Magnetic and Dielectric Response of CoFe$_2$O$_4$@PU composites

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The combination of organic polymers and magnetic, semiconducting nanoparticles is a promising approach for the development of interactive polymer materials with a broad spectrum of magnetic and electric properties. The magnetic particles employed consist of nanocrystalline cobalt ferrite CoFe$_2$O$_4$ in the size range of 5 to 15 nm[1] modified with 3-methacryloxypropyl trimethoxysilane (MTS). These particles show ferromagnetic behavior, and are expected to display good loss properties. The nanoparticles serve as probes for the response to the applied external field.

In this work we present the magnetic and dielectric response of these CoFe$_2$O$_4$ nanoparticles homogeneously incorporated in a polyurethane (PU) matrix. By accomplishing the preparation in the external magnetic field, composites with a permanent anisotropy are obtained. Temperature dependent static and dynamic magnetization experiments give insight to the magnetic mobility in the matrix.[2]

Dielectric spectroscopy measurements offer the possibility to detect molecular motion in polymer matrices and thus to gain insights into the structure-property relationship of magnetic nanocomposites. The observed α- and β-relaxation processes were investigated for their temperature dependence. The glass transition temperature T_g calculated from the α process is compared to T_g obtained from differential scanning calorimetry (DSC). For the β process we observe an Arrhenius-like progression of the relaxation time, and the related activation energy with dependence on particle content. Evidently, the particles facilitate the β relaxation process in the polymer matrix, which results in higher dielectric losses.

The presented results give substantial insight to the structure-property relationship of nanocomposites subjected to external fields and may be of interest for the development of transparent, electromagnetically-active polymer coatings.
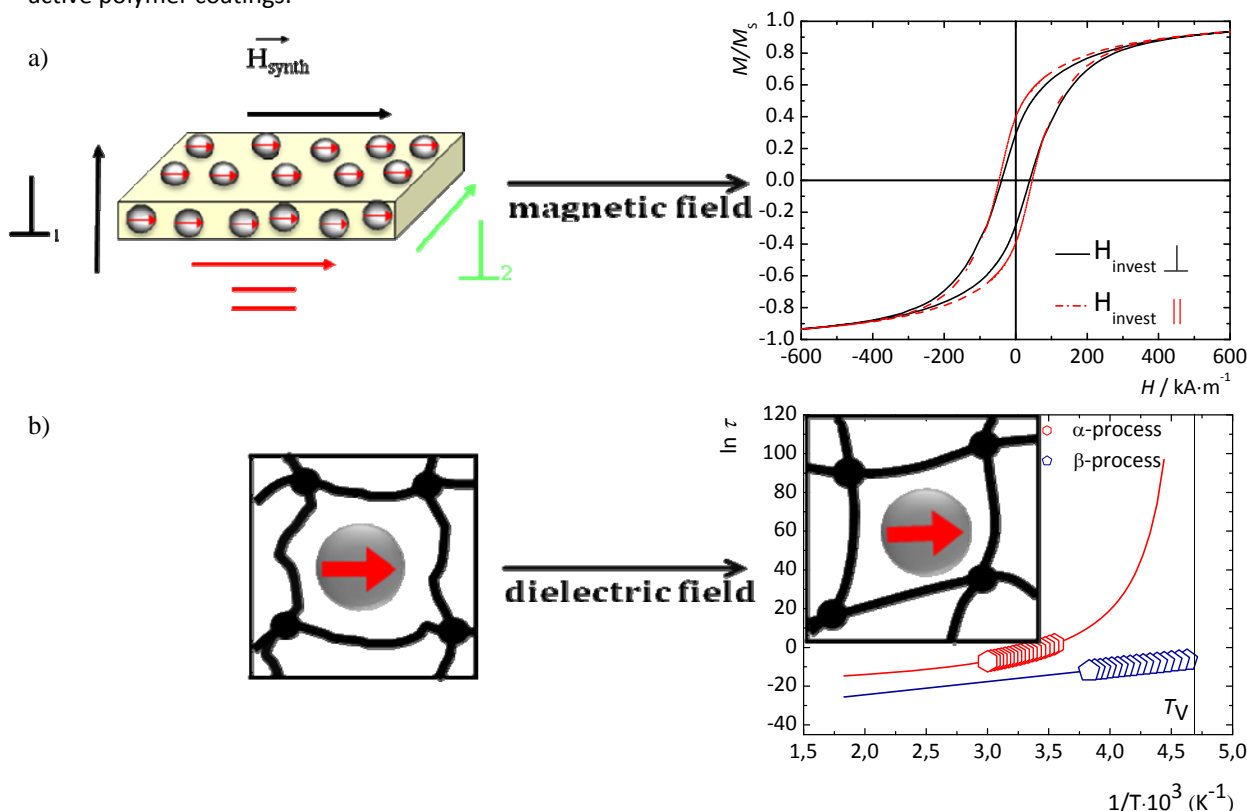
Figure 1: a) quasi-static magnetic properties of anisotropic CoFe$_2$O$_4$@PU composite; c) fitted curves of α- and β-relaxation processes from dielectric experiments

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2. Fricke, N.; Greenbaum A.; Gottlieb, M.; Schmidt A. M., Magnetic Properties and Dielectric Relaxation Dynamics in CoFe2O4@PU Nanocomposites. J. Phys. Chem., 2011, in revision