Barium Titanate-Polydimethylsiloxane Nano/Micro-composites: Development, Characterization, Functionality and Energy Storage

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Composites are materials in which the micro/nano-sized dispersed phase in a suitable matrix can enhance some of the existing properties, as well as give rise to new ones. Elastomers micro/nano-composites are of great interest because the addition filler improves electrical, mechanical and thermal response and can also modify other properties. Polydimethylsiloxane (PDMS) elastomer is an electrorestrictive polymer having excellent electrical, elastic, mechanical and thermal properties [1, 2]. The composites derived from PDMS elastomer can be used in various applications including actuation, sensing, artificial muscles, biocompatibility and microfluidics, exhibiting also good environmental stability. Elastomer matrix composites incorporating ceramic nanoinclusions receive enhanced scientific and technological interest, because of their advanced performance. Barium titanate is a wide band gap semiconductor with ferroelectric properties. Ferroelectric particles are considered as active dielectrics, since they undergo a structural transition from the polar ferroelectric phase to the non-polar paraelectric phase, at a critical temperature.

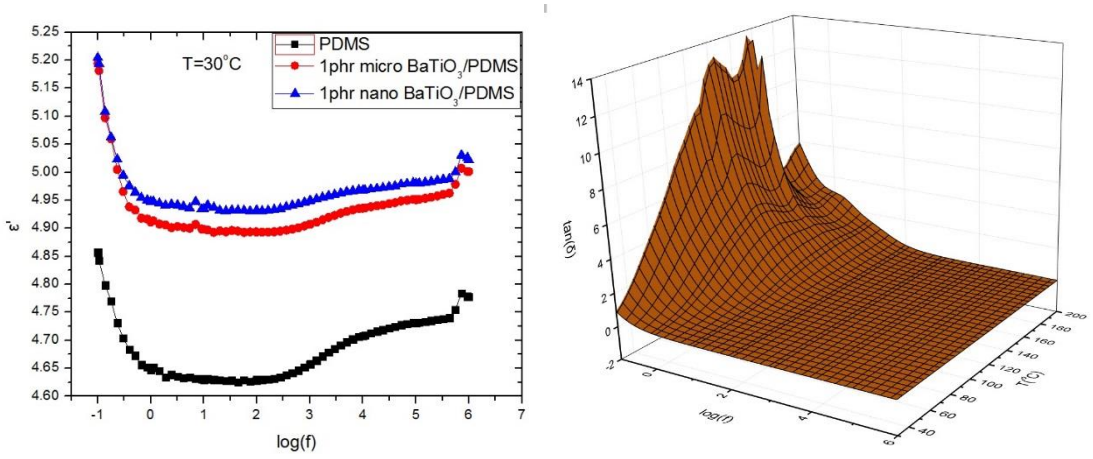

Fig 1. Real part of dielectric permittivity versus frequency for pure PDMS and micro- and nano- composites with 1 phr $BaTiO_3$ (left), loss tangent versus frequency and temperature for nanocomposite with 1 phr $BaTiO_3$ (right).

Polar oxides/elastomer dielectrics exhibit tunable polarization, related to the piezoelectric and/or ferroelectric behaviour of the filler. The electrical response of these composites can be suitably adjusted by controlling the type and the amount of the ceramic inclusions [3-5], addressing the engineering demands for suitable dielectric properties in tandem with improved mechanical strength and ease processing at a relative low cost. In this study, various ceramic polar oxides are embedded in an elastomer matrix. The employed fillers are micro and nanoparticles $BaTiO_3$, for each size of filler a series of nanocomposites is prepared varying the ceramic content. Morphology, mechanical behaviour, thermal properties and dielectric response are investigated by means of scanning electron microscopy, dynamic mechanical analysis, differential scanning calorimetry, and broadband dielectric spectroscopy, respectively. Data analysis is focused in realizing the optimum type and amount of reinforcing phase with respect to dielectric behaviour, functionality and energy storage efficiency.

References

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