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Short Communication

Characterization of mechanical properties of epoxy resin reinforced with submicron-sized ZnO prepared via in situ synthesis method

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ABSTRACT

In this paper, ZnO/epoxy composites with homogeneous dispersion were prepared via two simple steps: firstly, in situ preparation of zinc hydroxide ($Zn(OH)_2$)/epoxy from the reaction of aqueous zinc acetate ($Zn(Ac)_2 \cdot 2H_2O$) and sodium hydroxide (NaOH) at 30 °C in the presence of high viscosity epoxy resin; secondly, thermal treatment of the as-prepared $Zn(OH)_2$/epoxy hybrid into ZnO/epoxy composites. Meanwhile, the structure, composition and mechanical properties of the resultant products were successfully investigated. From the result of characterization we found that the composite had the optimal mechanical property at ZnO fraction of 5 wt.%. Compared to pure epoxy resin, the improvement of ultimate tensile stress, elongation at break, tensile modulus and flexural strength achieved about 40.84%, 24.35%, 27.27% and 51.43%, respectively. The crack arresting mechanisms included particle matrix debonding, plastic void growth, in the composites with a stronger interface, significant plastic deformation of the matrix around the well bonded particles. At the same time, the possible reactive mechanism of the preparation of ZnO/epoxy composite was discussed in this paper.

1. Introduction

Epoxy resin, which is a class of versatile thermosetting polymers, has been developed rapidly since invented, and are widely used in adhesive, electronic, wear resistance and light-emitting diode (LED) package due to the small volume shrinkage in curing and outstanding electrical performance. In some case, inorganic particles were dispersed in epoxy resin matrix due to enhance the physical properties such as mechanical strength. Ability to control good dispersion of particles in polymers is one key challenges to overcome for achieve optimal performance of these inorganic/polymer hybrids. Some studies reported the modified epoxy with different inorganic particles with directly embedding [1–8], inevitably, which would result in significant phase segregation owing to inorganic crystals often possess organophobic surface characteristics. Extensive research effort has been devoted to resolve the above question by surface modification of inorganic crystals through organic capping agents [6,9], by in situ polymerization of polymer/inorganic composites [10] or by in situ synthesis of inorganic crystals in polymers [11,12]. Each of the methods mentioned above can result in a better dispersion of inorganic crystals in polymers than direct melt mixing. However, it has some disadvantages such as organic capping agents resulting in add cost and reduce the potential performance of the composites.

ZnO is a self-activated crystal of hexagonal wurtzite structure with direct wide band gap energy of 3.37 eV at room temperature [13,14], and has strong excitonic emission in the ultraviolet range even at room temperature due to its large exciton binding energy of 60 meV which is significantly larger than other materials [15]. ZnO has wide application in various fields, such as short-wavelength light-emitting diode and room temperature UV lasing diode, field emission display, gas sensors and catalyst [16–24]. Therefore, it is important to prepare polymer/ZnO composites with easy processabilities [25–27].

In situ synthesis is an important method to prepared nanoscaled particles with well dispersion in the polymer matrix [28]. Sangermano et al. [29] reported that in situ synthesis of silver-epoxy nanocomposite was achieved by simultaneous photoinduced electron transfer and cationic polymerization processes. Singh and Khanna [30] successfully prepared silver nano-particles in polymethylmethacrylate (PMMA) using *N*, *N*-dimethylformamide (DMF) as a medium with excellent optical property. However, until recently in situ formation of well dispersed metal oxide nanoparticle/epoxy resin composites have been scarcely investigated.

In the present study, we introduced a novel approach of in situ synthesis of zinc hydroxide ($Zn(OH)_2$)/epoxy from the reaction of aqueous $Zn(AC)_2$ and NaOH taking place in epoxy resin/water emulsion. Whereafter, ZnO/epoxy composites were facilely

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