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Creep and recovery of polypropylene/carbon nanotube composites

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ABSTRACT

The creep and recovery of polypropylene/multi-walled carbon nanotube composites were studied. It was found for thermoplastics in general that the creep strain reduces with decreased temperature, and with enhanced content of carbon nanotubes. The incorporation of nanotubes improved the recovery property remarkably, especially at high temperature. The unrecovered creep strain of nanocomposites with content of 1 and 2.8 vol.% carbon nanotubes decreased by 53% and 73% compared to that of polymer matrix. To understand the mechanisms, the Burger's model and Weibull distribution function were employed since the variations in the simulating parameters illustrated the influence of nano-fillers on the creep and recovery performance of the bulk matrix. To further study the recovery properties, the particular contribution of each Burger's element to the total deformation was obtained and the recovery percentage was calculated. The time–temperature–superposition-principle was applied to predict the long-term creep behavior.

1. Introduction

Polymer nanocomposites have gained enormous interests in science and engineering during the past decades due to their unique properties. Nanoparticles which may be dispersed on nanoscale can influence material properties more efficiently compared to micro-particles with the same volume content. Mechanical, magnetic, and electrical properties (Alig et al., 2007; Bao et al., 2008; Kanagaraj et al., 2007; Song et al., 2006; Zhang et al., 2010) of polymer nanocomposites have been extensively studied nowadays. For applications, many other performances, such as flame retardancy and gas permeability, are important issues.

Creep, as a time and temperature dependent phenomenon, is of importance for material applications requiring long-term durability and reliability (Aifantis, 1987; Krempl and Khan, 2003). Some studies on the creep performance of various materials were carried out, and the related modelings were developed accordingly (Barai and Weng, 2008). Creep deformation which causes by poor dimensional stability of thermoplastics, as an inherent defect, becomes a more serious problem (Morra et al., 2009). The effects of filling spherical nanoparticles and nanoclay into various thermoplastics associated with improved creep resistance have become one of the important issues in polymer nanocomposites. However, both positive and negative influences of fillers on the creep resistance of polymers have been reported. Some researchers (Ganß et al., 2007; Pegoretti et al., 2004; Vlasveld et al., 2005) obtained that the creep compliance could be decreased in thermoplastics filled with nanotubes and layered silicates. It was found that (Yang et al., 2006a,b) a dramatic increase of the creep resistance by adding various kinds of nanofillers, i.e. spherical particles and nanoclay, under different stress levels. Starkova et al. (2008) reported

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