Magnetorheological elastomers as multifunctional materials for smart devices and applications

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Abstract

Magnetorheological elastomers (MREs) are active materials composed of a polymeric matrix and an inorganic magnetic filler [1], with rheological and mechanical characteristics that can be actuated using a magnetic field. Typically, the inorganic component is a soft magnetic material with high saturation magnetization, so that switching between rheological states is achieved rapidly [2]. In this work, we explored the effect of different nanosized fillers ($CoFe_2O_4$, Fe_3O_4, Co, Ni and $Ni_{80}Fe_{17}Mo_3$) with distinct magnetic properties on the structural, magnetic, thermal, mechanical, and magnetorheological properties of MREs based on styrene-ethylene-butylene-styrene (SEBS) thermoplastic elastomer. The structure of the polymer does not significantly vary when the particles are included, and they distribute uniformly with the polymer matrix, showing an homogeneous distribution of small clusters (Figure 1a). A maximums saturation magnetization of 17.8 Am^2/kg is achieved for magnetite (Fe_3O_4) based composite (Figure 1b). All samples retain the magnetic behaviour (in terms of magnetic hardness) of the pure nanofillers, indicating good compatibility with the matrix. The thermal properties of the polymer show a slight increase in the degradation temperature with the inclusion of the magnetic fillers (Figure 1c). The elastic modulus increases by at least a factor of 2, from 0.7 MPa of the SEBS to a maximum of 1.8 MPa in the case of the sample with Fe_3O_4 nanoparticles (Figure 1d). Regarding the magnetorheology, the samples respond to the magnetic field by increasing their storage modulus, while the loss modulus remains almost unaltered. Further, it has been determined that the particles with higher saturation magnetization and lower coercivity are more appropriate in terms of enhancing the magnetorheological effect (Figure 1e). This study helps finding the most adequate nanofillers to fabricate MREs, with the advantage that these nanoparticles can be tuned with different sizes, shapes, orientations, differently from the traditionally used microparticles.

References

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Figures

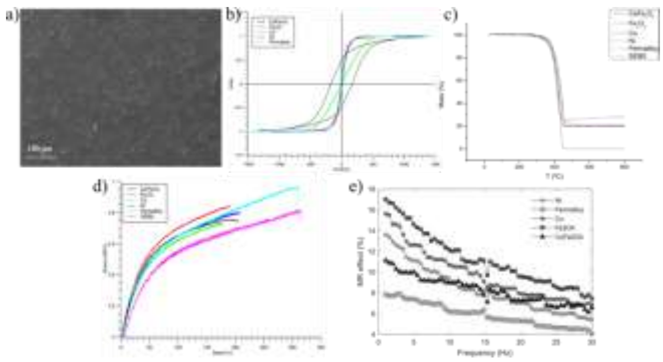

Figure 1: a) SEM image of the $CoFe_2O_4$ @ SEBS composite. b) Magnetic properties measured by VSM. c) TGA curves of the composites. d) Mechanical properties of the samples. e) Magnetorheological effect of the prepared composites.