

Preparation and characterization of carboxylated styrene butadiene rubber (XSBR)/multiwall carbon nanotubes (MWCNTs) nanocomposites

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Abstract This study deals with the preparation of carboxylated styrene butadiene rubber (XSBR)/multiwall carbon nanotubes (MWCNTs) nanocomposites prepared in the latex form by means of a ball mill. Two types of CNTs, i.e., non-functionalized and OH-functionalized (CNT–OH) were used. The rheological properties, FTIR spectrums, SEM micrographs and stress relaxation experiments were exploited to evaluate the resulting nanocomposites. For a given frequency, both the viscosity and storage modulus increased as the concentration of CNT was augmented with the greatest value for the nanocomposites loaded with CNT–OH. The viscosity of nanocomposites exhibited a shear thinning behavior throughout applied frequency and indicated a power law index of about $n = 0.22$. Nanocomposite ATR analyses revealed the presence of physical interaction of H-bonding type between hydroxyl group of CNT–OH and carboxyl group of XSBR for XSBR–CNTOH nanocomposites. A mechanism based on the chemistry of medium was proposed to explain the development of H-bonding. SEM micrographs confirmed the uniformity of carbon nanotubes dispersion in the resulting microstructure. A two-step innovative stress relaxation experiment was performed on the prepared nanocomposites through which the resulting microstructure of nanocomposites was further explored. The relaxation behavior of nanocomposites (both in first and second steps) were modeled and well predicted using Prony series and the parameters of generalized Maxwell equation for stress relaxation, τ_i and g_i were computed, as well.

Keywords Carboxylated styrene butadiene rubber · MWCNT · Rheological properties · Relaxation behavior · Microstructural characterization

Introduction

Polymer nanocomposites are a progressively large category of hybrid materials. Since the introduction of carbon nanotubes (CNTs), their nanocomposites have attracted an immense attention [1, 2]. Due to the unique optical, electrical, rheological and mechanical properties they are introduced to the polymer matrix. However, even after two decades of research, the use of CNTs as an established reinforcing agent has been extremely limited. The arising restrictions are mainly due to difficulties associated with the dispersion and breakup of the bundles of CNT self-assemblies during processing and the poor interfacial interaction between CNT and macromolecular chains of polymer matrix.

As a result of strong van der Waals forces resulting from high specific surface area and small size, CNTs have tendency to agglomerate and form clusters which are hard to be broken by normal mixing apparatus. In fact, the key challenge is to obtain a homogeneous dispersion of CNT in the matrix. To do so and to exploit the exclusive advantages of this material, the aggregates should be broken. The eventual result in the enhancement of the interfacial bonding leads to prevent slippage. The assessment of CNT dispersion is another obstacle of this field.

Due to the nano size dimension, optical microscopy methods cannot be helpful to characterize these materials. Electronic microscopes are frequently used for this issue; however, they show just a scant part of a sample rather than the whole bulk. Hence, the results could be deceptive.

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