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ORIGINAL PAPER

Reinforcement of polymethyl methacrylate with silane-treated zinc oxide nanoparticles: fire retardancy, electrical and mechanical properties

M. Ameen Khan[1] · G. M. Madhu[2] · R. R. N. Sailaja[1]

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Abstract Polymethyl methacrylate (PMMA)/zinc oxide (ZnO) composites were prepared using melt mixing process. A nano ZnO-treated with aminopropyl triethoxysilane (APTS) was used as reinforcing particles. PMMA composites were obtained with different ZnO loadings of 0, 0.5, 1 and 2 parts by weight. This research was focused on determination of the influence of different loadings of silane-treated ZnO particles on the morphology, electrical, mechanical and flammable properties of the PMMA composites. Addition of ZnO to the PMMA composite was observed to enhance the thermal properties and char formation. The results from cone calorimeter showed 21% reduction in the peak heat release rate for the composite loaded with 1.5 wt% of ZnO as compared to that of neat PMMA. The surface resistivity, volume resistivity and EMI shielding properties of the composites as a function of ZnO loading were estimated. The results showed that the surface and volume resistivity of the composites reinforced with ZnO particles decreased and the EMI shielding increased almost linearly with increasing ZnO volume content. However, the tensile strength of the composites showed a slight decrease with increase in ZnO content. The SEM micrographs and AFM images showed dispersion of ZnO particles in the PMMA matrix. The nanoparticles were distributed evenly on the surface. Nevertheless the pockets of agglomerates could be seen at higher ZnO loading level.

Keywords Zinc oxide · APTS · Polymethyl methacrylate · Mechanical properties · Thermal properties · Electrical properties

Introduction

The inclusion of nanoparticles into polymers imparts and enhances the properties of the base matrix by improving mechanical, optical or fire retardant characteristics. PMMA is one such polymer, which is being extensively used for a wide variety of applications owing to its optical transparency, good mechanical strength and ease of moldability. Zinc oxide (ZnO) also has gained very much attention owing to its antibacterial properties, catalysis activity and ultraviolet/infrared absorption characteristics. The nanoparticles of ZnO have high surface energy and area and thus can be used as filler in polymer matrices [1]. It is well known that a composite comprised of an organic matrix like PMMA and inorganic nanoparticles leads to products with improved mechanical, thermal, fire retardant, electrical and optical properties [2]. Enhanced wear properties, modulus and strength values have also been obtained by incorporating ZnO nanoparticles in ABS resins [3]. An optimal loading of ZnO nanoparticles in poly (styrene-*co*-acrylonitrile)/PMMA has been found to increase modulus and impact strength [4]. ZnO nanoparticles were used as reinforcement in commonly used thermoplastics such as PP, PE and their binary blends with elastomers. It was found that the stiffness and strength improved while the coefficient of friction reduced due to the addition of nano-sized ZnO [5]. Improved UV and thermal stability have been obtained by adding ZnO nanoparticles in PMMA as reported by Anzlovar et al. [6]. Similar observations have been reported by Tang et al. [7] for methacrylic acid-modified ZnO nanoparticles blended

✉ R. R. N. Sailaja
Sailajab@teri.res.in

[1] The Energy and Resources Institute (TERI), SRC, Bangalore 560 071, India

[2] Department of Chemical Engineering, M.S. Ramaiah Institute of Technology, Bangalore, India