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Modelling of electro-active elastomers on the basis of molecular chain statistics

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Mechanical response of dielectric elastomers can be influenced or even controlled by an imposed electric filed. It can, for example, cause mechanical stress or strain without any applied load. The latter phenomenon is referred to as electrostriction. There are many phenomenological hyperelastic models describing this electro-active response of dielectric elastomers. There, coupled electro-elastic terms are of special importance. So far, these terms have not got any physical reasoning. In the simplest case, the electric potential is represented by a quadratic function of an electric variable such as electric field, displacement or polarization. Some polyconvex electroelastic strain energies have also been proposed. In this contribution (see also [1] for more details), we propose an electro-mechanical constitutive model based on molecular chain statistics. The model considers polarization of single polymer chain segments and takes into account their directional distribution. The latter one results from the non-Gaussian chain statistics taking finite extensibility of polymer chains into account. The so resulting (one-dimensional) electric potential of a single polymer chain is further generalized to the (three-dimensional) network potential. To this end, we apply directional averaging on the basis of the numerical integration over the unit sphere. A numerical algorithm with 45 points on a half-sphere has been utilized. In a special case of the eight-chain (Arruda-Boyce) model the directional averaging is obtained analytically. It results in an analytical invariant-based electroelastic constitutive model of dielectric elastomers. The proposed model includes a few number of physically interpretable material constants and demonstrates good agreement with experimental data.

REFERENCES

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