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Study on thermal and mechanical properties of nano-calcium carbonate/epoxy composites

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ABSTRACT

A study on evaluating the effect of nano-$CaCO_3$ particles on thermal and mechanical properties of epoxy resin cast was performed by TGA and mechanical tests. A silane coupling agent KH550 as an interfacial modifier was introduced into nanocomposites through preparing KH550/nano-$CaCO_3$ master batch. It is revealed that epoxy resin cast filled with nano-$CaCO_3$ particles represents higher thermal stability and mechanical strength. The improvement of thermal and mechanical properties is attributed to the surface modification of nano-particles, which can enhance the interfacial properties between nano-$CaCO_3$ fillers and epoxy resin. The mechanical properties of nano-$CaCO_3$/epoxy/carbon fibres composites based on the modified epoxy matrix are also enhanced.

1. Introduction

Epoxy resins are the most commonly used in a variety of applications due to their excellent properties, such as thermal stability, mechanical response, low density and electrical resistance. The important factors that influence their performance are the molecular structure, curing conditions and the ratio of the epoxy resin and the curing agents. However, because of its high cross-linked structure, epoxy resin exhibits poor resistance to crack initiation and propagation, which prevents its wider applications [1]. Toughness reinforcement of epoxy resin has attracted considerable attention. Studies have shown that performance of polymeric materials can be improved by introducing some small amount fillers (<5 wt.%) without impairing weight or processability of the composites [2–5]. In contrast to conventional microcomposites or macrocomposites which are characterized by reducing mechanical properties [6], the nanocomposites are stronger.

Nano-$CaCO_3$ is the cheap and commercially available, and has a low aspect ratio and a large surface area [7,8]. In addition, their low aspect ratio but large surface area could result in a strong interfacial interaction between filler and polymer matrix. Wu et al. [9] studied the mechanical properties of nanocomposites of poly(vinyl chloride)/calcium carbonate. They found the elongation at break, Young's modulus and impact strength increased with increasing the nano-$CaCO_3$ loading. However, few works were performed to investigate the effect of nano-$CaCO_3$ on the properties of epoxy matrix [10,11].

Nevertheless, invalidation of nano-particles is caused by the fact of agglomeration and inhomogeneous dispersion, which has motivated researchers to find a better way of gaining de-agglomeration and better dispersion. Techniques such as ultrasonication and ball milling have been used with some success [12,13]. Another approach is to control the bonding between the matrix and the fillers. This can be achieved by using coupling agents such as organofunctional silanes [2].

In this study, the effect of nano-$CaCO_3$ content on the thermal and mechanical properties of epoxy/nano-$CaCO_3$ composites was investigated. To give full play of nanoparticles, nano-$CaCO_3$ particles were pretreated by coupling agent KH550 to prepare KH550/nano-$CaCO_3$ master batch, and then they were mixed with epoxy to prepare epoxy cast and epoxy/fibres composites, respectively. As a result, the ternary nanocomposites represented an obvious improvement in thermal and mechanical performance.

2. Experimental

2.1. Materials

Commercially available difunctional diglycidyl ether of bisphenol-A (DGEBA, trade name: E-51) with an epoxy value of 0.48–0.54 was purchased from Shanghai Research Institute of Synthetic Resins. The curing agent 4,4′-diaminodipheylsulfone (4,4′-DDS) was obtained from Sinopharm Chemical Reagent Co. Ltd., China. A KH550 silane coupling agent (γ-aminopropyl triethoxy silane),

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