Ceramic and/or Carbon/Polydimethylsiloxane Composites: Thermomechanical Response, Dielectric Behavior and Energy Storage Efficiency

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Crosslinked polysiloxane elastomeric networks constitute a scientifically and technologically important class of inorganic polymeric system over the last 50 years. These materials have found widespread applications in a number of diverse technological, commercial and research areas. The high mechanical strength, low weight, ease of processing and low cost are part of their advantages. The integration of two or more complementary materials in a new composite system results in a material, with properties superior of the properties of the individual constituents. In recent years, nanoinclusions offer new opportunities for designing composite materials. Interfaces affect the dielectric and mechanical response of composite systems dramatically [1–5]. It is crucial for a potential application the combination of mechanical, physical and dielectric properties. Therefore, multicomponent ceramic and carbon fillers are preferred as reinforcing phases in the fabrication of polysiloxane composites. Fillers are of particular importance as physical property modifiers in polysiloxane systems and are typically micro or nano-scale materials (e.g. ceramic, carbon, aluminosilicate clay) that are introduced into the polymer matrix as a heterogeneous 2nd phase to form a composite with improved physical, thermomechanical and dielectric properties. The dielectric behaviour of elastomer nanocomposites can be tailored by simply controlling the type and amount of the nanofiller.

The goal of this study was to develop lightweight, easy-to-make, low-cost dielectric materials able to store energy and harvest it with minimum losses, and with appropriate mechanical performance. For this reason, different series of composite materials were fabricated and studied. In particular, the following composite systems were prepared: $BaTiO_3$ microparticles/PDMS composites, multiwalled carbon nanotubes (MWCNTs)/PDMS composites, and hybrids of PDMS incorporating at the same time $BaTiO_3$ nanoparticles and MWCNTs, varying each time the amount of the employed filler content. Morphology, viscoelastic properties and dielectric response of all systems were investigated by means of scanning electron microscopy (SEM) and X-ray diffraction (XRD), dynamic mechanical thermal analysis (DMTA) and broadband dielectric spectroscopy (BDS). The determined properties between $BaTiO_3$/PDMS, MWCNTs/PDMS and $BaTiO_3$/MWCNTs/PDMS hybrid composites were compared in order to provide an understanding of the structure properties relationships and to specify the optimum amount and filler type. Finally, the energy density of all studied systems was calculated, targeting to investigate the energy storage efficiency of the prepared composites.

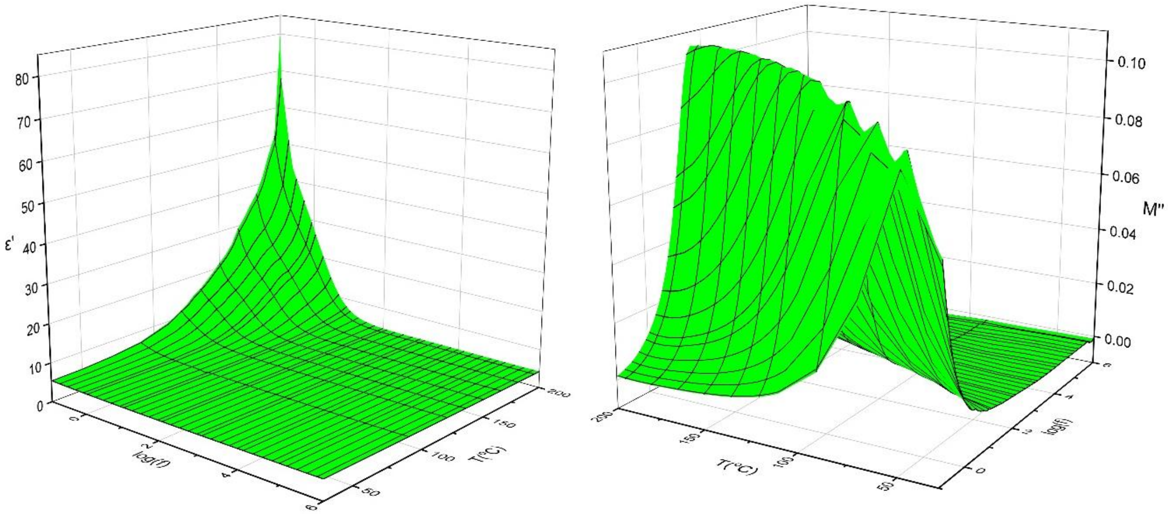

Figure 1. Real part of dielectric permittivity (left) and imaginary part of electric modulus (right) versus frequency and temperature for the hybrid composite with 5 phr $BaTiO_3$ + 1 phr MWCNTs.

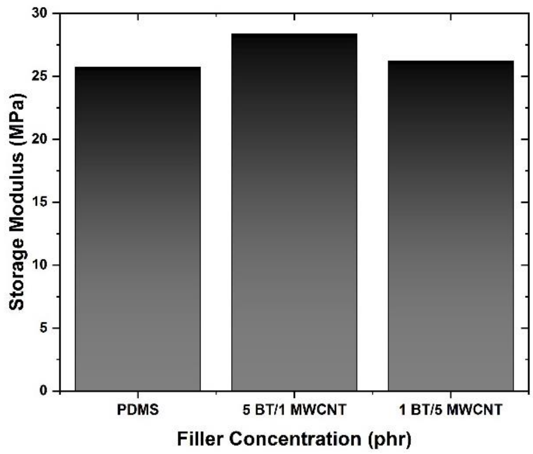

Figure 2. Storage Modulus as a function of filler concentration at temperature T=200^{o}C.

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