Iran Polym J (2013) 22:377–383
DOI 10.1007/s13726-013-0137-3

ORIGINAL PAPER

Preparation and properties of KH550-Al_2O_3/PI–EP nanocomposite material

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Received: 13 November 2012 / Accepted: 13 February 2013 / Published online: 5 March 2013

Abstract First, polyimide (PI)–epoxy resin (EP) polymer matrix was prepared from 3,3′-diethyl-4,4′-diamino diphenyl methane (DEDADPM), benzophenone tetracarboxylic acid dianhydride (BTDA) and epoxy resin (E-51), through thermal imide process. Then, the nanometer alumina (Al_2O_3) modified by the coupling agent, (3-aminopropyl)triethoxysilane (KH550), was doped into the PI–EP polymer matrix, using an in situ sol–gel method to prepare a series of KH550-Al_2O_3/PI–EP nanocomposite materials based on different KH550-Al_2O_3 contents. Fourier transform infrared spectroscopy (FTIR) indicated that in the presence of chemical reaction between poly(amic acid) and epoxy resin, an imide ring was formed, the thermal imidization reaction of the materials was completed and the KH550-Al_2O_3 had doped into the PI–EP polymer matrix. The heat-resistance, dielectric specification and mechanical properties of KH550-Al_2O_3/PI–EP nanocomposite materials were evaluated. The results showed that the decomposition temperatures were ranged between 438 and 450 °C, dielectric constant and dielectric loss were in the range of 3.32–3.71 and 1.5×10^{-3}–2.5×10^{-2}, respectively, and they all increased with the increase of KH550-Al_2O_3 content (0–10 wt%), but the shear strength first increased and then decreased, attained its maximum value of 10.64 MPa at 8 wt%, which was about 119 % higher than that of undoped material. The adhesive forces of nanocomposite materials were all at higher level (one or two levels). Thus, the overall performance of KH550-Al_2O_3/PI–EP nanocomposites was the best when the doping amount of KH550-Al_2O_3 was 8 wt%. The properties such as high heat-resistance, dielectric properties and ready attachment of impregnating varnish to steel plate with very high strength fully met the necessary requirement.

Keywords Polyimide · Epoxy resin · Nano-Al_2O_3 · Synthesis

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Introduction

In the past three decades, polyimides (PI) have gained wide popularity as high performance polymers because of their high thermal stability, excellent mechanical properties, good chemical resistance and low dielectric constant [1, 2]. Therefore, they have been widely utilized in microelectronic industry such as in semiconductor integrated circuit (IC) packaging and buffer coating layer applications. With the rapid development of advanced IT technology, people have increasingly put forward high expectations to modify these materials. The conventional polyimide does not completely meet the requirements of fine performance and further miniaturization of electronic devices, due to the disadvantages of polyimide as insulation adhesive and dipping paint application due to low solid content and toughness, shear strength and bad adhesion grade, with high processing temperature [3]. Epoxy resins (EP) have excellent adhesive characteristics, good mechanical properties, high cohesion and highly efficient mixing properties. However, the epoxy adhesives for most inorganic non-metallic materials, metals and polar polymer materials