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Surface Modification of Fumed Nanosilica with Epoxy Molecule

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Abstract

Fumed nanosilica was surface modified by epoxy molecules using imidazole as catalyst. The structural properties of the modified products were investigated by Fourier Transform Infrared spectra (FTIR) and Proton Magnetic Resonance Spectroscopy (^{1}H-NMR). The comparison of FTIR and ^{1}H-NMR spectra of pure fumed silica and the modified silica, suggests that epoxy molecules could be chemically bonded onto the silica surface. This is supported by Thermogravimetri Analysis (TGA) thermograms of modified sample. FTIR spectra of the waste sample indicate that the surface modified silica surface was free from excess chemical and catalyst.

Keywords: Fumed Nanosilica, Modified Silica, Epoxy Resin, Nanocomposite.

Introduction

Advancement in computerization and information technology systems, has encourage many researchers to study and improve the properties of integrated circuit, (IC), (device manufacturing) to meet the industrial requirements such as superior thermal stability. Epoxy Molding Compound (EMC), most popularly used as encapsulation materials for semiconductor device to provide protection for IC device is well known for its balance properties including good heat, solvent, moisture and chemical resistance and adhesion to most of the substrate [1-5]. However, it is established that epoxy resin cannot be used alone to achieve the high performance applications especially for the electrical applications because of low thermal properties. As a common practice, inorganic fillers was added to overcome these problems [6,7].

Fumed nanosilica based materials are normally used because of its low cost, no interior surface and have been produced for decades. It has many applications such as rheological controlling agent in epoxy resin systems, as fillers in toothpaste and car tires and as starting material for optical fibers [8]. The interaction between organic and inorganic phase is expected to improve the properties of the nanocomposites. To achieve this objective, it is suggested that the silica surface need to be modified using organic molecule. The filler modification not only will enhance interface interaction between components but also improve the dispersibility of the filler in organic media which are required during applied loading on the composite [6, 7, 9-13].

In this paper, fumed nanosilica was surface modified by epoxy molecules using imidazole as catalyst. The effectiveness of washing techniques was investigated using FTIR and TGA. The occurrence of the reaction between silanol and epoxy group was confirmed by FTIR and ^{1}H-NMR analysis.

Experimental

Materials

Nanoscale silica particles used was fumed nanosilica (99.8 % purity), manufactured by Sigma. The mean particle sizes are in range of 15-30 nm.

A diglycidyl ether of bisphenol A (i.e epoxy resin) was used as surface modifier and manufactured by Durcupan ACM. The concentration of epoxy resin was varied from 20 to 80 % by percentage weight of silica.

Reaction catalyst used was imidazole and manufactured by Fluka with activating temperature at 100 °C. Concentration of imidazole is 25 wt % (based on weight of silica used).

Sample preparation

The fumed silicas and epoxy resin were dispersed in 50 ml of toluene in the presence of imidazole. The mixture was then refluxed at 100 °C for 2 hours. Later, centrifuge washing techniques were conducted three times using