

STUDY ON DIELECTRIC PROPERTIES OF CNF/PEI COMPOSITES

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Introduction

The rapid development of electronic technology has brought about a demand for materials with not just good physical and mechanical properties, but also demand for electrical properties. Functional polymer composites have the ability to meet these needs[1]. A common approach for enhancing the dielectric properties is using various conductive fillers, such as metallic, ceramic and carbon black particles, which have been extensively explored[3-5]. Carbon nanofibers (CNFs) are important nanoscale materials that show promise as fillers for polymer nanocomposites. However, very little research has been focused on the dielectric properties of the composites enhanced by these nanofillers. In this study, CNFs/PEI membranes were prepared by electrospinning, and the effects of CNFs on dielectric constant and dielectric loss of CNFs/PEI membrane were studied.

Experimental

Materials

Carbon nanofibers(CNFs) used as fillers were supplied by Showa Denko Co., Japan. The PEI used in this study (ULTEM 1000) in a granular form was supplied by General Electric Co., USA. N-methylpyrrolone(NMP) were purchased from Beijing Chemicals Co., China, which was used as the solvent. The fibrous membranes were collected on aluminum foil covering a rotary drum.

Apparatus and Procedures

The electrospun fiber membrane were dried under vacuum at 60°C for 24h in a vacuum oven. Scanning electron microscopy (SEM,

Hitachi S4700) was employed to observe the morphologies of composite fibers, and Image-J software was used to measure the diameter of the fibers. The dielectric properties of the samples were recorded on a radio frequency (RF) impedance/capacitance material analyzer (Hewlett Packard Model 4291 A) in the frequency range of 100Hz to 10MHz and at 50% relative humidity (25°C) under ambient atmosphere.

Results and Discussion

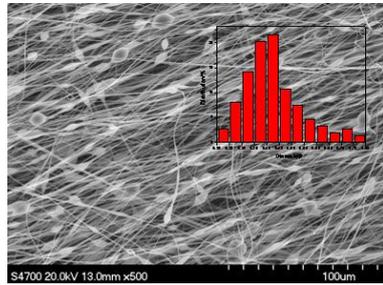
The Fig.1 shows the morphologies and diameter distributions of PEI electrospun fibers with different spinning solution concentration. When the concentration of PEI is 0.24g/ml, some “beads” in PEI electrospun fibers can be seen in Fig.1(a). By increasing the concentration of PEI, the “beads” disappear and smooth fibers can be obtained as shown in Figure1(b),(c),(d). As the concentration of PEI increases, the diameter of the fibers increase. And with the addition of CNFs ,the diameter of fibers decrease.

In Fig.2. We can see that the neat PEI fibrous membranes has very low dielectric constant (about 0.4), and the electric constant of all the samples exhibited low frequency dependence. Moreover the addition of CNFs leads the dielectric constant to a higher level than that of neat polymer. With the increasing of CNFs loading, the dielectric constant of sample increases (Fig.2(a)). At the same time, almost all the samples show similar low dielectric loss (Fig.2(b)).

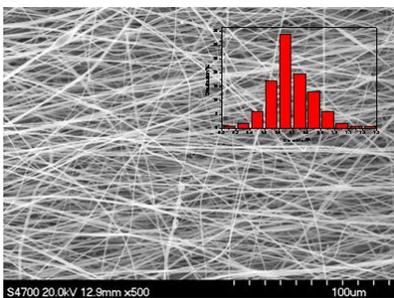
Conclusion

The concentration of PEI affected the morphology and diameter of electrospun fibers. The loading of CNFs can also influence the

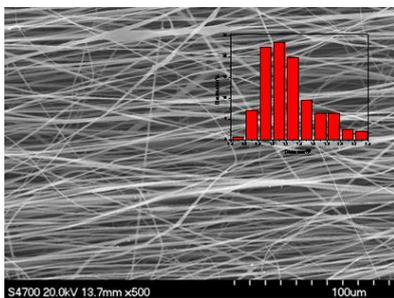
microstructure of fibers. The addition of CNFs raised the dielectric constant of fibrous membranes, but the dielectric loss exhibited small changes.



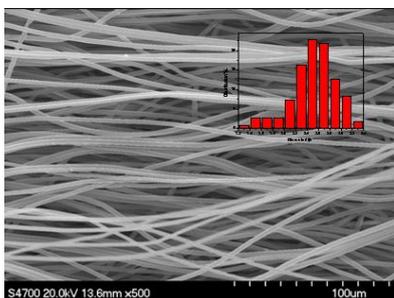
(a)



(b)

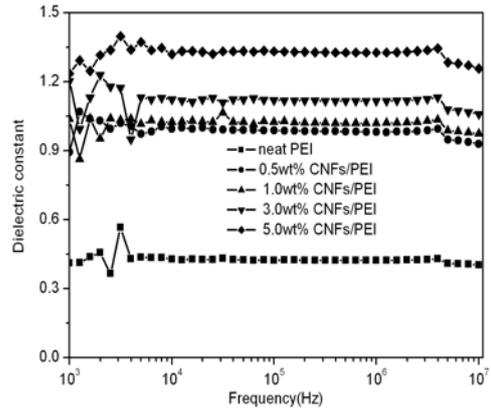


(c)

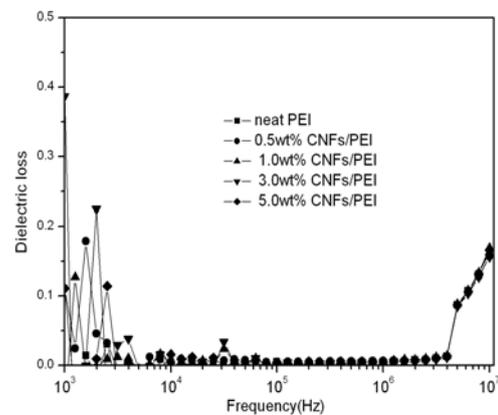


(d)

Fig.1 SEM images of PEI electrospun fibers with different spinning solution concentration: (a) 0.24g/ml; (b) 0.26g/ml; (c) 0.30g/ml; (d) 0.36g/ml



(a)



(b)

Fig.2 Dielectric constants and loss for neat PEI and CNFs/PEI composite fibrous membranes

References

- 1.Sui, G., Jana, S. and Zhong, W.H. *Acta Materialia*, **56** (2008) 2381-2388.
- 2.Windlass, H., Raj, P.M., Balaraman, D., Bhattacharya, S.K. and Tummala, R.R. *IEEE Trans. Adv. Packag.*, **26** (2003) 10.
- 3.Popielarz, R., Chiang, C.K., Nozaki, R. and Obrzut, *J. Macromolecules*, **34** (2001) 5910.
- 4.Saujanya C, Radhakrishnan S. *Polymer*, **42** (2001) 6723.