Electrical and Damping Behaviors of CPE/$BaTiO_3$/VGCF Composite

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The electrical and damping behaviors of chlorinated polyethylene (CPE)/barium titanate ($BaTiO_3$)/vapor-grown carbon fiber (VGCF) composites have been investigated. CPE/$BaTiO_3$/VGCF composite exhibits a lower percolation threshold compared to the two component system of CPE/VGCF. The dynamic mechanical analysis shows that the storage modulus CPE/$BaTiO_3$/VGCF increases with VGCF content in the room temperature region (around 25℃). However, the loss factor reaches the maximum at 8 vol% VGCF content, which corresponds to the beginning of the second percolation stage for the composites. This may imply that the piezo-damping effect is directly related to the formation of conductive networks in the composites and a new damping material with both a higher loss factor and a higher stiffness in the region of practical temperature can be obtained by changing the composition the composite. The further examination demonstrates that the piezo-damping effect is highly temperature and frequency dependent.

Key words: chlorinated polyethylene (CPE); barium titanate ($BaTiO_3$); carbon fiber; dynamic mechanical behavior; damping material

1. Introduction

Many efforts have been made to control the unwanted vibration and noise. One of the most common methods is the application of a viscoelastic material, such as rubber with a broader and a higher damping peak in its glass transition region. However, the improvement on damping efficiency of such materials is, to some extent, limited. Firstly, the width and height of the loss peak can not be independently adjusted, as the broadening of the loss peak usually results in a decrease in its maximum height [1]. Secondly, most rubbers exhibit relative low moduli at room temperature and their glass transitions are usually lower than the application temperature.

In order to obtain a damping material with both a high loss factor and a high stiffness in the wider temperature region, a novel polymeric composite containing piezoelectric ceramic powders and electrical conductive particles has been developed and attracted great attention [2-4]. The damping mechanism of such a composite is assumed to be due to the energy transferring effect through the cooperation among the components. The mechanical vibrating energy is first transmitted to the piezoelectric ceramic powder and converted into alternating electrical potential energy by the piezoelectric effect. Then, the electrical potential energy is further converted into Joule's heat through the networks of electrical conductive particles in the polymeric matrix. For simplicity, such an energy transferring effect is rather hereafter referred to the piezo-damping effect hereby.

Although the damping mechanism of such a new damping material has been basically ascertained mainly by the damping peak at a critical content of electrical conductive filler, many related details have not been well understood [5]. Therefore, it is necessary to explicate such elementary problems as to what extent and on what condition the piezo-electric effect can really function. In the present work, the electrical and damping behaviors of CPE/$BaTiO_3$/VGCF composite was studied for providing further experimental verifications to support the new damping mechanism.