Magneto-mechanical Coupling in Ferrohydrogel Composites

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The combination of magnetic and elastic properties by the incorporation of dipolar nanoparticles into polymer networks has proven to be a versatile way to manipulate the shape or mechanical performance of the matrix by external magnetic fields in several ways. Depending on the material´s assembly and the mode of the applied field, magnetostriction, the induction of dipolar interactions or magnetic heating are available.[1, 2] By using magnetically blocked particles, a direct cross-correlation between magnetic and mechanical characteristics is possible, as their magnetic reorientation is achieved by particle rotation.[3] This allows the investigation of the particles dynamics and the counter-forces of the polymer matrix concerning viscous and elastic effects by analyzing the magnetic properties in respect to hysteresis effects and the initial susceptibility of the integrated particles.[4, 5]

In this talk, we present the results of the analysis of magnetic properties of $CoFe_2O_4$ nanoparticles embedded in different polyacrylamide (PAAm) matrices. The utilized $CoFe_2O_4$ nanoparticles show magnetically blocked behavior and therefore it is possible to investigate the matrix's impact on the particles behavior. In detail, the variation of the architecture of the PAAm matrix and variation of the integration of the particles into the matrix opens the possibility to analyze the impact of different forms of interaction between the two components of the composite.

A novel class of ferrohydrogels is presented, that exhibit a direct covalent coupling between the particles and the polymer network segments. The coupling is generated by using surface functionalized $CoFe_2O_4$ nanoparticles as multifunctional cross-linkers in the synthesis of PAAm hydrogels. The particle-linked ferrohydrogels (NP-FHG) show an isotropic composition, and the swelling properties depend directly on the particle fraction.[6] We compared the magnetic behavior in VSM and swelling characteristics of the particle-linked ferrohydrogels with those of the conventional cross-linked PAAm ferrohydrogels (figure 1).[7]

The presented results give substantial insight in the network architecture and the multifaceted behavior of the novel materials, and open a pathway for the nanoscopic mechanical investigation of different materials by using magnetically blocked, dipolar particles as probes for viscous and elastic effects at the nanometer scale.

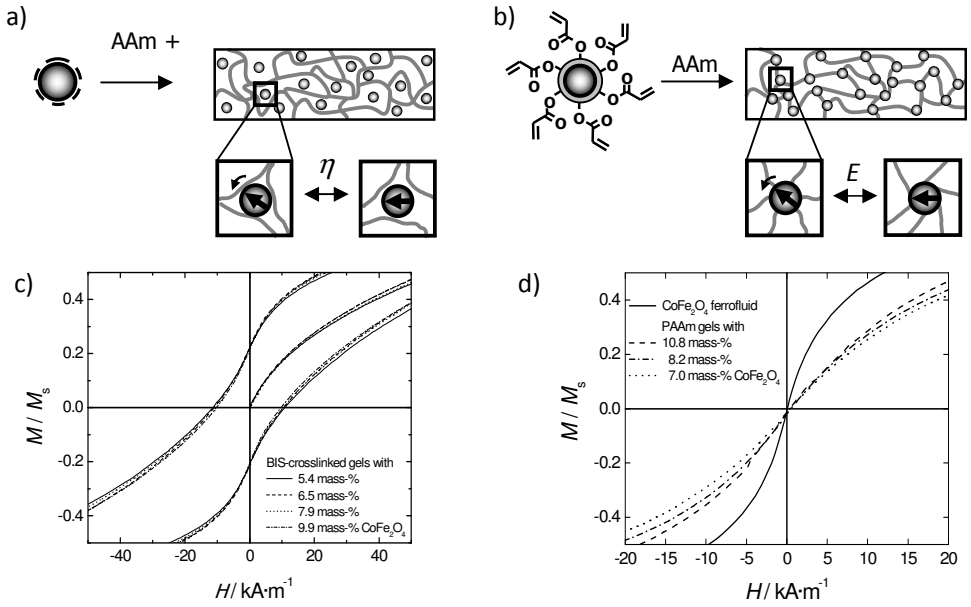

Figure 1: Synthesis and quasi-static magnetic properties of PAAm ferrohydrogels containing $CoFe_2O_4$ nanoparticles; a) conventionally cross-linked ferrohydrogels without chemical coupling between $CoFe_2O_4$ particles and the PAAm matrix; b) particle-linked ferrohydrogels where $CoFe_2O_4$ serve as multifunctional cross-linkers; c) normalized magnetization graphs of conventionally cross-linked gels and d) particle-linked gels of different composition

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