RATIONAL DESIGN OF POLYPROPYLENE-BASED COMPOSITES WITH ORGANIC/INORGANIC FILLERS

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ABSTRACT

Polypropylene (PP) compounding is a key technology in modifying their mechanical and processing properties and in introducing new functionalities. However, the apolar PP matrix generally suffers from poor interaction with polar fillers or additives, leading to unsatisfactory modification. Two novel concepts will be reported in order to control the afore-mentioned interaction.

PP is known to easily undergo oxidative degradation initiated by heat, light, and etc., and addition of stabilizers is essential for the practical application. Since the lifetime of PP can be regarded as the time until which the stabilizers effectively work in the matrix, a variety of stabilizers has been synthesized for each specific application. In the first part, a new concept utilizing a molecular capsule is introduced aiming at long-term stabilization of PP. The key issue for long-term stabilization is to restrict physical loss of stabilizer in the application, through volatilization to the atmosphere or through elution to contacting liquids. The most frequently applied strategy to the physical loss is to employ high molecular-weight stabilizers. However, increase of the molecular weight of stabilizers generally accompanies the deterioration of the diffusivity, i.e. its effectiveness. We have introduced a hyper-branched polyester (HBP) into PP without increasing the molecular weight of stabilizers. HBP with a molecular capsule structure did not have a stabilization effect as itself but largely improved the stability of the material through interaction with stabilizers in thermal oxidative degradation. HBP enhanced the affinity between the matrix and stabilizers to prevent their volatilization, while did not decelerate their diffusion. A molecular capsule structure of HBP was believed to play an important role for reversibly trapping and releasing stabilizers in the matrix.

In the second part, we will present how to design interfacial structure between PP and inorganic fillers using a polymerization functionalization technique. In detail, end-functionalized PP was synthesized by controlling chain transfer reactions in propylene polymerization with a metallocene catalyst, and grafted with SiO_2 nanoparticles. Thus synthesized PP-grafted SiO_2 was found to improve the dispersion of SiO_2 without any compatibilizers, which are known to deteriorate mechanical properties and material stability. Moreover, the grafted PP chains notably accelerated the nucleation in crystallization, compared with neat SiO_2. It was plausible that the grafted chains whose one chain end was pinned to SiO_2 became nuclei of the crystallization of matrix PP. Such that co-crystallization between the matrix and grafted chains directly bridges between the matrix and SiO_2 nanoparticles, facilitating effective load transfer. As a result, large mechanical reinforcements in terms of the Young's modulus and tensile strength were obtained with the addition of a small amount of SiO_2.