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Tunable Electrical Conductivity of Polystyrene/Polyamide-6/Carbon Nanotube Blend Nanocomposites via Control of Morphology and Nanofiller Localization

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Abstract. The electrical conductivity and percolation behavior of polymer blend nanocomposites were investigated as a consequence of polymer-filler interaction and blend morphology. The nanocomposites were derived from melt compounding of carbon nanotubes (CNTs) in polystyrene (PS)/polyamide 6 (PA6) blends. The electrical conductivity of co-continuous PS/PA6 (50/50) blends stayed constant in the semi-conductive region (6.75×10^{-8} - 1.50×10^{-7} S·cm⁻¹) over a wide range of CNT loading (0.5-3.5 phr). Nevertheless, (50/50) blends presented higher electrical conductivity than PA6/CNT nanocomposites with the same effective CNT concentration. Contrary to common intuitions, at high loadings of CNTs, higher electrical conductivity was observed for the blends wherein the CNT-rich PA6 phase was in the form of dispersed droplet morphology rather than co-continuous one. For instance, at the CNT loading of 3.5 phr, the conductivity of blend with PS/PA6 volume ratio of (90/10) is approximately 4 orders of magnitude higher than co-continuous (50/50) blend. This observation is attributed to a two-level percolation mechanism (primary and secondary), as verified by optical and transmission electron microscopy. The primary percolation occurs by selective localization of CNTs in PA6 droplets due to their thermodynamic affinity for the PA6 phase. Once the PA6 droplets are impregnated with CNTs, the excess CNTs (at high loadings) localize in the PS phase and act as effective electrical bridges for the highly conductive PA6 droplets (secondary percolation).

Keywords: Carbon nanotube, Interfacial interaction, Selective localization, Morphology, Electrical conductivity, Polymer blend.

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