Article

Thermal, Mechanical, and Morphological Characterisations of Graphene Nanoplatelet/Graphene Oxide/High-Hard-Segment Polyurethane Nanocomposite: A Comparative Study

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Abstract: The current work investigates the effect of the addition of graphene nanoplatelets (GNPs) and graphene oxide (GO) to high hard-segment polyurethane (75% HS) on its thermal, morphological, and mechanical properties. Polyurethane (PU) and its nanocomposites were prepared with different ratios of GNP and GO (0.25, 0.5, and 0.75 wt.%). A thermal stability analysis demonstrated an enhancement in the thermal stability of PU with GNP and GO incorporated compared to pure PU. Differential Scanning Calorimetry (DSC) showed that both GNP and GO act as heterogeneous nucleation agents within a PU matrix, leading to an increase in the crystallinity of PU. The uniform dispersion and distribution of GNP and GO flakes in the PU matrix were confirmed by SEM and TEM. In terms of the mechanical properties of the PU nanocomposites, it was found that the interaction between PU and GO was better than that of GNP due to the functional groups on the GO's surface. This leads to a significant increase in tensile strength for 0.5 wt.% GNP and GO compared with pure PU. This can be attributed to interfacial interaction between the GO and PU chains, resulting in an improvement in stress transferring from the matrix to the filler and vice versa. This work sheds light on the understanding of the interactions between graphene-based fillers and their influence on the mechanical properties of PU nanocomposites.

Keywords: high hard-segment polyurethane; graphene nanoplatelets; graphene oxide; nanocomposites; thermal stability; mechanical properties

1. Introduction

It is critical to design high-performance polymer nanocomposites by achieving a uniform dispersion of nanofillers and strong interfacial adhesion between nanofillers and polymer matrices in nanocomposite systems [1–3]. Recently, many researchers have focussed their attention on the use of various types of nanofillers such as graphene, carbon nanotubes, and nanoclays, among others [4–6]. Nanocomposites' performance depends on the substantial features of the nanofiller (the geometrical dimensions, surface area, aspect ratio, etc.) and the dispersion/distribution state of the nanofiller, as well as nanofiller–nanofiller and nanofiller–polymer interactions [5,7]. Poor dispersion and weak interfacial bonding still pose a challenge in the design of effective carbon nanofiller–polymer matrix nanocomposites [8].

Polyurethanes (PUs) are semicrystalline copolymers consisting of alternating hard and soft segments [9–12]. Most PUs are formed from polyether/polyester polyols along with