Modeling of field-controllable polymers for mechanical applications

M. Saphiannikova

Leibniz Institute of Polymer Research Dresden, Theory of Polymers, Hohe Strasse 6, 01069 Dresden, Germany, E–mail: grenzer@ipfdd.de

Field-controllable polymers define a class of applied materials exhibiting a strong coupling of mechanical and external fields. Typically, such polymers represent at least a two-component system: polymer matrix and functional moieties either embedded into the matrix or attached to it covalently. Although the external field acts only on functional moieties, its work is transformed to the polymer matrix due to mechanical coupling between the phases. Prominent examples of field-controllable polymers are (i) photo-deformable azopolymers which are able to transform light energy into mechanical stress and (ii) magneto-sensitive elastomers (MSEs). The latter are loaded with micron-sized iron particles and feature mechanical moduli that become strongly enhanced under magnetic field as well as the ability for magnetically induced deformations.

Obviously, both materials have a great potential for diverse actoric applications, e.g. serving as artificial muscles. For example, complex director fields imprinted into azo-containing liquid crystalline elastomers lead to sophisticated photomechanical response, resembling autonomous mechanical actions in living systems. Because of their unique properties, there is strong commercial interest to the applications of MSEs in numerious fields, from automotive to medicine. Prediction of mechanical properties is based on minimisation of the free energy which contains the elastic energy of the polymer matrix as well as the interaction energies of functional moieties with the field and each other. The application of external fields oft causes a considerable evolution of the local material structure. For azopolymers it is possible to predict time-dependent reorientation of the polymer backbones and appearance of the light-induced stress that dictates a direction of the macroscopic deformation.

In this presentation, a recent progress in the modeling of both field-controllable materials will be discussed. In particular, some examples how the local material structure defines the macroscopic properties and appropriate material models will be given.