Fabrication Processes and Properties of Carbon Nanomaterials Filled Nanocomposites

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Abstract
Carbon nanomaterials including graphene and carbon nanotube (CNT) are promising fillers for composite materials to overcome the limitation of traditional reinforcements in composites due to their excellent mechanical and functional properties. In previous researches on carbon nanomaterial filled nanocomposites, limited improvement of properties have been shown because of strong agglomeration of the carbon nanomaterials and poor interfacial bonding between carbon nanomaterials and matrices. To solve these important issues, a new fabrication process, named “molecular level mixing process”, has been developed to fabricate carbon nanomaterials filled nanocomposites in order to maximize the effect of filler addition in various matrices. The molecular level mixing process to fabricate carbon nanomaterials filled nanocomposite powders is composed of several steps described in Fig. 1. As a first step, the carbon nanomaterials are functionalized by attaching functional molecular groups on surfaces. Second step is to fabricate a precursor carbon nanomaterial bonded with matrix ions induced by chemical interaction. Third step is to mix the carbon nanomaterial with matrix by nucleation and growth of matrix phase. Fourth step is the synthesis of nanocomposite powders, in which the carbon nanomaterial and matrix phase are homogeneously mixed together.

Homogeneous dispersion of carbon nanomaterials with strong interfacial bonding with matrices have been achieved by molecular level mixing process. Inorganic matrices nanocomposites filled with carbon nanomaterials, such as CNT/Cu, CNT/Al, Graphene/Al$_2$O$_3$, exhibit outstanding mechanical properties including strength, modulus and fracture toughness. Also, wide scope of possible applications as stretchable conductors, electrode for supercapacitor and organic photovoltaic materials are expected for polymer matrix nanocomposites filled with carbon nanomaterials, such as AgNW/Graphene/PDMS, CNT/carbon fibers and Graphene/P3HT:PCBM. It is suggested that the carbon nanomaterials filled nanocomposites are new emerging materials for multi-functional applications.
Fig. 1. Schematics depicting strategies and procedures for the molecular level mixing process, (a) functionalization of carbon nanotube, (b) molecular level reaction between the inorganic ions and the functional group on the surface of carbon nanotube, (c) nucleation and growth of inorganic phase on the surface on carbon nanotube, (d) synthesis of carbon nanotube/metal nanocomposite powders in which carbon nanotubes are homogeneously distributed in matrix.

References