Preparation and properties of electrically conductive PPS/expanded graphite nanocomposites

Y.F. Zhao, M. Xiao, S.J. Wang, X.C. Ge, Y.Z. Meng *

State Key Laboratory of Optoelectronic Materials and Technologies/Institute of Optoelectronic and Functional Composite Materials, Sun Yat-Sen University, 135 Xingang West, Guangzhou 510275, PR China

Received 24 February 2006; received in revised form 16 November 2006; accepted 19 December 2006
Available online 11 January 2007

Abstract

Nanocomposites based on poly (phenylene sulfide) (PPS) and expanded graphite (EG) or ultrasonicated EG (S-EG) were prepared by melt blending. Morphologies of the nanocomposites were examined using both SEM and TEM. Electrical conductivity and thermal stability of PPS were notably enhanced by the introduction of EG. The percolation threshold values are 1 wt% (S-EG) and 2 wt% (EG) for PPS/S-EG and PPS/EG nanocomposites, respectively. The variation of mechanical strength with the weight fraction of EG and S-EG in the nanocomposites showed somewhat correlation with the threshold filler concentration. The crystallization behavior of PPS matrix in the nanocomposites was investigated using DSC, and the results indicated that the crystallization process was significantly accelerated, leading to an increase in crystallinity.

Keywords: A. PPS; A. Expanded graphite; A. Conducting polymer; A. Nanocomposite

1. Introduction

Polymer nanocomposites with conducting fillers have been the focus for many research groups in past few decades. The electrically conductive polymeric composites can be utilized in light emitting devices, batteries, electromagnetic shielding, anti-static, corrosion resistant coatings, and other functional applications [1,2]. The conducting fillers often used included natural graphite flake, carbon black and metal powders. Among the various conducting fillers, natural graphite, which possesses good electrical conductivity of about 10⁴ S/cm at ambient temperature, has been widely used [3,4]. In most cases, relatively large quantities of graphite were needed to reach a critical percolation value. However, large quantity of graphite could lead to materials poor mechanical properties and high density of composite. In order to solve the problem of materials that have high conductivity and poor mechanical properties, nanoscale fillers have been extensively employed.

Graphite shows layered crystal structure. The carbon atoms are bonded covalently in a hexagonal arrangement within the layer and these layers are bonded to each other by weak van der Waals forces. The d-spacing between the carbon layers is 0.335 nm. Since the van der Waals forces are relatively weak, it is possible for a wide range of atoms, molecules and ions to intercalate between graphite layers to form the graphite intercalation compounds (GICs).

Expanded graphite (EG) is generally produced by subjection H₂SO₄–GICs to rapid thermal treatment. EG maintains the layered structures similar to natural graphite flake but produces tremendous different size of pores and nano-sheets with very high aspect ratio. Many polymeric nanocomposites using EG as conducting fillers, such as PMMA/EG [2,5], PA-6/EG [6], PE/EG [7], Nylon 6/EG [8,9], PS/EG [10,11], POBDS/EG [4,12–14], have been extensively reported recently.

Poly (phenylene sulfide) (PPS) is a typical engineering polymer that shows exceptional mechanical properties.
room temperature when the specimen was tested. The resistivity or conductivity of the specimen was determined by the following equation:

\[ \rho = R_s L = \frac{(R_1 - R_2)A}{L} \]  
\[ \sigma = \frac{1}{\rho} \]

where \( \rho \), \( \sigma \), \( A \) and \( L \) are the resistivity, the conductivity, the cross-sectional area and the thickness of the specimen, respectively. \( R_1 \), \( R_2 \) and \( R_s \) are total resistance, reference resistance and specimen’s resistance, respectively.

When \( \sigma \) of the specimen was greater than \( 10^{-3} \) S/cm, it was tested by SDY-4 four-probe instrument (Guangzhou, China).

2.4.2. Mechanical property

Three-point bending tests were performed on Sansi testing machine (CMT4104, China) at room temperature. The crosshead speed was 1 mm/min and the support span was 25 mm. The sample dimensions were \( 30 \times 3 \times 2 \) mm\(^3\), five specimens of each composition were tested and the average values were reported.

2.4.3. Morphology observation

Morphologies of EG and PPS/EG composites were examined on a scanning electron microscope (JSM-6380LA, JEOL). Prior to the test, the specimens were cryo-fractured and the fracture surface was sputtered with gold. Transmission electron microscopy (100CX-II, JEOL) micrograph was obtained using an acceleration voltage of 100 KV. Ultrathin samples were obtained using an IB-Vmicrotome.

2.4.4. Thermal property

Thermogravimetric analysis (TGA) was performed on a Perkin-ElmerTG/DTA 6300 instrument at a heating rate of \( 20 \) °C/min under \( N_2 \) (300 ml/min) atmosphere. Differential scanning calorimetry (DSC) analysis was carried out on NETZSCH DSC-200PC under \( N_2 \) atmosphere. Samples were heated from room temperature to 320 °C at a rate of 20 °C/min and held at that temperature for 3 min to eliminate the heat history. The samples were then cooled to 50 °C at a rate of 20 °C/min. After keeping at 50 °C for 3 min, samples were heated to 320 °C at a rate of 20 °C/min again. The thermal parameters were obtained from the cooling and reheating scans for the crystallization and melting behavior of PPS composites. The degree of crystallinity was calculated from the following equation:

\[ \%X_c = \frac{\Delta H_c}{\Delta H_f (1 - W_f)} \times 100\% \]

where \( X_c \) is the degree of crystallinity, \( \Delta H_c \) is the heat of crystallization, \( \Delta H_f \) is the heat of crystallization of a 100% crystalline PPS, \( W_f \) is the weight fraction of EG content in the composite.
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات