PREPARATION AND THERMAL PROPERTIES OF GRAFTED CNTS COMPOSITES

Jifen Wang [a, b], Huaqing Xie [a, *], and Zhong Xin [b]

[a] School of Urban Development and Environmental Engineering, Shanghai Second Polytechnic University, Shanghai 201209, China; [b] State Key Laboratory of Chemical Engineering, East China University of Science and Technology, Shanghai 200237, China

Introduction

The current surge in interest in carbon nanotubes (CNTs) is fueled by their significant potential in various technological applications. However, the intrinsic van der Waals attraction among CNTs, in combination with their high surface area and high aspect ratio, often leads to significant agglomeration, thus preventing efficient transfer of their superior properties to the matrix. The self-aggregation of CNTs in the composite hinders the development of homogeneity in the composite [1]. There are several main methods reported for solving the problem, such as high-power ultrasonication [2], high temperature and high shear forces in melt blending [3], and functionalization of CNTs [4]. The chemical functionalization is an effective way to make homogeneous CNT composites. However, when chemical treatment increases the CNT resolvable in the organic matrix, the change of the structure caused by chemical process weakens the intrinsic CNT properties.

Experimental

Materials and Sample preparation

Pristine multi-walled CNTs (P-CNTs) were supplied by Chendu Organic Chemicals Co., Ltd., Chinese Academy of Sciences. The purity of the CNTs was 95%. The average diameter, average length, and specific surface area of the CNTs were 30 nm, 50 μm, and 60 m^2/g. Palmitic acid (PA, 98%) with melting temperature of 62.5 - 64 ^oC was obtained from Sinopharm Chemical Reagent Co., Ltd.. Acid treatment was used to add the COOH group on the surface of P-CNTs. Then, the dried and cleaned CNTs were boiled in $SOCl_2$ [containing dimethylformamide (DMF)] at 70 ^oC for 48 hours. After centrifugation, the solid remaining was washed with anhydrous tetrahydrofuran (THF) for three times before dried under vacuum. The sample was further stirred with octanol at 50 ^oC for 120 hours, respectively. After removed the excess organic solvent, the black solid was dried under vacuum at room temperature.

The P-CNTs and grafted CNTs were added into melting PA in a mixing container. The mixture was subjected to intensive sonication to make well dispersed and homogeneous composites with CNT mass fraction of CNTs, ϕ_m=0.005.

Characterization

Various analytical methods have been applied to characterize the treated CNTs and investigate the thermal properties of the composites. Transmission electron microscopy (TEM) pictures were taken on a JEOL 2100F high resolution TEM device. The microstructures of the organic matrix and the composites were investigated by a

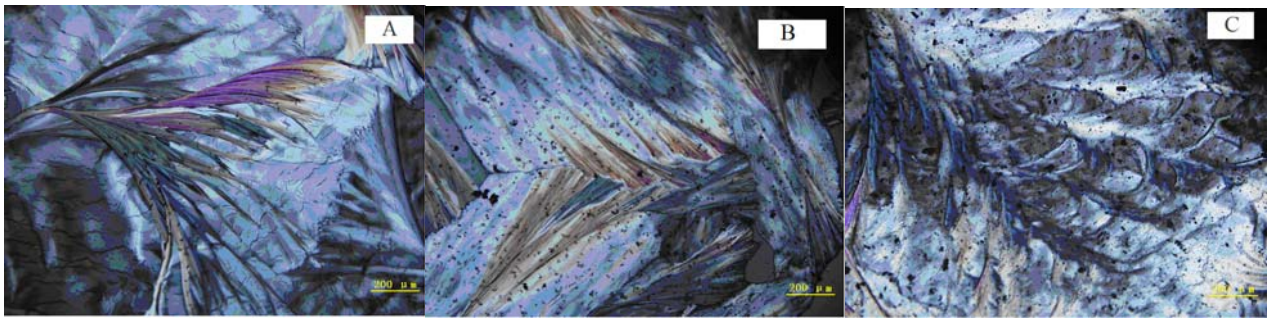

Fig. 1 POM images of PA (A), P-CNT/PA (B) and G-CNT/PA(C)

microscope (POM, BX51, Olympus Optical Co., Ltd., Japan). Melting temperature (T_m) and latent heat capacity (L_s) of pure PA and the composites were measured using a differential scanning calorimetric (DSC) instrument (Diamond DSC, Perkin Elmer, USA). The DSC measurements were performed at a heating rate of 5 ^{o}C /min and in a temperature range of 15-70 ^{o}C.

Results and discussion

Characterization of CNTs and compatibility of composites

TEM images showed the trace of organic membrane on the CNT. The attachments on the surface of the G-CNT are the organic groups introduced onto the CNT surfaces during the grafting process. The P-CNT/PA had delamination only after one time phase change. After 80 times repeated heating and cooling, the sample of G-CNT/PA turned up to grads thickness Fig. 1 presents the POM images of the PA and the composites. The Scale bar in the picture is 200μm. It is observed that the grafted CNT composite were homogeneous even after heating and cooling repeated 80 times.

Melting temperature and latent heat capacity

DSC analysis was conducted to investigate the influence of CNTs addition on the thermal properties including melting temperature and the latent heat storage capacity of the composites. In order to investigate the effect of the grafted CNTs on the properties of the composites, the grafted CNTs were added into the organic matrix of PA.

Table 1 The T_m and L_s of the materials

PCM	T_m (^{o}C)	L_s (J/g)
PA	62.4	209.2
P-CNT/PA	62.4	204.3
G-CNT/PA	62.4	188.7

Table 1 presents a summary of the phase change temperature and the latent heat capacity of the base materials and their composites. In the table, T_s and L_s are the phase change temperatures and the latent heat capacity, respectively. Both composites have same T_m as the pure PA, but lower the L_s than that of PA.

Conclusions

We prepared grafted CNTs and dispersed the CNTs into the melting organic matrix to produce phase change composites. The composites with grafted CNTs were proved homogenous and stable. DSC analysis revealed that the addition of grafted CNTs into PA leaded to the decrease in latent heat capacity. Compared with pure PA, the addition of grafted CNTs into PA leads to the lower latent heat capacity. Our findings would help the community to understand the thermal transport mechanism in CNT grafted composites.

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