EFFECTS OF ADDITIVES ON RHEOLOGY AND FILM BLOWING OF POLYPROPYLENE/CLAY NANOCOMPOSITES

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Abstract

Polymer nanocomposites with organically modified nanoclay have two different types of interface sites: edges with hydroxyl groups and gallery faces with oxygen atoms. In this study, the polymer-particle interface was strengthened by a coupling agent, aminoalkyltrimethoxysilane, which allowed the formation of covalent bonds between silane treated organoclay and maleic anhydride groups of the long chain compatibilizer. The objective of this research is to investigate effects of reactive coupling at these interfacial sites on rheology of polypropylene (PP)/clay nanocomposites in dynamic shear and uniaxial extensional flow for blown film applications.

For preparation of PP nanocomposites, two different organoclays, with different aspect ratios and surfactants, before and after silane treatment via a wet process were used as the additives. In the case of organoclay with the greater interlayer packing of surfactants (Nanocor I.44P), the silanols reacted only at the nanolayer edges while in the other case with primary onium ion surfactants (Nanocor I.30P), the silanols entered the
interlayer galleries. The effect of reactive coupling in both cases was noticeably improved dispersion with thinner stacks of clay nanolayers. The uniaxial extensional viscosity of these melts displayed greater strain hardening and more so in the case of reactive coupling at both faces and edges despite the aspect ratio of this organoclay being significantly lower. Upon reprocessing, the nanostructure and strain hardening behavior were stable for nanocomposites with silylated I.44P while severe aggregation of nanoclays and drastic reduction of extensional viscosity were observed for nanocomposites with silylated I.30P. This was attributed to detachment of loosely held silanes from the gallery sites.

A dry, solvent-free process was also introduced for silane treatment. This approach was shown to lead to better penetration of the interlayer galleries of the I.44P organoclay by silanes than through the solvent based or wet process. As an additional advantage of this treatment, good thermal stability was maintained for silylated I.44P. This ensured its applicability for high temperature processing. The silylated I.44P nanoclay was then compounded with the compatibilizer to prepare masterbatch additives for letting down with a high molecular weight polypropylene. Blown films with a thickness of 25 μm were prepared with these compounds and exhibited elevated bubble stability and thickness uniformity. These films were also evaluated for mechanical properties and the transverse direction mechanical properties were much closer to those along the machine direction and hence much greater than the values for the base polypropylene film. In particular, the strain to failure in the transverse direction was significantly greater than for the base polypropylene film.
A linear viscoelastic model proposed by Sarvestani was applied to the dynamic shear rheology of PP nanocomposites prepared with non-silylated and silylated organoclays. The model described the dynamics of free chains and particle-attached chains that formed two different types of entanglements to account for the effects of attractive polymer-particle interactions on chain relaxation. The volume fraction of attached chains in different compounds was estimated from the dynamic shear moduli, along with the effect of particle attachment on slowing of the chain relaxation. The parameters revealed that silylation reduced the volume fraction of polymer chains attached to nanolayers, which was responsible for the lower dynamic storage modulus of nanocomposite with silylated I.44P compared to that with non-silyated I.44P.

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