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Influence of deformation on the magnetic fabric and remanence of magnetic nanoparticles in an elastic matrix

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One of the earliest uses of the anisotropy of magnetic susceptibility (AMS) was to explain the deviation of paleomagnetic directions that were thought to be anomalous. Since these studies in the 1960's, later investigations focused on how the natural remanent magnetization in sediments can be deflected assuming that ferromagnetic minerals are reoriented during deformation of a rock or sediment. Because ferromagnetic grains are often rheologically stronger than the matrix material, they are modeled by rigid particles in a ductile matrix. This study examines how magnetic fabric and remanence are altered under uniaxial extension of a hybrid nanocomposite that contains ellipsoidal particles of maghemite embedded in a liquid-crystalline elastomer network. The dimension of the maghemite particles is approximately 310 nm by 55 nm, and they are covered with a silica shells that adds about 22 nm in length and 18 nm in width. Their concentration in the elastomer is 10% in weight. Analysis of first order reversal curves indicates that there is very little particle interaction in the undeformed and deformed materials. The AMS was measured in both low field on an AGICO MFK-1a susceptibility bridge and in high field with a torsion magnetometer. The undeformed sample shows no anisotropy in the plane of the elastomer film using low-field AMS. When the nanocomposite film is stretched with lambda = 3.2, the AMS is 25% higher and the maximum susceptibility is in the direction of stretching. The increase in anisotropy is less than predicted by the Stoner-Wohlfarth theory, which can be explained by the fact that the particles may not be purely single-domain, and are not perfect ellipsoids. The high-field AMS further validates these results.

The nanocomposite material was given an anhysteretic or isothermal remanent magnetization either perpendicular to the stretching direction or at 45°. Initial tests show that low extension (lamda = 1.1) leads to a slight increase in the degree of magnetic anisotropy but no deflection in the direction of the remanence. Higher extension (lambda = 1.46) leads to a stronger lineation. The deflection in the direction of remanent magnetization, however, is on the order of a few degrees. Results from the experiments will be compared to theoretical relationships comparing the remanence deflection with passive and ductile deformation.