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Novel PEN/$BaTiO_3$/MWCNT Multicomponent Nanocomposite Film with High Thermal Stability for Capacitor Applications

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In this work, novel nanocomposite films formed from polyarylene ether nitrile (PEN), barium titanate ($BaTiO_3$), and multiwalled carbon nanotubes (MWCNTs) were successfully prepared by the solution casting method combined with continuous ultrasonic dispersion technology. The micromorphology, thermal, mechanical, and dielectric properties of the nanocomposite films are investigated. All of the nanocomposite films exhibited excellent thermal stability and mechanical strength almost the same as pure PEN film. Their initial decomposition temperatures were up to 492°C, and the tensile strength was over 82 MPa. Besides, the nanocomposite films had excellent flexibility, as the films could be curled easily into cylinders with several layers. Furthermore, it was found that the film with 1.5 wt.% MWCNTs and 20 wt.% $BaTiO_3$ had the best comprehensive dielectric properties, with potential for application in organic film capacitors.

Key words: Polyarylene ether nitrile, barium titanate, carbon nanotubes, nanocomposites, dielectric properties, thermal properties

INTRODUCTION

In recent decades, polymer nanocomposites have been in the limelight as next-generation materials in view of their advantages and unique properties synergistically derived from the nanoscale structure, displaying enhanced mechanical, thermal, electrical, magnetic, and optical properties.[1–4] Composites with a conductive phase and an insulating phase are widely used in the electronics industry. The percolation phenomenon of conductive–insulating composites has attracted extensive attention because of their wide practical applications in the electronics industry. These materials possess special physical properties different from metals, such as lower thermal conductivity and higher resistance.[5–10] Generally speaking, conductive–insulating materials can be prepared by dispersing conductive particles into the melt or solution of an insulating matrix, such as a polymer matrix, by thermal compression of a mixture of conductive and insulating powders, or by growing a thin film on a substrate. In such a material, when the weight or volume fraction of the conductive filler reaches a critical value, its electric conductivity sharply increases by several orders of magnitude. This critical value is referred to as the percolation threshold, at which a conductive network is formed to span the entire cross-section of the body of the material. The electrical conductivity of conductive filler-based composites exhibits a characteristic percolation behavior.[11,12]

Polyarylene ether nitriles (PENs) are well known for their outstanding properties such as radiation resistance, thermal stability, excellent mechanical properties, and chemical inertia,[13–15] which make them very attractive for use at high temperatures and in aggressive chemical environments encountered in aerospace, industrial, and automotive applications.[16–19] Multiwalled carbon nanotubes (MWCNTs) have excellent mechanical, electrical, chemical resistance, and electromagnetic properties,

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