

Nanoconfined segmental dynamics in miscible polymer blend nanocomposites: the influence of the geometry of nanoparticles

Ehsan Chehrazi · Nader Taheri Qazvini

Received: 7 June 2012 / Accepted: 11 May 2013 / Published online: 30 May 2013
© Iran Polymer and Petrochemical Institute 2013

Abstract The influence of nanoconfinement on segmental relaxation behavior of poly(methyl methacrylate) and poly(styrene-*ran*-acrylonitrile) miscible blend and its nanocomposites with spherical and layered nanoparticles have been investigated. Dynamic mechanical analysis was employed to examine the effect of geometry of nanoparticles on the temperature dependence and relaxation function breadth of segmental dynamics (α -relaxation) in the glass transition region. The maxima of the loss modulus curves were used to fit to the Vogel–Fulcher–Tamman equation to describe the temperature dependence of the characteristic relaxation times. Furthermore, the T_g -normalized semi-logarithmic Arrhenius plots (fragility plots) were exploited to indicate the changes in cooperative segmental motions across the glass transition. The master curves for relaxation modulus were also constructed for each sample as a function of time using the time–temperature superposition principle. The investigated nanocomposites showed a narrower segmental dispersion in the glass transition region compared to the neat systems. The relaxation modulus master curves were fitted by the

Kohlrausch–Williams–Watts (KWW) function. It was observed that the distribution parameter of segmental relaxation time increased with addition of nanoparticles which was correlated with a decrease in fragility index. In addition, the increase of the KWW distribution parameter (β_{KWW}) for spherical silica nanocomposites was less than that for nanocomposites prepared with layered silicates (organoclay).

Keywords Glass transition · Nanoconfinement · Nanocomposites · Segmental dynamics · Polymer blends

Introduction

Blending of two or more polymers is a novel technique to obtain balanced properties for a specific application [1, 2]. Recently, nanoscale fillers have been extensively used for preparing nanocomposites having excellent processability and mechanical properties compared with the conventional filler-based polymer composites [3]. Although polymer/nanoparticle nanocomposites have been widely studied by many researchers, there is not much literature on the copolymer/homopolymer/nanoparticle nanocomposites [4–6]. Interactions in polymer blend nanocomposites are more complicated as compared to homopolymer nanocomposites, because of more interfaces involved in these materials. Furthermore, modification of polymer blend properties depends mainly on the miscibility behavior of the polymer pair used in polymer blend nanocomposites [7].

From a fundamental point of view, the structure and properties of glassy polymer systems are controlled by the segmental motions and relaxation dynamics in the glass transition region [8]. Therefore, the study of the

E. Chehrazi
Department of Polymer Engineering, Amirkabir University of Technology, Mahshahr Branch, Mahshahr, Iran

N. Taheri Qazvini (✉)
Polymer Division, School of Chemistry, University College of Science, University of Tehran, Tehran, Iran
e-mail: ntaheri@khayam.ut.ac.ir

N. Taheri Qazvini
Biomaterials Research Center (BRC), University of Tehran, Tehran, Iran