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Characteristic Improvements of Nanocomposites using Polypropylene-grafted Nanosilica

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It is an important issue for the reinforcement of polymer nanocomposites to strengthen the interfacial connection between the matrix and filler. Annual production of polypropylene (PP) has exceeded 60 million tons in the world because of its versatile properties and wide range of applications, which was characterized by a number of advantages such as low cost, light weight (0.90 g/cm^3), high melting temperature (165°C, compared with other polyolefins), good processability, balanced mechanical properties, low environmental load (only carbon and hydrogen atoms) and so on. PP-based nanocomposites have attracted great attention in order to further expand its versatility and to explore a new specialty. However, PP-based nanocomposites is extremely challenging owing to the extreme inertness of PP against inorganic nanoparticles, in contrast to other polymers containing polar functional groups. Moreover, nanoparticles do not disperse well in PP but make large and compact aggregates, which result in marginal reinforcement as well as other problems like embrittlement, enhanced degradation, and so on. In order to overcome the compatibility problem, a variety of strategies have been proposed. In particular, Polymer-grafting method is a potentially versatile and scalable approach due to the direct applicability to the conventional melt mixing process, which aims at not only improved dispersion through organic modification and steric prevention of filler agglomeration but also better interfacial connection through interdiffusion and entanglement between grafted and matrix polymer chains. The select of grafted PP chain is the most excellent means for matrix. PP chain-grafted nanosilica (PP-*g*-SiO_2) can form a physical cross-linkage structure made by co-crystallization between the matrix and grafted chains, where SiO_2 nanoparticles bridge neighboring lamellae through the grafted chains (**Figure 1**). However, the effect of the physical cross-linkage is not investigated in detail. Hence, the purpose of this study clarifies influences of the physical cross-linkage on mechanical properties of PP/PP-*g*-SiO_2 nanocomposites.

Effects of physical cross-linkage on the tensile properties of PP-based nanocomposites were estimated using PP-*g*-SiO_2 having different molecular weights, grafted PP amounts and filler contents. PP-*g*-SiO_2 was synthesized by propylene polymerization, terminal functionalization and grafting reaction. After reaction, unhydroxylated Polymer is removed by hot filtration. Nanocomposite films were prepared by melt mixing and hot press.

In dispersion state, all PP/PP-*g*-SiO_2 nanocomposites improve the dispersion states compared with PP/SiO_2 nanocomposite due to improvement of the miscibility and the block of filler aggregation by grafted PP chains. The Young's modulus and tensile strength of PP/PP-*g*-SiO_2 improved up to 30% compared with pristine PP by physical cross-linkage. The dependence on the graft amount was totally different between the Young's modulus and tensile strength. It was suggested that the dispersion of SiO_2 nanoparticles dominated the Young's modulus. Tensile strength was improved by grafted amount rather than number of particles. As a consequence, I consider that characteristic improvements of PP-based nanocomposites are successes.

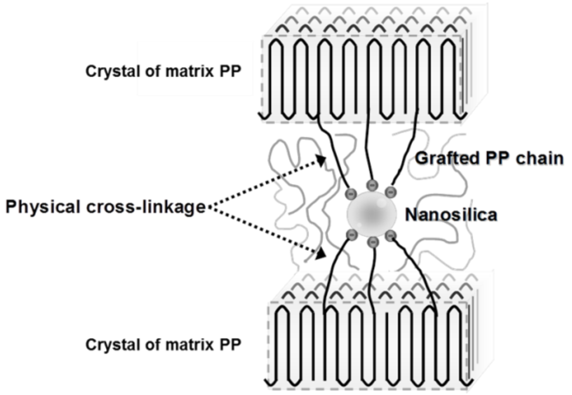

Figure 1. Structure of physical cross-linkage

Key Words: Polypropylene, Nanocomposite, Grafting reaction, Mechanical properties, Physical cross-linkage