

Nanostructure of New Epoxy-PMMA-Clay Composites

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Abstract – New epoxy-PMMA-clay nanocomposites have been prepared and their structure investigated by X-ray diffraction (XRD) and Small-Angle X-ray scattering measurements. The quantitative determination of size and fraction of clay tactoids and aggregates in the polymer matrix show the good dispersion of clay at low clay contents (up to 2.5 wt%), leading to much better thermal and mechanical properties compared to epoxy network.

Polymer/layered silicate nanocomposites show, generally, improvement in mechanical properties, barrier properties, thermal resistance and flame retardant properties at lower clay loading in contrast to traditional polymer composites, which has attracted much attention in many fields. However, it is well-established that the control of dispersion and exfoliation degree of layered silicate in polymer matrix is the key for improving and monitoring properties of the resulting composites. In the present work we have synthesized nanocomposites of epoxy resin modified by low molar mass poly(methyl methacrylate) (PMMA) and organophilic montmorillonite (Cloisite 20A, Southern Clay Products). The weight fraction of clay in the materials are 0.1% (N1); 1% (N2) and 2.5% (N3). Our goal was to understand how the nanostructural features of the materials should affect their properties, aiming their improvement for future use in technological applications. The XRD patterns of the samples (Figure 1) show the characteristic diffraction peak located at $2\theta = 3.4^\circ$ ($d_{001} = 2.4$ nm) for organoclay. This diffraction peak was not observed for the epoxy-clay nanocomposites. The results indicate that the epoxy resin have diffused into clay galleries and expanded the basal spacing. The small-angle X-ray scattering (SAXS) intensity is due to the electronic density contrast between the silicate of the clay and polymeric phase. On the SAXS patterns of the nanocomposites (Figure 2) no peak for nanocomposite N1 is observed, indicating the complete exfoliation of the organoclay by epoxy resin. For the nanocomposites N2 and N3 an interference peak located around $q_{\max} = 1.9$ nm⁻¹, revealing the existence in the polymer matrix of clay tactoids or small aggregates constituted of lamella separated by a distance $d = 2\pi/q = 3.3$ nm. SAXS measurements allowed to determine the fraction of clay tactoids of different thicknesses. For this purpose, we have used the stacked-disc model assuming for tactoids the aspect ratio of a plate and we have considered a wide distribution of tactoid thicknesses [1]. The SAXS spectra were considered as being the sum of contributions of several populations, a fixed number of platelets in a stack constituting a population. The SAXS signal was fitted to the weighted sum of the contributions arising from entities of thickness t_i : $P(q) = \sum (B_i/q^2) t_i^2 (\sin(qt_i/2)/qt_i/2)^2$. A least square fitting procedure was applied to determine the parameters B_i and t_i . The parameter B_i being proportional to the tactoid area, the fraction P_i of tactoids of thickness t_i within the matrix was then estimated from $P_i = B_i/\sum B_i$. Three main populations of tactoids were determined, the results evidence the good dispersion of the organo clay in the modified epoxy matrix, with a high fraction of small clay aggregates of thickness around 3 nm and a few proportion of tactoids of size around 13 nm and 35 nm. The glass transition temperature, elastic modulus and degradation temperature of all nanocomposites present a clear improvement compared to epoxy neat network.

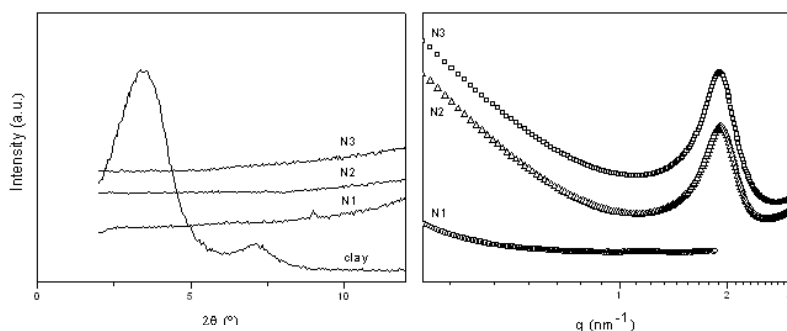


Figure 1: XRD patterns of epoxy/clay nanocomposites.

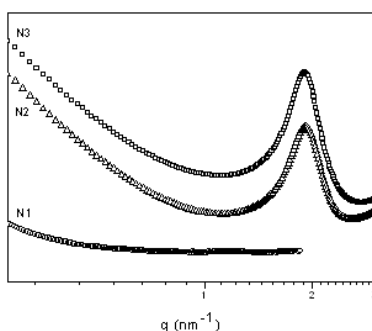


Figure 2: SAXS patterns of epoxy/clay nanocomposites.

References

[1] M. Hernandez, B. Sixou, J. Duchet and H. Sautereau, *Polymer*, 48 (2007), 4075



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