Processing of composites of polymers and carbon based nanoparticles

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Abstract

Despite almost two decades of research effort with regard composites of carbon nanoparticles and polymers, their widespread commercial exploitation has yet to be fully realised. This in the main is a consequence of the combined challenges of achieving effective dispersion and distribution of nanoparticles in polymer melts and of fully characterizing and modelling the interface between particle and polymer across the length scales. An appreciation of the parameters which govern nanoparticle dispersion during melt mixing has been studied intensively for only a small number of polymer/CNT systems and much less so for composites of polymers and graphene(GO). It has been proposed that CNT dispersion in polymer melts follows three distinct mechanisms; infiltration of the polymer melt into CNT primary agglomerates, agglomerate rupture and erosion of CNTs from agglomerate surfaces, all of which are governed by the melt temperature and the forces acting on the melt during mixing. Typically, the relationship between varying processing parameters, including screw speed, residence time, melt temperature, screw configuration, and nanoparticle dispersion is investigated using a combination of microscopic techniques and the extent of nanoparticle dispersion interpreted by assessing nanoparticle network formation studied using electrical and rheological techniques. Processing variables as well as thermodynamic considerations also play a role in the localization of CNTs in immiscible polymer blends. The majority of the published literature has focused on understanding the factors which effect nanoparticle dispersion during mixing. However, the as-extruded polymer carbon nanoparticle composite can then experience a second thermo-mechanical cycle as in injection moulding. Furthermore, secondary processing in the solid state and quasi-solid state, as in thermoforming and blow moulding, of composites of polymers and carbon nanoparticles has largely been ignored to date. Efforts are also on-going to improve nanoparticle dispersion by using a combination of processing techniques, including using a three roll mill after melt mixing in a twin screw extruder. The presentation will provide an overview of processing of composites and blends of polymers and carbon based nanoparticles, with a focus on carbon nanotubes.