Scientists study 'smart' magnetic gel in a magnetic field

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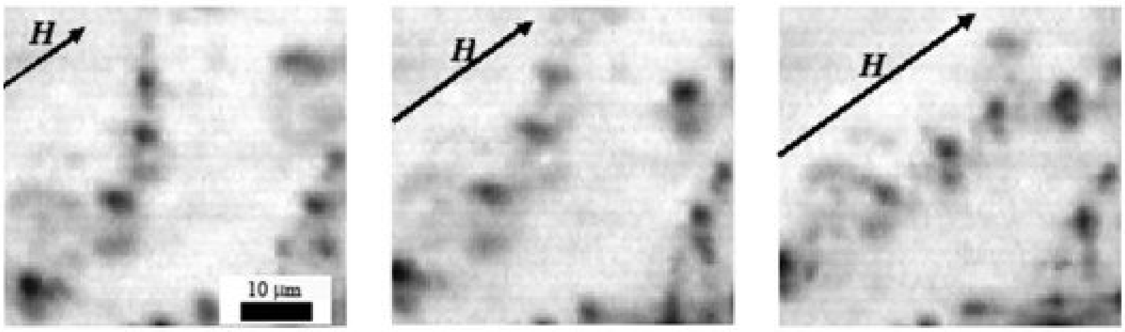

Microphotographs of magnetic polymers with particles forming chain aggregates directed along the magnetic field H. Credit: Andrey Zubarev

Magnetic gels are the new generation of "smart" composite materials. They consist of a polymer medium and nano- or micro-dimensional magnetic particles embedded in it. These composites are frequently used in magnetically controlled shock absorbers, stabilizers, safety systems, and mechanical stress amplifiers, as well as in biotechnology for the purpose of regeneration of biological tissues. A remarkable feature of magnetic gels is their ability to change their elastic properties under the influence of moderately strong magnetic fields. However, the dependence of elastic characteristics of these materials on the external field remains a poorly studied issue. Recently, the physical nature of these dependencies was investigated by Alexander Zubarev, a professor at the Ural Federal University. He presented his findings at the international conference IBEREO 2017 (Valencia, Spain, 6-8 September).

Magnetic gels are a relatively new type of composite multifunctional material. The first studies on their synthesis date back to the late 1980s to the early 1990s, but studies began in earnest only 10 years ago. Magnetic gels are manufactured on the basis of both synthetic and biological polymers depending on the application. The size of the embedded magnetic particles varies from scores of nanometers to scores of microns. One of the most interesting features of magnetic gels is their ability to change their mechanical properties (coefficients of elasticity and viscoelasticity) by several times and even orders of magnitude under the influence of moderate magnetic fields, easily created in laboratories and in industry.

These unique properties are based on the ability of magnetic particles to preserve the most energetically favorable mutual position in a magnetic field of a given magnitude. When the material is deformed, this arrangement is disrupted, but the particles, under the influence of magnetic interaction forces, tend to return to it. This generates an additional, often very strong, elastic reaction of the material to its deformation. The ability to control the elastic response of a magnetic gel with a magnetic field is very promising for many industrial and medical technologies.

It has been demonstrated that the magnetoelastic phenomena in magnetic gels are largely determined by the initial spatial arrangement of the particles in the carrier polymer. In the new work of Andrei Zubarev (professor of the Department of Theoretical and Mathematical Physics, Ural Federal University, Russia), the deformations of a polymer sample with an initial homogeneous (as a molecule in gas) spatial distribution of magnetizable particles were investigated. The results achieved by Zubarev and his colleagues reveal the peculiarities of the change in the mutual arrangement of particles under the influence of the field and the general deformation of the composite, the influence of these features on the elasticity coefficients of the material. The theory predicts the possibility of radical increase of the stiffness of the composite in an external field.

In the future, scientists are going to work with materials that are synthesized in an external magnetic field. In this case, the particles, under the influence of magnetic attraction, form different structures (linear chains, dense columns, etc.), which are able to greatly strengthen both the elastic properties of the material and the magnetomechanical phenomena in it.

Provided by Ural Federal University

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