Surface Modification, Magnetic Field and Solvent Effects in Magnetoactive Elastomer Composites

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Magnetoactive elastomers (MAEs) are a class of soft composite materials composed of magnetic nano- or microparticles embedded within polymer matrices, capable of dynamically altering their mechanical behavior in response to external magnetic fields [1,2]. This tunable response makes MAEs highly attractive for applications in soft robotics, adaptive actuators, and vibration damping systems [1–3]. However, limitations in reproducibility and a lack of comprehensive understanding of their structure–property relationship continue to hinder their broader application.

This study investigates the effects of filler concentration, surface modification, solvent environment, and magnetic field exposure during curing on the microstructure and mechanical properties of MAEs based on a polydimethylsiloxane (PDMS) matrix with hexaferrite (HF) fillers. A primary focus is on preventing particle agglomeration and improving both filler distribution and compatibility with the polymer matrix. Surface modification of strontium hexaferrite (Sr-HF) microparticles using dodecylbenzene sulfonic acid (DBSA) slightly reduces agglomeration and enhances distribution. However, the use of 1-butanol as a solvent introduces porosity due to evaporation, affecting the mechanical properties of MAEs. The application of an external magnetic field during curing promotes some alignment of filler particles, in contrast to the random filler distribution observed in samples cured without a magnetic field. Rheological analysis reveals that 1-butanol, when used with scandium-substituted barium hexaferrite (BSHF) fillers, significantly delays curing (from 47 min in pure elastomer to 77 min in the MAE) and reduces crosslink density, thereby softening the polymer network (*G’* reduced from 7400 Pa to 3500 Pa). By systematically analyzing these effects and optimizing surface-modification strategy, this research aims to advance rational design of MAEs with programmable mechanical and magnetic responses.

Keywords: magnetoactive elastomers, hexaferrite, surface modification, soft robotics

References

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