LETTER

Dielectric Nanocapacitance Effect of Thermoset Polymeric Matrix Nanocomposites

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INTRODUCTION

Recently, researchers have extensively investigated polymer and layered silicate clay composites, called nanocomposites, to obtain a fundamental understanding of the nanosizing effects and subsequently to enhance the mechanical, physical, and electrical properties of nanocomposites. 1,2 Although silicate laminae are insulating materials, the mobile cations in the interlayer space are thought to increase the electrical conductivity associated with the charged nanoplatelet layers. 3-7 In these materials, the ionic conduction of cations is likely ensured by the nanosizing of organic polymer chain segments to inorganic surfaces, which affects the mobility of the cations while avoiding the mobility of the anions from the charged silicate layers. These organic/inorganic hybrid composite systems have attracted a great deal of attention in such electrochemical devices as fuel cells, batteries, biomimetic electrostrictive actuators, and organic display systems. 8-10 In particular, the dielectric constant and dielectric strength of insulation materials are specifically required to be controlled, for example, to lower than 4.0 and higher than 0.5 MV/cm, respectively, in such applications as thin-film transistor/organic light-emitting devices, depending on the electric circuit components and configurations, to prevent the cross-talk of electrical signals. Because the dielectric constants of many insulation polymers range from 2.0 to 4.0, it is desirable to tailor the dielectric properties, for example, by the incorporation of small amounts of charged nanoparticles without changes to the whole material systems or processes.

The nanoclay-layered silicate montmorillonite \( \text{MMT; } [\text{M}_{x}\text{Al}_{4-x}\text{Mg}_{x}\text{Si}_8\text{O}_{20}(\text{OH})_4, x \approx 0.67} \) belongs to a family of phyllosilicates consisting of two tetrahedral silica thin layers with a central octahedral sheet of magnesia. 1,2,11 Isomorphous substitution within the layers creates intrinsic surface-negative charges. The forces holding the stacks together are ionic in nature and hydrophilic; therefore, the intercalation of appropriate molecules between the layers is sometimes needed to achieve the hydrophobic status of nanoclays.

In this study, a commercially available phenolic resin (Plyophen 43243, Durez Corp.), composed of formaldehyde, phenol, isopropyl alcohol, and ammonia was incorporated with a layered nanoclay provided by Southern Clay Products. Among several alkylammonium cations, the one reported in this study was dimethyl benzyl hydrogenated tallow quaternary ammonium (2MBHT; 125 mequiv of 2MBHT/100 g of MMT;