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ORIGINAL PAPER

Mechanical and thermal properties of epoxy-POSS reinforced-(biphenyl diol formaldehyde/epoxy hybrid resin) composites

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Abstract To enhance the properties of epoxy composites, the biphenyl diol formaldehyde resin (BPFR) and glycidyloxypropyl polyhedral oligomeric silsesquioxane (G-POSS) were synthesized and used for modification of fiber-glass reinforced composites of epoxy resin (ER). The BPFR was employed to cure epoxy resin with different G-POSS contents and the laminates of fiber-glass reinforced hybrid composites prepared from BPFR, ER and G-POSS. The dynamic mechanical properties, thermal properties, mechanical and electrical properties of the hybrid composites were characterized by dynamic mechanical analyzer, thermogravimetric analyzer and electroproperty detector. The results showed that the T_g of the composites is increased with the addition of G-POSS. When the content of G-POSS is 5 wt%, the tensile and impact strength of the hybrid composites are 249.87 MPa and 63.83 kJ/m^2, respectively, which are all 30 % higher than those of non-added composites. At G-POSS content of 7 wt%, T_g of the material is 9.6 °C higher than pure BPFR/ER composite, and the initial decomposition temperature, T_{id}, is enhanced by about 29 °C. Dielectric constant, ε, and dielectric loss, tanδ, of the hybrid composites are between 0.53–0.7 and between 0.004–0.012, respectively.

Keywords Epoxy resin · Biphenyldiol formaldehyde resin · Polyhedral oligomeric silsesquioxane · Mechanical property · Thermal degradation kinetics

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Introduction

Epoxy resins (ER) are high-performance thermosetting polymers, which have excellent adhesion, corrosion resistance, insulation, high mechanical strength, good electrical insulation and compatibility with a great number of materials [1]. It is widely used in adhesives, coatings, electrical insulating materials and composites, and is an indispensable basis for industrial materials. However, epoxy resin after curing is usually more brittle, and its fatigue resistance, heat resistance, impact strength are relatively poor, and it is also difficult to meet the requirements of modern engineering technology and applications. To improve the toughness and strength of the epoxy materials, the co-blending and co-curing with other polymers are used [2–5]. The properties of epoxy resin are directly affected by the structure and properties of the curing agent. All the commercialized curing agents of the epoxy resins can be divided into three basic categories: amine type (especially aromatic and aliphatic amines), anhydride type and polymer type (polyamide and phenol resin, etc.) [5, 6]. The materials cured by polymer have good physical and mechanical properties which usually combine both the properties of epoxy resin and polymeric reagent.

Phenol–formaldehyde resin (PFR) is an excellent thermosetting resin which has good mechanical properties, flame retardancy and heat resistance; it has been used in preparing fiber-glass reinforced laminates, molding compounds, insulation materials and adhesives; especially in the high-technology fields, such as spaceflight, rocketry, etc. [7]. PFR can also be used as curing agent of epoxy resin, which has better thermal properties than the phthalic anhydride-cured epoxy, with a higher glass transition temperature (T_g) and a higher thermal decomposition temperature [8, 9]. By changing the ratio of phenol and