

**SYNTHESIS AND MECHANICAL CHARACTERIZATION OF
MAGNETIC ELASTOMERS**

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ABSTRACT

Emerging applications that utilize magnetic polymer nanocomposites are currently developing at a high rate. Magnetic actuation in microelectromechanical systems (MEMS) and medical devices is a very powerful enhancement to traditional techniques. Thermal actuation and multi-functionality are other valuable properties that have produced an increased demand for development of these magnetic nanocomposites.

This work pursues the fabrication and characterization of nanocomposites based on polydimethylsiloxane (PDMS) with nickel nanoparticles and nanowires as fillers. Several attempts have been attempted to develop a successful mixing procedure that led to composites with uniform particle dispersions and good mechanical properties. In all cases, the ratio of the base to the curing agent was 10:1 and initially polymer curing was performed at room temperature. Early efforts include composite fabrication with and without sonication mixing of bare nickel nanoparticles in the PDMS matrix. Through evaluation of scanning electron microscope (SEM) images it was shown that dispersion was enhanced with sonication; however, the composite was still highly non-uniform. To further enhance uniformity, 1-octadecanethiol (ODT) was added as a surfactant to help prevent particle agglomeration. However it was discovered that ODT interacts with the polymer base even for very small particle concentrations (1% vol.), hindering the curing process. Finally, allyltrimethoxysilane (ATS) was used as a surfactant, which led to fabrication of composites with uniformly dispersed nanoparticles.

Next composites with ATS surfactant coated nanoparticles were prepared at 1%, 5%, 10%, 15% and 20% vol. concentration using the mixing process with sonication. They were cured at room temperature without degassing. All these samples underwent mechanical characterization, where stress strain curves collected from an Instron 5843 were evaluated over the elastic region of the curve to obtain Young's modulus. It was observed that the elastic modulus of the material decreased with increasing particle concentration, contradicting existing theory which predicts an increase. Furthermore the physical appearance of the samples with high particle concentration suggested a problem with the curing process, Hence differential scanning calorimetry (DSC) was used to characterize the curing properties of the polymer composite. It was concluded that the

curing temperature must be increased to 100°C to allow the polymer to fully cure in the presence of this increased amount of filler. In addition, a degassing process was implemented just before curing to remove air bubbles which may also affect mechanical properties of the composites. A new set of samples at particle concentrations of 5%, 10% and 15% were prepared under the elevated temperature with degassing. It was found that the elastic moduli of these samples are in agreement with predictions of the Einstein-Smallwood model, indicating that the polymer successfully cured at elevated temperatures and voids were successfully removed. Finally a qualitative magnetic characterization of the composites is carried out via magnetic force microscopy (MFM), which also indicated that the sample was highly uniform.