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Cost efficient PMMA/NG nanocomposites for electromagnetic interference shielding applications

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Abstract

Cost-efficient polymethylmethacrylate/exfoliated nanographite (PMMA/NG) nanocomposites were prepared through the melt blending technique. The crystalline size of NG in nanocomposites was estimated using Scherrer's formula and was found to be in the range of 42.4–50.6 nm. Scanning electron micrographs showed the homogeneous dispersion of NG in the PMMA matrix. The thermal degradation temperature (T_d) of nanocomposites was found to rise monotonically with increase in the loading of NG. Differential scanning calorimetry measurement showed a significant improvement in glass transition temperature (T_g) from 97.2 °C for neat PMMA to 106.4 °C for 4.0 wt% PMMA/NG nanocomposites. DC electrical conductivity measurement revealed that the prepared nanocomposites exhibited a low percolation threshold of 0.45 vol%. The *s*-parameters (S_{11} and S_{21}) were measured through vector network analyser and were explored in the estimation of electromagnetic interference (EMI) shielding effectiveness (SE). The EMI SE of 19.2 dB (~ 99% attenuation of incoming microwave (MW) power) was attained in the 4.0 wt% PMMA/NG nanocomposite at 12.7 GHz MW frequency. Moreover, the observed broadband EMI SE spectra indicate that the prepared nanocomposites can be employed in lightweight and low-cost commercial EMI shielding applications.

1. Introduction

In recent years, undesirable electromagnetic interference (EMI) has reached an inescapable level of disturbance due to the resurgence of and revolution within electronics industries. For the proper functioning of electronic devices, it is necessary to shield them against incoming contaminating EM signals, especially in the microwave (MW) frequency range [1–4]. In the proto-technological period of communication, metals were selected as the most physically reliable EMI shielding candidates owing to their high electrical conductivity and ability to reflect MW radiation. In the present day, metallic EMI shielding is discontinued for technological and compatibility reasons (its heavy weight, lower rigidity and high environmental sensitivity) [5]. With the objective of improving the shielding performance and achieving better compatibility, polymer composites filled with conducting materials are appreciated in MW shielding applications as they offer high flexibility, light weight and low cost [6].

The EMI shielding effectiveness (SE) parameter determines the shielding ability of a polymer composite against incoming EM radiation, and mainly depends on its physical parameters, e.g. electrical conductivity, dielectric constant, and volume density of the conducting filler. In literature reports, carbon-based fillers such as graphite, graphene, graphene oxide (GO), carbon nanotubes (CNTs) and expanded graphite (EG) have proven their superiority over metals due to their low density, large specific surface area, easy processing, high electrical conductivity and low percolation threshold [1, 2, 8–13]. Yu *et al* reported a percolation threshold of 1–2 wt% in polyphenylene sulfide (PPS)/CNT composites [14]. Pang *et al* achieved an electrical conductivity of 0.04 S m^{-1} at only 0.62 vol% of graphene in a polyethylene matrix [15]. Zhan *et al* prepared graphene/rubber composites

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