimes representing different fire scenarios. Samples containing zinc borate, zinc stannates, ammonium polyphosphate with and without nanoclay are analyzed for smoke generation using cone calorimetry (well-ventilated fire), a tube furnace (fully developed fire), and a smoke d. chamber (under-ventilated fire). Carbon monoxide (CO) and carbon dioxide (CO<sub>2</sub>) measurements using thermogravimetry-evolved gas anal. (TG-EGA), cone calorimetry, and tube furnace have also been analyzed and compared. Results have confirmed that the production of smoke, CO, and CO<sub>2</sub> depend upon smoke suppressants and fire conditions used during testing samples. From this study it is evident that tin additives have very little influence on flammability of unsatd. polyester resin but they reduce smoke formation. The slight flame retardant action of the Res/APP/ZB sample is due to enhanced crosslinking of APP in the presence of zinc borate, whereas zinc stannates do not promote crosslinking of APP and hence show no improvement in flame retardancy. Finally, the presence of nanoclay in flame retarded resin shows significant reduction in smoke formations in both well-ventilated and under-ventilated fire condition. However, in the presence of smoke suppressants used in this study, the nanoclay is not instrumental in further suppressing smoke formation.

### **The property and formation mechanism of unsaturated polyester-layered silicate nanocomposite depending on the fabrication methods**

Suh, D. J., Lim, Y. T., & Park, O. O., *Polymer* 2000, 41, (24), 8557, [Full text](#)

The properties of unsatd. polyester (UP)/montmorillonite (MMT) nanocomposites greatly depend on the prepn. procedure because of the chem. reactions and phys. interactions involved. To investigate the properties and formation mechanism of UP/MMT nanocomposite, samples were prepd. by two different mixing methods. The first method, simultaneous mixing, is similar to the method used for prepg. the conventional unsatd. polyester and filler composite. The second method is sequential mixing, a new approach for prepg. unsatd. polyester-layered silicate nanocomposite. In the first step, pre-intercalates of the unsatd. polyester and MMT nanocomposites were prepd. In other words, mixts. of the UP and organophilic-treated MMT are prepd. in the first step; a styrene monomer was then added to the pre-intercalates of UP/MMT with varying mixing time. The structures of UP/MMT nanocomposite were investigated by x-ray diffraction and transmission electron microscopy. To investigate the formation mechanism of UP/MMT nanocomposite, dynamic mech. thermal anal., soln.-rheometry and melt-rheometry were performed. The properties and formation processes depending on two methods are compared. These tests provided a means of understanding the mechanism of UP-silicate

nanocomposite formation. Based on this mechanism, it is possible to increase the crosslinking density and the degree of dispersion in UP/MMT nanocomposites.

### **Tough, Low Mass SMC Development for Transportation Applications**

COMPOSITES 2006 Convention and Trade Show, American Composites Manufacturers Association, [Full text](#)

The need for low mass composites in the transportation industry has intensified as OEM's have looked for ways to reduce vehicle weight in the face of rising oil prices, increasing regulation, and political unrest in the major oil producing countries. Low mass SMC is not a new concept and has been practiced in the industry for several years. However, the limitations of traditional low mass technology have restricted its use to specific applications. The combination of properties to produce low mass Class A SMC without glass microspheres while maintaining the required mechanical and physical properties has not been available. With the introduction of tough SMC technologies in the last few years, molders as well as OEM's are demanding this technology for future applications to benefit from the performance advantages they bring. This paper will report on recent developments in tough, low mass Class A SMC that achieve a specific gravity of 1.6 and are more robust to molding conditions and exhibit lower water absorption properties than previous developments. Technology and properties of tough, low mass structural SMC with a specific gravity of 1.15 and 1.5 will also be discussed with emphasis on improved mechanical properties as compared to traditional low mass SMC.

### **Preparation and Properties of Unsaturated Polyester-Montmorillonite Intercalated Hybrid** Yonghua Zhang, Q. C., Zhijie Jiang, Kecheng Gong, *J Appl Polym Sci* 92: 2038-2044, 2004 2004, [Full text](#)

An unsaturated polyester-organophilic montmorillonite hybrid was prepared by dispersing polymerizable quaternary ammonium-modified montmorillonite in an unsaturated polyester resin, followed by crosslinking reaction. The purpose of this investigation was to discover the role of the polymerizable group of quaternary ammonium in improving interfacial interaction between the silicate layers and polymer chains and the mechanical properties of unsaturated polyester-montmorillonite hybrids. It is found that when the content of organophilic montmorillonite is between 2 and 5%, the tensile strength, impact strength, heat resistance, and swelling resistance of the hybrid are obviously enhanced and are better than that of the composites prepared with pristine or nonpolymerizable quaternary ammonium-modified montmorillonite. Results of X-ray diffraction and transmission electron microscopy show that unsaturated polyester and styrene in the resin can be intercalated into the interlayer space of organophilic montmorillonites.

### **Properties and morphology of unsaturated polyester/acrylate-terminated polyurethane/organomontmorillonite nanocomposites**

You, C.-j., Xu, J.-g., Xi, S., Duan, X.-x., Shen, J., & Jia, D.-m., *Chinese Journal of Polymer Science* 2005, 23, (5), 471, [Full text](#)

Unsaturated polyester resin (UPR)/acrylate-terminated polyurethane (ATPU)/organo-modified montmorillonite (OMMT) nanocomposites were prepared by the in situ intercalative polymerization method. Samples were prepared by the sequential mixing, i.e. mixture of the ATPU and styrene (S) and OMMT were prepared in the first step; UPR was then added to the

pre-intercalates of ATPU/S/OMMT. Results indicate that the mech. properties and thermal properties of UPR/ATPU/OMMT nanocomposites greatly depend on the amount of ATPU and OMMT. Results show that the addition of ATPU could increase the impact strength of UPR/ATPU composites, but the tensile strength, flexural strength and heat resistance of the materials are obviously decreased. When the weight ratio between UPR, ATPU and OMMT were 82:15:3, the impact strength and heat distortion-temperature of nanocomposite were greatly improved, meanwhile there was little change for other properties of the nanocomposites. The synergistic enhancement effects of ATPU and OMMT on the composites were observed. The structures and morphol. of the composites were investigated by X-ray diffraction, SEM and transmission electron microscopy.

### **Cure behavior of unsaturated polyester/modified montmorillonite nanocomposites**

Zhou, Y. Y., Xiaoyun; Jia, Demin, *Polymer International* 2007, 56, (2), 267, [Full text](#)

Dynamic rheol., differential scanning calorimetry and in situ Fourier transform IR spectroscopy were used to study the cure behavior of unsatd. polyester/modified montmorillonite nanocomposites. The results showed that their gel times increased markedly at the same cure temperature, and that the activation energy of the nanocomposites was higher than that of the pure unsatd. polyester. Their peak temps. of enthalpy increased as well. The total exotherm of the cure reaction declined and the cure rate decreased. In the curing process of pure unsatd. polyesters, the conversion of styrene was higher than that of the double bonds on unsatd. polyester macromol. chains. The cure mechanism of the unsatd. polyester/modified montmorillonite changed because of the presence of double bonds in the layers of modified montmorillonite. However, the conversion of styrene in the nanocomposites was lower than that of double bonds on unsatd. polyester chains during cure at room temperature, and the conversion of styrene was increased after post-curing and was higher than that of the double bonds on unsatd. polyester chains at the end of the cure reaction. Moreover, the degree of reaction of double bonds on unsatd. polyester chains of the nanocomposites was higher than that of unsatd. polyesters.

### **Effect of layered silicate nanocomposites on burning behavior of conventionally flame-retarded unsaturated polyesters**

Kandola, B. K. N., S; Horrocks, A. R., *Polymeric Materials: Science and Engineering* 2004, 91, 34, [Full text](#)

This work reports that when organically modified nanoclays are used in unsatd. polyester resin and tested with cone calorimeter, the peak heat release values are reduced, ease of ignition unaffected and burning times are increased compared to the neat resin. In order to develop acceptable levels of flame retardancy, the nanoclays are used with conventional char forming flame retardants such as ammonium polyphosphate. Laminates of resin containing 5% organically modified clays with and without 20% flame retardants are cast. Their flammability properties are studied with thermal anal. and cone calorimetric techniques and results discussed in terms of effect of additive components on various cone parameters of neat resin.