85

Microparticle restructuring in densely packed magneto-active elastomers probed by neutron scattering

Author: Izidor Straus[1]

Co-authors: Arne Geldof[2]; Hartmut Lemmel[3]; Gašper Kokot[4]; Jürgen Klepp[5]; Raphael Kriegl[6]; Mikhail Shamonin[6]; Irena Drevensek Olenik[7]

[1] *Faculty of Mathematics and Physics, University of Ljubljana*
[2] *University of Ljubljana*
[3] *Institut Laue-Langevin (ILL), Grenoble, France; Faculty of Physics, University of Vienna, Vienna, Austria*
[4] *University of Ljubljana, Faculty of Mathematics and Physics, Ljubljana, Slovenia*
[5] *Faculty of Physics, University of Vienna, Vienna, Austria*
[6] *East Bavarian Centre for Intelligent Materials (EBACIM), Ostbayerische Technische Hochschule (OTH) Regensburg, Regensburg, Germany*
[7] *University of Ljubljana, Faculty of Mathematics and Physics*

We investigated magneto-active elastomers (MAEs), fabricated as composites of carbonyl iron microparticles (CIP) embedded in a soft PDMS matrix, that show large changes in their mechanical and surface properties when exposed to a magnetic field [1]. The main aim was to reveal the field-induced redistribution of microparticles in the elastomer matrix. We used ultra-small-angle neutron scattering (USANS) to probe *in situ* how the embedded microparticles reorganize under an applied magnetic field. The samples were films with a thickness of around 200 μm prepared with two different concentrations of CIP, 30 wt% and 75 wt%. The USANS beamline S18 at the ILL provided access to structural correlations over the length-scale interval 0.2–30 μm.

Using multilevel Guinier–Porod analysis of the detected scattering signal, we identified hierarchical structures and found that their characteristic length scales depend strongly on particle concentration. The analysis also revealed some limitations related to particle size polydispersity, interparticle interactions, and magnetic scattering contributions. In a magnetic field of around 300 mT, we observed clear anisotropic changes in the scattering signal, with different behavior parallel and perpendicular to the field. Changes at micrometer length scales were associated with particle rearrangement, while features detected on smaller length scales were attributed to magnetic scattering effects. To quantitatively interpret the observations, we performed Monte Carlo simulations based on dipole–dipole interparticle interactions. The simulations reproduced the observed anisotropy and revealed that particle displacements are relatively small and only weakly directional. Our work demonstrates that USANS is a powerful tool for direct probing of mesoscale restructuring in MAEs. It also provides new insight into the relationship between particle restructuring and modifications in the material's macroscopic mechanical properties.

Reference

[1] Stoll, A., Mayer, M., Monkman, G. J. & Shamonin, M. *Evaluation of highly compliant magneto-active elastomers with colossal magnetorheological response.* Journal of Applied Polymer Science 131 (2014).

Acknowledgments: We acknowledge financial support of ARIS (grant P1-0192), the Slovenian-German bilateral research project (ARIS-DAAD, BI-DE/25-27-003, Project-ID: 5773025), and the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation), project number 524921900.

Type:
Oral