Influence on the Microphase Separation Structure of PU by Low-content CNT Fillers

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Abstract. Microphase separation are the decisive factor for the performance of polyurethane. The blends of polyurethane/carbon nanotubes were prepared by the method of solution blending, and the influence of carbon nanotubes on the microphase separation behaviors of polyurethane was studied. The results show that carbon nanotubes play as the nucleating agent in the blends of polyurethane/carbon nanotubes. The average diameter of the polyurethane phase was improved even only a very small amount of carbon nanotubes were present.

Introduction

As a well-known thermoplastic elastomer material, polyurethane (PU) is widely used in the fields of building material, garments, biomedical materials, etc. Recent years, carbon nanotubes (CNT) has been frequently applied to improve the mechanical properties and thermal stability of PU[1-9]. These improvements are greatly caused by the modification of the microstructure of PU. In this paper, the influence of CNT on the micro phase separation structure of PU was discussed.

Experimental

The type of PU is Bayer 985U. The type of CNT is TNIM4. It’s a multi-wall CNT and was purchased from Chengdu Organic Chemical Co., Ltd. N,N-dimethyl formamide (DMF) were purchased from Shanghai Chemical Reagent Co., Ltd. To prepare the PU/CNT blend, PU solution was first prepared with DMF. Then certain amount of CNT was added into the solution and the solution was stirred for 24 h at the speed of 100 RPM.

For the preparation of film, certain amount of PU/CNT blend solution was poured on the dry clean glass plate (10 × 10 cm² in size). A film with the thickness of 100 μm was prepared with an adjustable film maker (Shanghai Le Ao Test Instrument Co., Ltd.). The film was then dried in the vacuum oven in the temperature of 80 °C for 24 h. After that the film was peeled off from the glass plate, and observed with the phase contrast microscope (AE2000, Shanghai Yiyuan Optical Instrument Co., Ltd.).

Results and Discussions

The interaction of PU and CNT was first investigate by viscosity of PU solution. The results are displayed in Figure 1. From Figure 1 we can see that very small amount of CNT could cause a significant increase of the solution viscosity. This was caused by the entanglement between PU molecular chains and the structure of CNT.

Figure 2 shows the microphase separation structure of PU/CNT blends with various CNT contents. The morphology of PU microstructure refers to the shape, size and composition of the phases, the width of the phase boundary layer and the degree of molecular entanglement of the two neighboring phases, which are closely related to the properties of PU materials. From Figure 1, a bicontinuous phase separation structure can be observed. This structure was formed by the rigid segments and soft segments of PU molecular chains. The phase size of the sample without CNT (Figure 1-A) is small,
while the addition of CNT significantly increased the phase size. Although the total amount of CNT added in the blend is small in all the other three samples (less than 0.1wt%), the influence of CNT on the microphase structure of PU were all significant.

![Figure 1. Influence of CNT content on the viscosity of PU solution.](image)

For further analysis, the average phase diameter of each sample was calculated by computer sampling, and the results are showed in Figure 3. It can be seen that with the addition of carbon nanotubes, the average phase diameter increases, the phase separation of PU is thus more obvious. The reason why low-content CNT fillers can cause the change could be attributed to the role of nucleating agent of CNT in the blends.

We can also found from Figure 2 that, when the content of CNT increased further, the microphase size leveled off. This is because with the increase of the concentration of CNT, simple blending process could not make good dispersion for CNTs. The new-added CNT aggregated together, and could not lead to more phase separation.
Conclusion

The blends of PU/CNT were prepared by solution blending method, and the influence of CNT on the microphase separation structure of PU was studied. The results show that CNT play as the nucleating agent in the blends of PU/CNT. The average diameter of PU phases was improved even only a very small amount of carbon nanotubes were present. However, when more CNT was added, the effect became weak since good dispersion cannot be guaranteed.

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References


