



Thermophysical and rheological behavior of polystyrene/silica nanocomposites: Investigation of nanoparticle content

Hossein Salehi Vaziri^{a,*}, Iraj Amiri Omaraei^a, Mohamadreza Abadyan^b, Mehrzad Mortezaei^c, Nariman Yousefi^d

^a Faculty of Materials and Manufacturing Processes, Malek-Ashtar University of Technology, Tehran, Iran

^b Mechanical Engineering Group, Islamic Azad University, Ramsar Branch, Ramsar, Iran

^c Islamic Azad University, Markazi Branch, Tehran, Iran

^d Polymeric Materials Research Group, Department of Materials Science and Engineering, Sharif University of Technology, Tehran, Iran

ARTICLE INFO

Article history:

Received 28 September 2010

Accepted 6 January 2011

Available online 18 January 2011

Keywords:

Extrusion

Polymer matrix composites

Thermal

ABSTRACT

In this work, solvent blending in combination with extruding are applied to provide polystyrene/silica nanocomposite specimens. Transmission electron microscope (TEM) and scanning electron microscope (SEM) show same nanoparticle dispersion in PS matrix in low to high filler loadings. Differential scanning calorimetry (DSC), dynamic mechanical thermal analyzer (DMTA) and thermogravimetric analyzer (TGA) were used to study the thermophysical characteristic of the nanocomposites in solid state. In addition, the melt state rheological behavior of the samples was investigated under constant and zero shear rates. Interestingly, different behaviors were detected in nanocomposites in low and high nanoparticle loadings. In addition, rheological characteristics of molten polymer are dramatically affected in samples with low nanosilica concentration while stabilized in high filler loadings.

© 2011 Published by Elsevier Ltd.

1. Introduction

Polymer nanocomposites have gained much interest in recent years. The superior mechanical, thermal, electrical, magnetic and optical properties that can be attained at a much lower loading of nanoparticles in comparison with the traditional microcomposites have played a major role in this shift of interests [1]. They are interesting in both fundamental academic researches and industrial applications, due to their potentials for advanced properties at very low filler fraction than conventional ones [2]. In recent years, many efforts have been made to improve the thermophysical properties of polymer nanocomposites. Because nanoparticles have extremely high surface area to volume ratios and they also alter the mobility of polymer chains near their interfaces, they have potential to drastically transform the thermophysical properties of the host polymer even in low concentrations [3–9]. Sarwar et al. showed that with increasing silica content in polyamide–silica nanocomposites, tensile modulus, yield strength and ultimate strength improved and glass transition temperature and the storage moduli increased [10]. Akbari and Bagheri [11] have observed a reduction in glass transition temperature of epoxy/clay nanocomposite with increasing the amount of organoclay. They claimed that formation of the regions

with lower cross-link density and higher mobility is responsible for reduction in the T_g of the nanocomposites. Kontou and Anthoulis [12] have recently investigated the thermomechanical properties of polystyrene/silica nanocomposites and reported changes in heat capacity of polymer with addition of nanoparticles. Schadler and her colleagues [13,14] reported decrease in T_g of PS/nanosilica nanocomposite with decreasing interparticle spacing.

Several methods can be applied to produce a commercial polymeric nanocomposite. The traditional melt-mixing method is very time-saving for industrial manufacturing. However, this method may not disperse nanoparticles well in the matrix [6,15], which in turn can limit the viability of the method. In a case of poor dispersion of nanoparticles, the thermophysical properties of nanocomposite may be highly deteriorated. For example, a decrease in thermal characteristics of nanocomposites is reported due to particle agglomeration [16] or non-uniform dispersion [11]. To tackle this problem, solvent-based methods can be applied to provide a good dispersion of nanoparticles in polymer matrix [6,15]. Some limitations of the melt-mixing in dispersing nanoparticles can be overcome via solution-mixing methods. The nanoparticle/polymer solution can then be casted after solvent removal. Although, solution-mixing could reduce particle agglomeration, this method is very time-saving. For industries, diluting masterbatch in the molten state are more favored, since this process is more convenient, time-saving and cost-effective in comparison with solvent-based

* Corresponding author. Tel.: +98 2182884355; fax: +98 2182884354.

E-mail address: h_salehi@modares.ac.ir (H.S. Vaziri).