



Perforative silica microsphere-modified phenolphthalein-based poly(arylene ether sulfone) composites: tensile and thermal properties

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Abstract

Perforative silica microspheres (PSMs) were prepared by an emulsion method coupled with sol–gel technology and phase separation. Next, phenolphthalein-based poly(arylene ether sulfone)/PSM composites (PES-C/PSM) were fabricated. PSM was characterized by scanning electron microscopy (SEM) and the Brunauer–Emmett–Teller (BET) method. The as-synthesized PSM exhibited a spherical shape with an external diameter of 2–10 μm , surface area of 166.5 m^2/g and pore volume of 1.35 cm^3/g . SEM and energy-dispersive spectroscopy (energy-dispersive spectroscopy) were used to characterize the morphology and the composition of the composite, respectively. Both SEM and energy-dispersive spectroscopy results revealed that the PES-C polymer chains penetrated into the PSM pores. In addition, the effect of PSM weight content on the mechanical properties and thermal stability of the composites was characterized by tensile tests and thermal analysis, respectively. A 19% increase in tensile strength and a 29% increase in breaking elongation of PES-C were achieved by the addition of 0.50 wt% PSM. Moreover, the thermal oxidative stability of PES-C was remarkably improved with the incorporation of PSM. Compared with pristine PES-C, the final degradation temperature was enhanced by 42 °C at 1.0 wt% PSM loading. Our studies have indicated that PSM is a kind of promising reinforcement for improvement of tensile and thermal properties of engineering plastics.

Keywords Tensile properties · Thermal properties · PES-C · Perforative silica microsphere · Composites

Introduction

Phenolphthalein-based poly(arylene ether sulfone) (PES-C) is an important commercialized engineering thermoplastic polymer with excellent mechanical properties, thermal and environmental stability, and good solubility in a few polar aprotic solvents [1]. PES-C and its derivatives have been extensively used as membranes for gas permeation [2, 3], adhesion [4, 5], ultrafiltration [6] or nanofiltration [7, 8], fuel cell [9–11] and ion exchange reactions [12]. Besides, PES-C can also be used as modifier for the mechanical and thermal properties of thermoset polymer composites, such as epoxy composites [13]. However, the introduction of cardo group into the backbone increased the rigidity of main chain and the brittle fracture problem limited the further application [14]. One simple way to reduce the brittle fracture problem

of the PES-C is to blend it with a thermoplastic polymer. Nevertheless, adding thermoplastic polymer in PES-C usually lowers the T_g of the modified PES-C. For example, the T_g of PES-C was decreased by 20 °C with the addition of 25 wt% of a thermotropic copolyester [15].

Impact resistance and fracture toughness of PES-C have been improved by addition of a thermoplastic polymer-modified PES-C, such as poly(phenylene sulfide) (PPS) [14] or thermotropic liquid crystalline polymer (LCP) [15, 16]. However, LCP or PPS addition into PES-C usually leads to a low T_g that adversely affects the working temperature of the modified PES-C. The addition of high-performance inorganic filler is one approach to develop reinforced PES-C composites. Up to now, many types of inorganic fillers, such as carbon fabrics [17], carbon nanotubes and graphene materials [18–20], phosphotungstic acid [21], zeolite [22], WS_2 [23], SiO_2 nanoparticles [24] and silsesquioxanes derivative [25], have been applied to improve the mechanical and thermal properties of PES-based materials. The tensile strength and T_g of PES were, respectively, increased by 2.34 MPa and 2.72 °C with the

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