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ORIGINAL PAPER

Organically modified-grafted mica (OMGM) nanoparticles for reinforcement of polypropylene

H. Mohammadi[1] · M. R. Moghbeli[1]

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Abstract
Polypropylene (PP) was reinforced by mica nanoparticles as a reinforcement of mechanical properties. For this purpose, mica was organically modified using diacetone acrylamide, a vinyl functional modifier, to enhance the interaction between the PP chains and mica silicate layers. The X-ray diffraction patterns demonstrated the intercalation of the modifier molecules into the mica gallery. Maleic anhydride-grafted polypropylene was grafted on organically modified mica (OMM) in an organic suspension media at different temperatures, 100, 120, and 130 °C. Fourier transform infrared spectroscopy was used to characterize the OMM and organically modified-grafted mica (OMGM). Various amounts of OMGM nanoparticles, 0–3 wt%, were used to reinforce PP. The effect of OMGM level on the crystallinity, tensile properties, impact, and fracture toughness of resulting nanocomposites was investigated. The results showed that the addition of 1 wt% OMGM, prepared at grafting temperature of 120 °C, enhanced the tensile strength to 12% and notched impact strength to 58%, while it changed the critical stress intensity factor (K_{1C}) slightly (5%) when compared to PP. Partial exfoliation of OMGM layers in the PP matrix was examined using transmission electron microscopy. The further increase in the OMGM level lowered the mechanical properties and fracture toughness due to OMGM nanoparticle agglomeration.

Keywords Diacetone acrylamide · Impact strength · Fracture toughness · Mica nanoparticles · PP

Introduction

Polypropylene (PP) is one of the most commonly used thermoplastic polymers with some advantages, such as good processability, low cost, and good solvent resistance. However, its poor impact and fracture toughness have limited its widespread applications in industry [1]. Nowadays, the reinforcement of PP using various types of nanoparticles, such as organically modified montmorillonites (OMMTs) [2, 3], nanosilica, and carbon nanotubes (CNTs) [4, 5], has attracted the interest of scientists and industries to improve its physical, mechanical, and barrier properties [6, 7]. One of the most important problems in the preparation of nanocomposites is the difficulty of nanoparticles dispersion inside the polymer matrix due to their poor interfacial interaction with the matrix [8]. Yuan and Misra [9] increased the impact strength of PP through using organically modified clays. However, the addition of the modified clay did not affect the fracture toughness of the resulting nanocomposite. Svoboda et al. [10] showed that the incorporation of organoclay into PP improved the tensile strength and modulus, while it lowered ultimate elongation regardless of the molecular weight of the polypropylene-grafted-maleic anhydride (PP-*g*-MAH) used. The presence of graphite and clay in PP matrix led to excellent mechanical properties when compared to the neat polymer matrix [11].

In addition, the use of nanoparticles with smaller lengths or aspect ratios cannot improve the polymer impact strength favorably. Mica and montmorillonites are both clay-type inorganic particles with a typical silicate-layered structure. These two species exhibit a tetrahedral–octahedral–tetrahedral (TOT) sandwich structure with a single sheet thickness close to 1 nm. However, the length of mica single layers is in the range of 3000–6000 nm, while for montmorillonite, the length is smaller in the range of 100–200 nm. Therefore, the mean aspect ratio of mica is approximately 30 times greater than that of the montmorillonites. Exfoliation of mica sheets can considerably influence the physical/mechanical

✉ M. R. Moghbeli
mr_moghbeli@iust.ac.ir

1 Smart Polymers and Nanocomposites Research Group, School of Chemical Engineering, Iran University of Science and Technology, Tehran 16844–13114, Iran