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Poly (Lactic Acid)/MMT Nanoclay Hybrid Nanocomposites : Mechanical and Thermal Properties

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ABSTRACT

Poly (lactic acid)/clay nanocomposites were prepared by solution-casting and melt-blending techniques, and their morphologies and mechanical properties were studied. In morphology studies revealed an intercalated–exfoliated mixed structure for the nanocomposites obtained by both techniques. SEM images show a good clay dispersion degree. Sodium lauryl sulphate (SLS here after called) is used to modify the MMT Clay to improve the surface characteristic of the clay. The mechanical properties of nanocomposites from the melt-blending technique were superior to those obtained by solution-casting method. In both cases, the highest elongation at break and Young's modulus were achieved at 5wt% SLS-montmorillonite SLS-MMT content.

Keywords: Nanocomposites, Poly (Lactic Acid), Montmorillonite, SLS

I. INTRODUCTION

Polylactide (PLA) is rigid thermoplastic polyester with a semicrystalline or completely amorphous structure depending on the stereopurity of the polymer backbone. PLA has gained a considerable interest due to its bioresorbability, biodegradability, and biocompatibility. Furthermore, its ability to be crystallized under stress, thermally crystallized, filled, and copolymerized, turn it into a polymer with a wide range of applications. The principal drawbacks of such a biodegradable polymer in terms of industrials application like food packaging are its poor thermal resistance, low mechanical and limited gas barrier properties. These drawbacks could be overcome by improving the thermo mechanical properties through copolymerization, blending, and filling techniques. However, the use of fillers appears to be the most attractive approach because of lower cost. There are different approaches for the preparation of PLA nanocomposites: *in-situ* polymerization, solution intercalation, and melt intercalation. Since melt intercalation provides more advantages as compared to others, this technique has been used as a standard method to develop polymer-layer silicate nanocomposites. Depending on the specific interactions between the polymeric matrix and the clay, different structures such as intercalated and exfoliated may be obtained. The clay layers may be well dispersed provided that a strong interaction can be developed between the clay and the polymeric matrix. Moreover, an increase in clay-PLA interactions can influence the mechanical properties. The lack of thermal stability of PLA at high temperature is another main problem. It has been found that hydrolysis, random main-chain scission reaction, oxidative reaction, and transesterification are the main undesirable reactions, strongly affecting the physical and mechanical properties of PLA. The main objective of this research is to develop PLA-clay nanocomposites, where control of PLA mechanical strength is achieved using chain extenders. Specific objectives are aimed at determining the influence of chain extenders on clay dispersion, and mechanical and barrier properties of the final extruded products [1-31].

This paper covers the synthesis of PLA, the preparation of PLA nanocomposites, the effect of clay on the mechanical and mechanical and thermal properties of the resulting nanocomposites and the degradation mechanisms of PLA.

II. METHODS AND MATERIAL

2.1 Materials

Poly (lactic acid) was supplied by Nature Works 4060D, and was used as a matrix. In addition, montmorillonite clay (1.28E) surface modified with 25-30% trimethyl stearyl ammonium (supplied by Nanocor® Inc., Aldrich, Nanomer®, USA), was used as filler material. SLS and chloroform (Merck, Germany)were used as a surfactant and solvent, respectively [9,10].

2.2. Modification of Montmorillonite (MMT)

Organoclay MMT was prepared by a cationic exchange process in an aqueous solution by vigorously stirring 20 g of montmorillonite dispersed in 800 ml of distilled water at 80 °C with a solution of 50 mmol SLS and 50 mmol concentrated HCl in 200 ml distilled water. The precipitate was filtered, washed with hot distilled water until no chloride was detected and dried at 60 °C for 24 h. The product was labelled SLS-MMT. Bath type ultra sonicator (BTUS) was used for mixing

Preparation of PLA/ODA-MMT nanocomposites

The procedures used to obtain the nanocomposite films are shown in Figure 1 for solution casting and Figure 2 for melt blending. Nanocomposites with SLS-MMT contents of 1, 3, 5, 7, and 10 wt % were also prepared. In the solution-casting technique, films of 0.5 mm thick were obtained using chloroform as a solvent in an ultrasonic bath at room temperature for 15 min. In the melt-blending technique, films 0.8 mm thick were obtained by hot pressing [12, 10, 13]. in kilojoules per meter (kJ/m). Scanning electron micro- scopy (SEM) studies of the fractured surface of the tensile specimen were carried out on a Jeol (6380LA, Japan). The specimen was sputter-coated with gold to increase surface conductivity. Tensile strength tests were carried out on par with ASTM D 53455. Tensile and flexural tests were performed on Instron universal testing machine (3369).

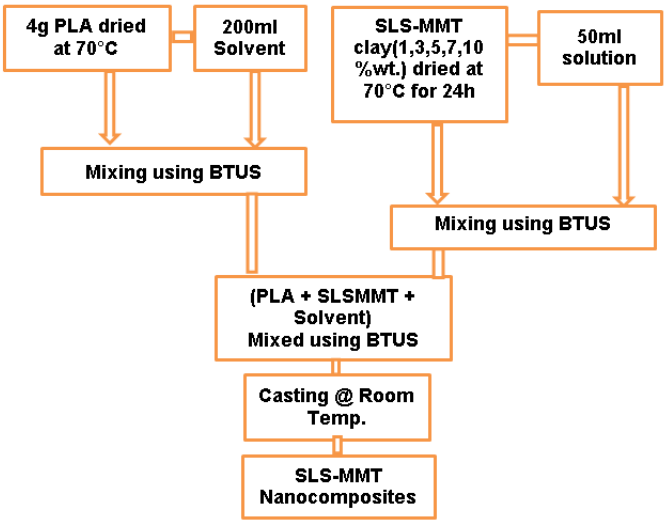


Figure 1 : Preparation of PLA/SLS-MMT nanocomposites films using solution-casting.

III. RESULT AND DISCUSSION

Mechanical Properties

Fig. 3 shows two important mechanical properties, namely the elongation at break and Young's modulus, for the PLA/SLS-MMT nanocomposites prepared by using solution-casting and melt-blending techniques. The highest value for elongation at break was obtained for 5wt% clay content in PLA. The highest Young's modulus, the mechanical property improved by clay incorporation in to the polymer matrix, was also obtained for 5 wt% SLS-MMT content [14, 19, 25].

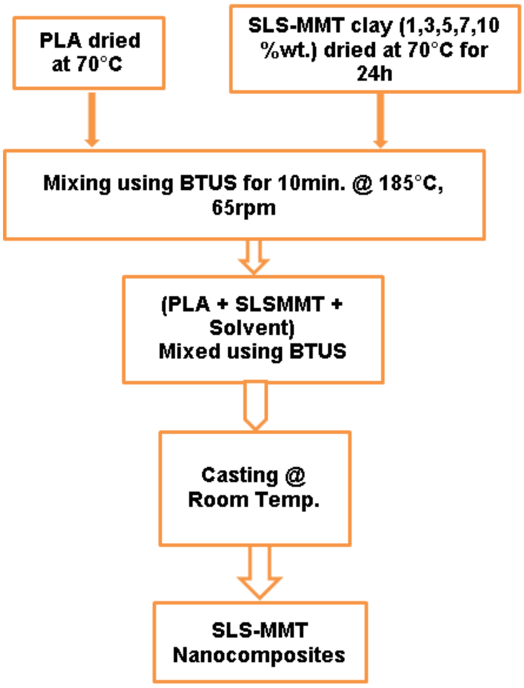
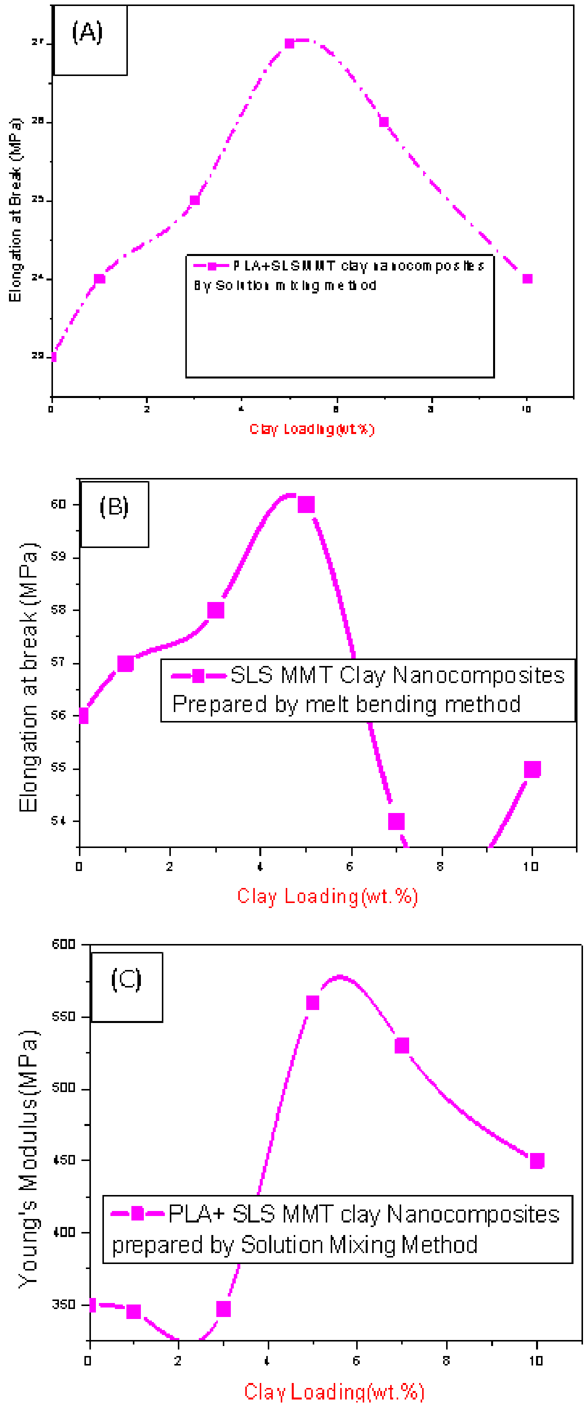


Figure 2: Preparation of PLA/SLS-MMT nanocomposites films using melt-blending.



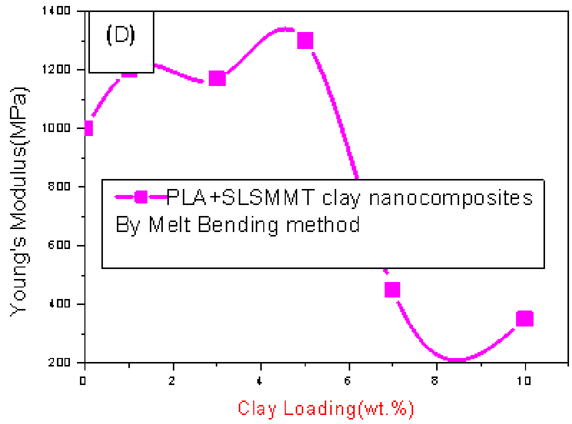
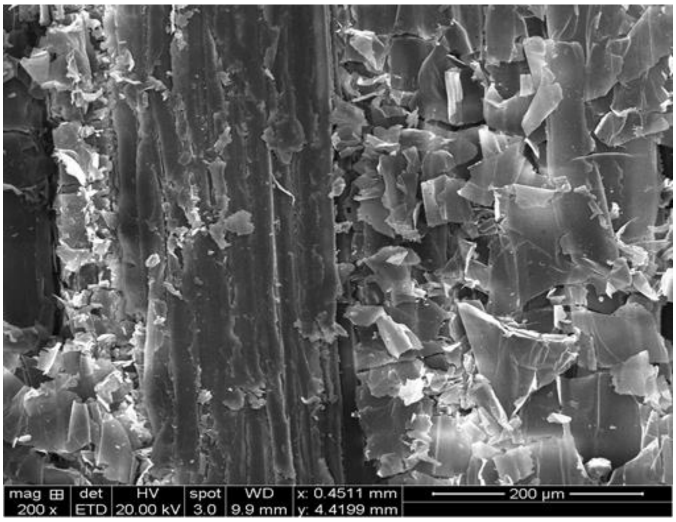


Figure 3 : Elongation at break (a, b) and Young's modulus (c, d) for PLA/SLS-MMT nanocomposites prepared by solution-casting and melt-blending techniques, respectively.

Scanning electron microscopy (SEM)

To examine exactly the dispersion of the clay layers in the film-type nanocomposites, we carried out SEM studies. Typical SEM images for the nanocomposites based on 5 wt% in solution- casting and melt-blending techniques are shown in Figure 4 (a & b).



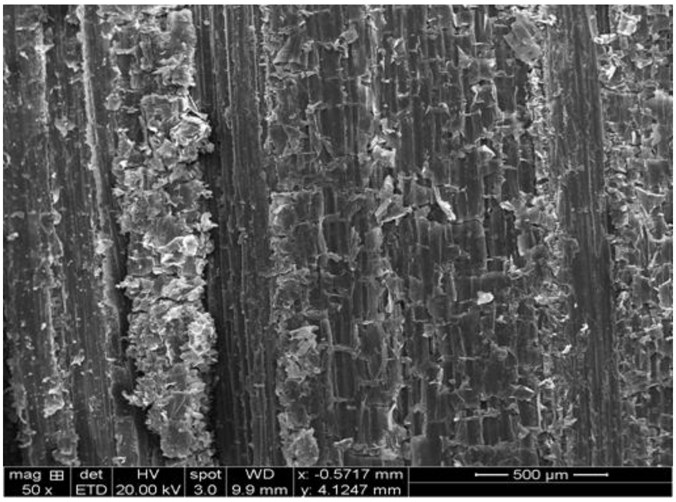


Figure 4 : SEM analysis of SLS-MMT clay Nanocomposites of 5wt.% clay loading prepared by (A) Solution Mixing (B)Melt Blending Methods.

Each clay displayed individual clay layers that were well dispersed, exfoliated, in the PLA matrix. The density and homogeneity of the samples are similar but dispersion in samples from melt-blending (Fig. 4b) is better than that of solvent casting (Fig. 4a). Similar observations were observed by the researchers [1-3].

IV. CONCLUSION

In this work, the PLA/SLS-MMT nanocomposites were prepared as an exfoliated structure by solution casting and melt blending methods. The optimum content of clay in both of methods was obtained at 5% because the highest elongation at break and Young's modulus were occurred in this content. Further the mechanical properties of obtained films by melt blending were superior of the films obtained by solution casting. In addition, the absence of solvents, which can produce environmental problems, is an advantage for the melt blending method.

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