

Mechanical properties of nano-MMT reinforced polymer composite and polymer concrete

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Abstract

Unsaturated polyester (UP) resin is widely used for the matrix of composites such as fiber reinforced plastic (FRP) and polymer concrete. Consequently, inexpensive and high performance resins are important for the future of polymer composites. One recent method for enhancing the performance of polymer composites is the manufacture of MMT (montmorillonite)-UP nanocomposite synthesized by intercalating the UP resin into the silicate layers of MMT. This study investigates the mechanical and thermal properties of MMT-UP nanocomposites, and those of polymer concretes using these nanocomposites. Test results indicate that the mechanical properties and thermal stability of MMT-UP nanocomposites are better than those of pure UP. The glass transition and main chain decomposition temperatures of the MMT-UP nanocomposite exceed those of pure UP. The compressive strength, elastic modulus, and splitting tensile strength of the polymer concrete using MMT-UP nanocomposites exceeded those of polymer concrete using pure UP. Also, the polymer concrete made with MMT-UP nanocomposite has better thermal performance than that of pure UP. The improved performance of UP is very important for the future of polymer concrete.

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1. Introduction

Polymer composites are increasingly considered as structural components for use in civil engineering due to their excellent strength-to-weight ratios. Due to its excellent adhesion properties, unsaturated polyester (UP) resin is widely used for the matrix of composites such as FRP and polymer composites. However, compared to other resins, unsaturated polyester (UP) resin has relatively poor mechanical properties, thermal stability, and fire retardant properties, which limits its use in advanced composites. The modification of polymers is of considerable significance from a material science and engineering point of

view. The performance of unsaturated polyester (UP) resin may be enhanced by the addition of inorganic fillers [5,7]. Conventional particulate polymer composites, often called filled polymers, are of significant commercial importance as materials in industrial applications. Polymer nanocomposites are a new class of composites derived from nano-scale inorganic particles. Their dimensions typically range from 1 to 1000 nm and they are homogeneously dispersed in the polymer matrix. Owing to the high aspect ratio of the fillers, the mechanical, thermal, flame retardant and barrier properties of polymers may be enhanced without a significant loss of clarity, toughness or impact strength. The layered silicate is generally made organophilic by exchanging the inorganic cation, which is located between the layers (d-spacing), with an organic ammonium cation. Clay-polymer composites can be classified into three types: conventional composite, intercalated nanocomposites and

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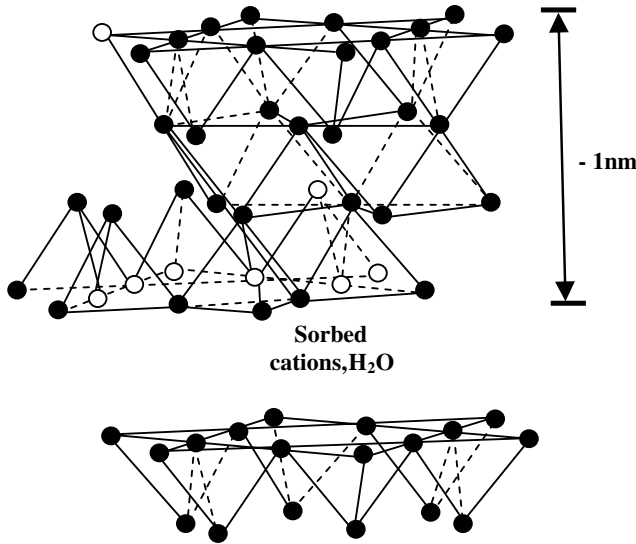


Fig. 1. The oxygen framework (solid circles) of smectite clay nanolayers.

exfoliated nanocomposites (Fig. 1). In a conventional composite the registry of the clay nanolayers is retained when mixed with the polymer, but there is no intercalation of the polymer into the clay structure (see Fig. 2a). Consequently, the clay fraction in conventional clay composites plays little or no functional role and acts mainly as a filling agent for economic considerations. An improvement in modulus is normally achieved in a conventional clay composite, but this reinforcement benefit is usually accompanied by a sacrifice in other properties, such as strength or elasticity. Two types of clay–polymer nanocomposites are possible [1,3,6]. Intercalated nanocomposites (Fig. 2b) are formed when one or a few molecular layers of polymer are inserted into the clay galleries with fixed interlayer spacings. Exfoliated nanocomposites (Fig. 2c) are formed when the silicate nanolayers are individually dispersed in the polymer matrix, where the average distance between

segregated layers is dependent on the clay loading. The separation between the exfoliated nanolayers may be uniform (regular) or variable (disordered). Exfoliated nanocomposites show greater phase homogeneity than intercalated nanocomposites. More importantly, each nanolayer in an exfoliated nanocomposite contributes fully to interfacial interactions with the matrix. This structural distinction is the primary reason why the exfoliated clay state is especially effective in improving the reinforcement and other performance properties of clay composite materials. The key to the extraordinary performance of polymer–clay nanocomposites is dependent on the complete dispersal (exfoliation) of the clay nanolayers in the polymer matrix.

The structure of the montmorillonite clay used as the filler comprises an octahedral alumina sheet sandwiched between two tetrahedral silica sheets. Alkylammonium ions lower the surface energy of the clay so that monomers and polymers with different polarities can enter the space between the layers and cause further separation of the silicate layers to form the nanocomposite [2,4].

The objective of this study is to enhance the performance of polymer composites using unsaturated polyester (UP) resin based recycled PET (poly ethylene terephthalate) [8]. Therefore, this work investigates the mechanical properties and thermal stability of MMT-UP nanocomposites and polymer concrete using the MMT-UP nanocomposite.

The results are supported by mechanical testing, X-ray diffraction (XRD), transmission electron microscopy (TEM), differential scanning calorimetry (DSC), and thermo gravimetric analysis (TGA).

2. Research significance

This study contributes to the understanding of the properties of MMT-UP nanocomposite and polymer concrete using MMT-UP nanocomposite as follows.

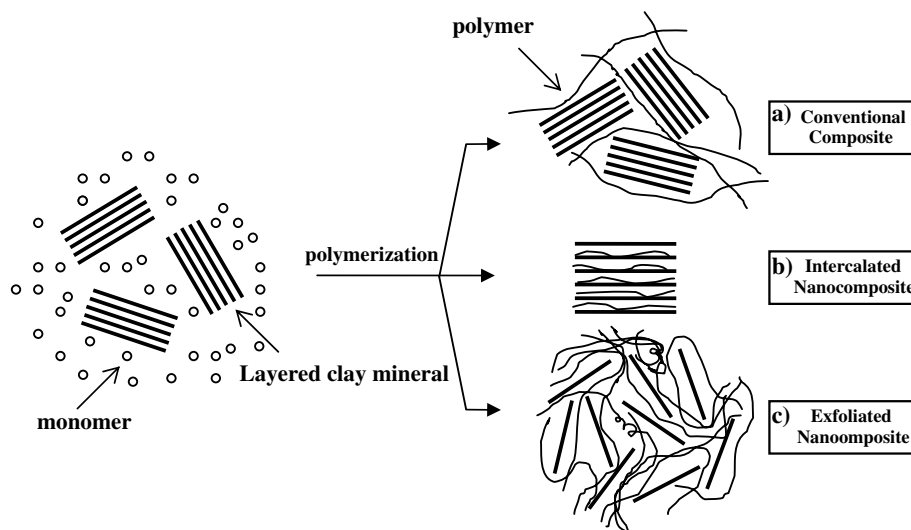


Fig. 2. Schematic illustrations of the structures.

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