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Influence of Organic Modifier Loading on Particle Dispersion of Biodegradable Polycaprolactone/Montmorillonite Nanocomposites

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Abstract : Natural sodium montmorillonite (NaMMT), Cloisite Na⁺ and two organophilic montmorillonites (OMMTs), Cloisites 20A and 15A were used. Polycaprolactone (PCL)/MMT composites containing 1, 3, 5, and 10 wt% of Cloisite Na⁺ and PCL/OMMT nanocomposites containing 5 and 10 wt% of Cloisites 20A and 15A were prepared via solution intercalation technique to study the influence of organic modifier loading on particle dispersion of PCL/ NaMMT composites. Thermal stabilities of the obtained composites were characterized by thermal analysis using the thermogravimetric analyzer (TGA) which showed that in the presence of nitrogen flow the incorporation of 5 and 10 wt% of filler brings some decrease in PCL thermal stability in the sequence: Cloisite Na+>Cloisite 15A > Cloisite 20A, while in the presence of air flow these fillers scarcely influenced the thermoxidative stability of PCL by slightly accelerating the process. The interaction between PCL and silicate layers was studied by Fourier transform infrared (FTIR) spectroscopy which confirmed moderate interactions between nanometric silicate layers and PCL segments. The electrical conductivity (σ) which describes the ionic mobility of the systems was studied as a function of temperature and showed that σ of PCL was enhanced on increasing the modifier loading at filler content of 5 wt%, especially at higher temperatures in the sequence: Cloisite Na⁺<Cloisite 20A<Cloisite 15A, and was then decreased to some extent with a further increase to 10 wt%. The activation energy E_σ obtained from the dependency of σ on temperature using Arrhenius equation was found to be lowest for the nanocomposite containing 5 wt% of Cloisite 15A. The dispersed behavior of clay in PCL matrix was evaluated by X-ray diffraction (XRD) and scanning electron microscopy (SEM) analyses which revealed partial intercalated structures in PCL/NaMMT composites and semi-intercalated/semi-exfoliated structures in PCL/OMMT nanocomposites containing 5 wt% of Cloisite 20A or Cloisite 15A.

Keywords : electrical conductivity, montmorillonite, nanocomposite, organoclay, polycaprolactone
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