Polypropylene/glass fiber/nanoclay hybrid composites: morphological, thermal, dynamic mechanical and impact behaviors

Normasmira A Rahman¹, Aziz Hassan¹, R Yahya¹, RA Lafia-Araga¹,² and PR Hornsby³

Abstract
Polypropylene/E-glass fiber/nanoclay were compounded with a twin-screw extruder and injection molded. Thermal, dynamic mechanical, and impact tests were carried out. Differential scanning calorimetry investigations showed that the incorporation of nanoclay into polypropylene/glass fiber composite shifted the melting temperature ($T_m$) to higher values. The degree of crystallinity ($X_c$) was strongly influenced by the presence of the glass fiber and nanoclay in the matrix. Dynamic mechanical analysis showed an increase in storage modulus ($E'$); indicating higher stiffness of the hybrid composites when compared to the glass fiber composites and the virgin matrix. From the tan δ curves, a strong influence of glass fiber and nanoclay content on the magnitude of tan δ$_{max}$ value was observed. Impact test showed a reduction in the critical strain energy release rate, $G_c$ for hybrid composites with higher nanoclay loading. The stress intensity factor, $K_c$ values showed insignificant effect with the presence of nanoclay and GF.

Keywords
Mechanical characterization, composites, nanostructured materials, fracture, nucleation

Introduction
Fiber-reinforced plastic (FRP) composites, with a wide variety of matrix polymers, have been developed as an alternative to thermoset fiber composites. Because of its well-balanced physical and mechanical properties, the relative ease of processing and its relative low cost,¹ polypropylene (PP), a semi-crystalline engineering thermoplastic) has many potential applications in the automotive and commercial products. Glass fiber (GF) reinforced polymers have been widely used in the automotive and aerospace industries because of their high strength and low-weight characteristics. However, due to high stress concentration and poor fiber-matrix adhesion, it has been shown, that incorporation of short GF (SGF) in PP increases the tensile modulus, yet decrease the tensile strength and impact toughness.² By contrast, Karger-Kocsis³ conducted a study on the dependence of the fracture and fatigue performance of polyolefins, related blends, and composites on their microstructural and molecular characteristics. The author reported that the fracture toughness and resistance of the related composites increases with increasing crystallinity up to a maximum, if other parameters such as lamellar thickness, orientation, amorphous layer, and tie molecules are constant.

Polymer nanocomposites based on exfoliated nanoparticles are a different type of composite material. They contain extremely small particles, with thickness in the range of 1 nm. In general, nanoparticles can significantly improve the stiffness, heat deflection temperature, dimensional stability, gas barrier properties,