Carbon nanofiber reinforced high modulus polypropylene filament

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Abstract: Polypropylene(PP) filament incorporating carbon nanofibre (CNF) has been spun using conventional fibre processing equipment. These filaments are drawn to high draw ratios using "Gradient Drawing" process. In case of PP filament, tand in DMA analysis shows a broad and shallow peak in the temperature range of -20° C to 40° C, where as nanocomposite filaments show a distinct tand peak at around 25oC. This may be associated with the oriented amorphous molecules surrounding the nanofibres in nanocomposite filaments. This observation is consistent with lower x-ray crystallinity of nanocomposite filament as 61%, as compared to PP filament crystallinity of 74%.

A relatively high storage modulus value of ~29 GPa is observed for the nanocomposite filament as compared to 20 GPa for PP. Reinforcing effect of CNF may be associated with orientation of these fibers during production of filament. Further, difference in thermal expansion coefficient of CNF and polymer molecules leads to CNF held tightly between polymer molecules during cooling after drawing process.

Tensile modulus, tenacity and elongation of highly drawn nanocomposite filament are 16.8 GPa, 0.77 GPa and 7.2% as compared to PP filament values of 16.4 GPa, 0.67 GPa and 4.5%. Gordeyev et al. has reported tenacity of 0.72GPa, modulus of 14.9 GPa and elongation at break of 10.3%, for polypropylene filament reinforced with vapor grown carbon fiber with a loading of 5%. In the present study, significantly superior properties in terms of modulus and tenacity have been observed with just one-percent addition of CNF.

Superior tenacity of nanocomposite and PP filaments is related to the gradient drawing system, which promotes fewer voids as compared to conventional drawing. Higher elongation at failure of nanocomposite filament of 7.2% as compared to PP filament of 4.5% can be associated with large percentage of oriented amorphous PP molecules and lower crystallinity.