

Preparation and Characterization of Polymethacrylic acid/ Na-montmorillonite/ Nano-SiO₂ Composites*

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Nanocomposites are a promising new class of technologically advanced materials, consisting of two or more phases in which at least one of its phases has one or more dimensions (length, width or thickness) in the nanometer size range, usually defined as 1-100 nm. Nanocomposites show conspicuously enhanced mechanical, thermal, optical and electro chemical properties compared to their neat or conventional composites.

Among various nanocomposites, much attention has been paid to polymer/Na-montmorillonite(Na-MMT) nanocomposites, in which nanometer-thick layers of clay are dispersed in polymers. Another importantly used nano material for the enhancement is nano SiO₂ particle.

However, there are few studies on the nanocomposites containing both Na-MMT and nano-SiO₂ particle have been reported so far. Weather the nanocomposites still have high thermal stability and enhanced mechanical property, when two kinds of nano materials with different forms, layered and particle are incorporated into the polymer matrix?

In the present work, the polymer/Na-MMT/nano-SiO₂ composites were prepared via in situ polymerization. The polymer matrix used in the present studies is polymethacrylic acid (PMAA). The structures, morphologies and thermal properties of the obtained nanocomposites were examined by FT-IR, XRD, TEM, DSC and TGA.

Fig. 1 displays the differences among the structures of Na-MMT, nano-SiO₂ and PMAA/Na-MMT/nano-SiO₂. The FT-IR spectrum of PMAA/Na-MMT/nano-SiO₂ shows that the intensity of the 3500-3200cm⁻¹ band is increased. The —OH stretching frequencies were broadened and displaced to lower frequencies. These shifts were attributed to the formation of hydrogen bonds. On the other hand, the peaks at 2940cm⁻¹ and 1490-1410cm⁻¹ were ascribed to the vibration of methylene groups. The peaks at 1700cm⁻¹ were due to the C=O stretching mode of carboxyl. These results show that methacrylic acid was polymerized in the MMT inter-lamellar. The absorption peak 1638cm⁻¹ disappears, which explains that nano-SiO₂ is copolymerized with MAA monomers completely.

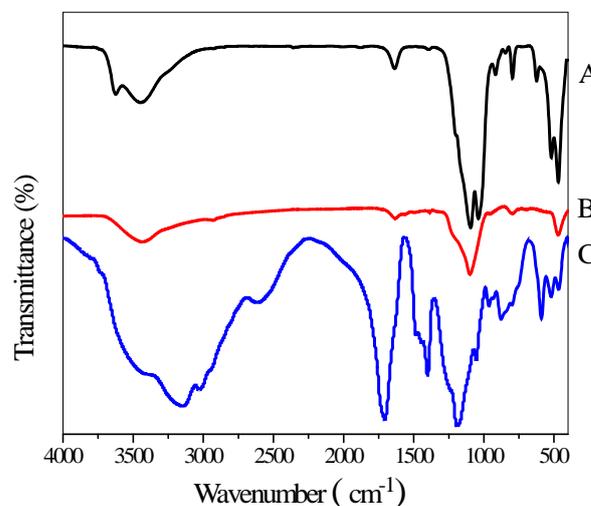


Fig.1 FT-IR spectra (A—Na-MMT; B—nano-SiO₂; C—PMAA/Na-MMT/nano-SiO₂)

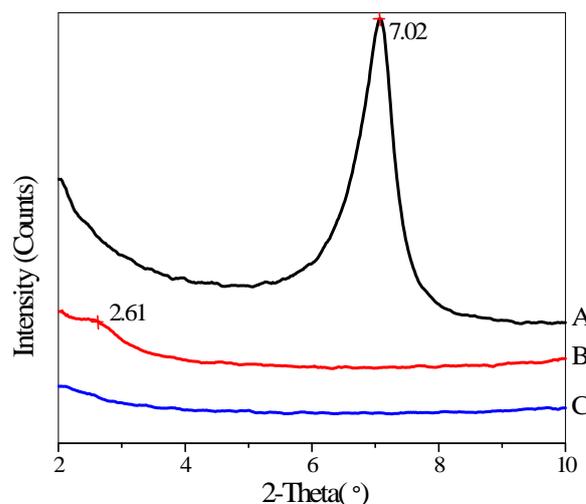


Fig.2 XRD patterns (A—Na-MMT; B—PMAA/Na-MMT; C—PMAA/Na-MMT/nano-SiO₂)

Shown in Fig.2 are XRD diffraction patterns of Na-MMT, PMAA nanocomposites containing Na-MMT and Na-MMT/nano-SiO₂. A strong 001 characteristic diffraction peak of pristine MMT appeared at the 2θ value 7.02° (curve A). Curve B is the result obtained for PMAA/Na-MMT. A diffraction peak at 2θ = 2.61° is visible in this nanocomposite. Curve C gives typical XRD pattern of PMAA/Na-MMT/nano-SiO₂. The XRD results suggest that the Na-MMT layers are exfoliated as indicated by

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the disappearance of the Na-MMT diffraction peak in curve C. In order to confirm the morphology of PMAA/Na-MMT/nano-SiO₂, TEM measurements were carried out. The dark slices stand for Na-MMT layers while the spherical dark particles are SiO₂. The PMAA matrix appears as light region. The Na-MMT layers together with the SiO₂ particles show a good dispersion in the PMAA matrix.

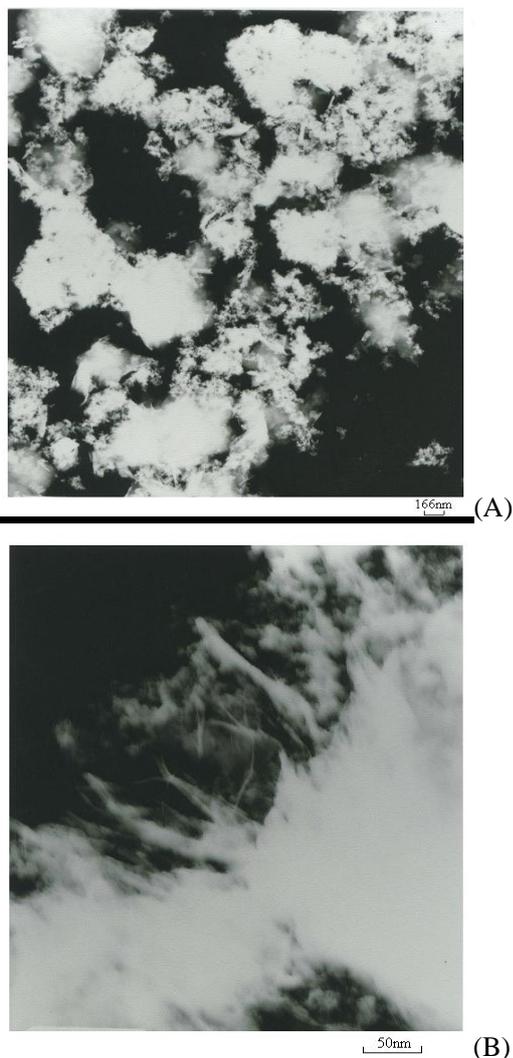


Fig.3 TEM pictures of PMAA/Na-MMT/nano-SiO₂

Fig. 4 displays the DSC thermographs obtained for PMAA/Na-MMT and PMAA/Na-MMT/nano-SiO₂. The glass transition temperature (T_g) of the PMAA/Na-MMT/nano-SiO₂ (T_g =194.4°C) is higher than that of PMAA/Na-MMT (T_g =176.2°C).

Thermal stability of PMAA/Na-MMT/nano-SiO₂ was evaluated using TGA in nitrogen atmosphere. For comparison, PMAA and PMAA/Na-MMT were also tested by TGA under the same conditions. The TGA data of weight change are shown in Fig.5. PMAA/Na-MMT/nano-SiO₂ exhibits an onset of thermal degradation of polymer main chains almost 30 higher than that of PMAA/Na-MMT and about 40 higher than PMAA.

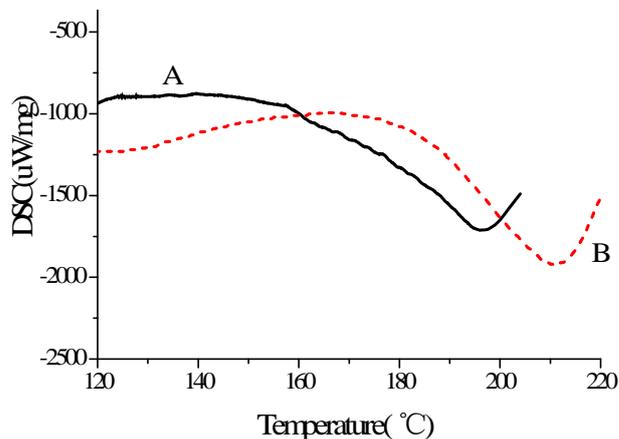


Fig.4 DSC thermographs (A—PMAA/Na-MMT; B—PMAA/Na-MMT/nano-SiO₂)

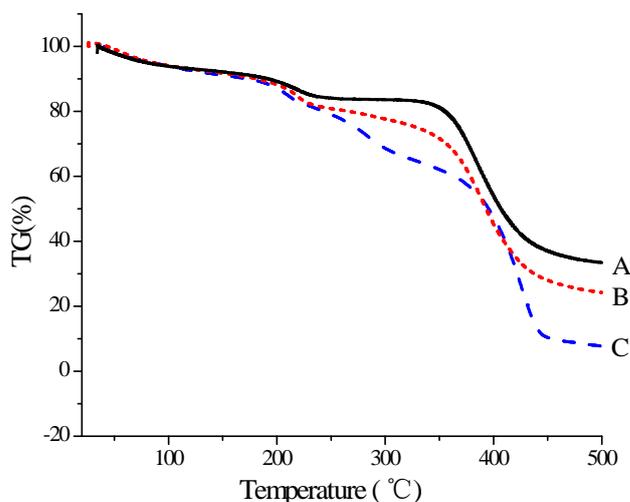


Fig.5 TGA curves (A—PMAA; B—PMAA/Na-MMT; C—PMAA/Na-MMT/nano-SiO₂)

PMAA/Na-MMT/nano-SiO₂ composite was prepared via in situ polymerization. Nano-SiO₂ is copolymerized with MAA monomers. Na-MMT layers are exfoliated during the polymerization process. The Na-MMT layers and SiO₂ particles exhibit good dispersion in the polymer matrix. It was found that the PMAA/Na-MMT/nano-SiO₂ composite exhibit considerably enhanced thermal properties compared with the PMAA/Na-MMT.

Reference:

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