

Viscoelastic changes in chlorinated butyl rubber modified with graphene oxide

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Abstract The glass–rubber transition region in multiple component systems is significant for studying the slow relaxation processes in amorphous polymers. It is the first time that graphene oxide (GO) is added into chlorinated butyl rubber (CIIR) to study the effect of GO on different relaxation processes of CIIR. We aimed to give a possible insight to the molecular relaxation behaviors of CIIR/GO nanocomposites. In this study, GO was synthesized by a revised Hummers method, and it was incorporated with CIIR at different contents of 0, 1, 2, 3 and 5 phr (parts per hundred rubber). The structure of GO and CIIR/GO nanocomposites was studied by Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), attenuated total reflectance-Fourier transform infrared (ATR-FTIR), scanning electron microscopy (SEM) and transmission electron microscope (TEM). Bound rubber was adopted to study the interfacial interaction between GO and CIIR. Differential scanning calorimetry (DSC) and dynamic mechanical analysis (DMA) were also performed. Since there were many conflicting results on the effect of nanoparticles in relation to the glass transition temperature (T_g) of polymer matrixes in correlative literature, we investigated the effect of GO on that of CIIR. The T_g determined by DSC shows slight shifting. However, the

maximum and the shoulder of $\tan \delta$ both shift to low temperatures. In addition, GO increases the coupling effect of CIIR, resulting the shoulder merged with the maximum. A mechanism, though still needs to be further refined, has been proposed to interpret the contradictory results in our case.

Keywords Glass–rubber transition · Segmental dynamics · Chlorinated butyl rubber · Graphene oxide · Slow relaxation processes

Introduction

Research works on glass–rubber transition are not only of great scientific importance but of practical interest for the development of damping materials. However, there are still open issues in the theoretical and experimental fields on this subject [1]. In glass–rubber transition region, the segmental dynamics modes change from local segmental motions (α processes) to slow relaxation processes (α' processes). The first mode is well known as the glass transition, while the latter is not totally understood since 1953 [2]. Ngai et al. [3, 4] proposed the coupling model to explain the thermorheological complexity in glass–rubber transition region, and they indicated that glass–rubber transition region consists of at least three segmental dynamics modes, namely, local segmental motion, Rouse mode, sub-Rouse mode. As described by coupling model, Rouse mode (motion of sub-molecular Gauss chains) and sub-Rouse mode (motion of those units which are longer than segments and shorter than sub-molecular Gauss chains) compose the slow relaxation processes (α' processes) [5]. Some relevant studies showed that different modes have different responses to external factors, such as temperature and frequency. These phenomena are ascribed

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