

Abstract

High density polyethylene (HDPE) is widely used in our daily life due to its toughness and water-proof ability. However, its application is limited by its relatively low strength and permeability to oil. Since PA6 characterizes high strength and is oil-proof, blending HDPE with PA6 is an ideal route to obtain new material with multiple properties. Nevertheless, the blend of HDPE and PA6 displays two-phase morphology and inferior mechanical property, because the difference between the chain structure of HDPE and PA6 is so large that they are immiscible of each other. Due to its high modulus, strength and aspect ratio, carbon nanotubes (CNTs) are used not only to strengthen the material but also significantly toughen the material by inhibiting the initiation and propagation of cracks. So, in this thesis, we firstly functionalized carbon nanotubes and then controled the localization and dispersion of these carbon nanotubes to obtain nanocomposites with excellent toughness and strength. Furthermore, the effects of blending protocols, CNTs contents and interfacial tension on the microscopic morphology and macroscopic properties are also analyzed. The main results obtained in this work are listed as follows:

- 1) HDPE is a non-polar material while PA6 characterizes high polarity. Considering the fact that the amidogen groups of PA6 chains can react with carboxyl group and the fact that materials with similar plarity have better affinity, the CNTs are modified to achieve better affinity with PA6. Thus the pristine carbon nanotubes are refluxed in concentrated nitic acid to obtain functionalized multiwalled carbon nanotubes (FMWCNTs) by oxidizing the defects on the outer surface of mlutiwalled carbon nanotubes into carboxyl groups.
- 2) Different blending protocols are applied to selectively disperse FMWCNTs in different locations of the nanocomposites, and subsequently leading to different mechanical properties of the nanocomposites. It is found that when all the FMWCNTs are pre-dispersed in PA6, they tend to remain in PA6 phase of the nanocomposites. When all the FMWCNTs are pre-dispersed in HDPE, they tend to migrate to PA6 to achieve thermodynamic equilibrium. However, due to various factors such as, viscosity and blending time, only some of the

FMWCNTs migrate into PA6 phase, leaving the other FMWCNTs on the interphase. The localization of FMWCNTs can exert “bridging effect” on the interphase and effectively inhibit the initiation and propagation of cracks along the interphase. In the mean time, the interfacial localization of FMWCNTs can prevent the coalescence of dispersed PA6 phase as well, leading to smaller PA6 particles and easier percolation of stress field in the nanocomposites. So, it is desirable to pre-disperse all the FMWCNTs in HDPE.

- 3) The addition of Maleic anhydride grafted high density polyethylene (HDPE-MA) as compatibilizer can further alter the dispersion of FMWCNTs and phase morphology of the nanocomposites, leading to significantly strengthened/toughened effects. It is found that different blending protocols have profound influence on the mechanical properties of the nanocomposites. When FMWCNTs/HDPE/HDPE-MA is use as master-batch, the nanocomposite characterizes the highest toughness. The increase toughness originates not only from the fact that the carboxyl group on the FMWCNTs can react with the amidogen end group of PA6 and thus inducing more FMWCNTs locating on the interphase, leading to increased interfacial interaction but also from the fact that the interfacial localization of FMWCNTs decreases the particle size of PA6 and thus leading to easier percolation of stress field in the nanocomposites. When FMWCNTs/PA6 is used as master-batch, all the FMWCNTs selectively disperse in the PA6 phase, forming condensed FMWCNTs networks, which are able to greatly enhance the strength of the PA6 particles. Considering the fact the compatibilizer can help effectively transfer external stress onto the PA6 particles and the fact that the strength of the nanocomposite increase with increasing strength of the dispersed particles, it is reasonable to deduce that the strength of the nanocomposites will be greatly enhanced as well.
- 4) Adding different amounts of FMWCNTs induce phase inversion in the nanocomposites. For the binary blend of HDPE and PA6 (50/50), HDPE disperses as isolated particles in the PA6 matrix, because the viscosity of HDPE is much higher than that of PA6. When small amount of FMWCNTs are added, they tend to disperse evenly in the PA6 phase, and these nanocomposites display similar morphology as the binary blend. Further increasing the amount of FMWCNTs leads to phase transformation and the nanocomposite disperse typical co-continuous structure when 5 wt% of FMWCNTs are added. The rheology test reveals that FMWCNTs begin to exist as networks when the content of FMWCNTs becomes greater than

2 wt%. Besides, the carboxyl group on the FMWCNTs can react with the amidogen end group of PA6 and thus induce PA6 to disperse along the FMWCNTs network, and the resulting nanocomposite would exhibit co-continuous morphology. When the amount of FMWCNTs increases to 10 wt%, FMWCNTs cease to exist as network structure and aggregate into spherical agglomerates, inducing PA6 to disperse alongside it as dispersed particles, leading to phase inversion.