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Bejenariu, Anca Gabriela; Skov, Anne Ladegaard

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New Soft Polymeric Materials Applicable as Elastomeric Transducers

Anca G. Bejenariu and Anne L. Skov
Department of Chemical and Biochemical Engineering, DTU
Soltofts Plads, Building 227
agb@kt.dtu.dk;al@kt.dtu.dk

Poster

An elastomer is a material characterized by the capability to regain its original size and shape after being deformed (stretched or distorted). An ideal elastomer for electroactive polymer (EAP) applications is a system characterized by high extensibility, flexibility and a good mechanical fatigue.

Dielectric elastomers (DEs) are part of electronic EAPs presenting a good combination of electromechanical properties such as high achievable strains and stresses, fast response speeds, long lifetime, high reliability and high efficiency[1].

Subjected to a voltage, a polymeric electroactive material sandwiched between two compliant electrodes will reduce its thickness and expand its area. The electrical energy transformed into mechanical energy is called actuation and it is studied in the technology of elastomeric transducers. While DEs deform under high voltage, the actuation varies for different materials (ceramics[2], glassy polymers[3] or soft polymeric networks[4-6]). The strain actuation for stiff materials such as glassy or semicrystalline polymers is limited by the electrical breakdown[7], while the deformation upon actuation for soft materials is limited by the electromechanical breakdown[8]. This paper presents new soft polymeric materials based on silicone with improved mechanical properties.

Figure 1 shows several materials that exhibit large deformation upon actuation[9].

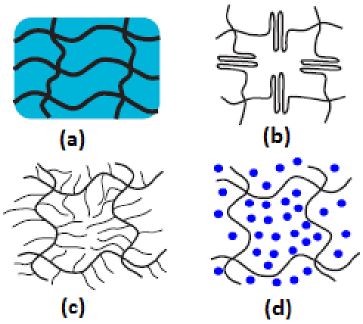

Figure 1. Polymeric networks that exhibit large strain actuation: (a) fibers embedded in a compliant matrix, (b) polymer network with folded domains, (c) polymer network with side chains and (d) polymer network swollen in solvent[9].

Silicone elastomers exhibit good characteristics including biocompatibility, oxidation resistance, thermal stability, fast mechanical response with good reproducibility and stable mechanical behaviour over a wide range of temperature[10-13]. However, silicone elastomer has weak intermolecular forces among polymeric chains, which limits its mechanical strength. Mechanical properties may be improved using different methods (adding fillers[14], interpenetrating network synthesis[15] or bimodal network synthesis[16]). In the present study hyperswollen silicone networks are synthesized and rheologically characterized. Their viscoelastic properties make them good candidates for elastomeric transducers.

Silicone networks are synthesized using a hydrosilylation reaction at room temperature between vinyl-terminated polydimethyl siloxanes (PDMS), a 4-functional crosslinker and a platinum catalyst. A 'one-step two-pot' mixing procedure is applied and to each premix 70% solvent (heptane) is added. The use of solvent causes networks with fewer entanglements, thus giving the polymeric chains opportunity to act as undisturbed ideal springs.

The viscoelastic behavior as function of the applied frequency (LVE diagram) is shown for different hyperswollen networks with varying stoichiometric imbalance (r). The results are compared with results of similar un-swollen networks. The hyperswollen networks are significantly softer and still easy to handle.

From a mechanical point of view, the materials for EAPs use have to be soft with sufficient mechanical strength so the rupture of the material can be avoided at high strain actuation. Considering the EAP requirements and the experimental data for the hyperswollen networks based on silicone, these materials may be considered as good alternatives for the EAP application.

References

1. Pelrine, R., Kornbluh, R., Pei, Q. and Joseph, J., Science 287, 836-839 (2000)

2. S. E. Park and T. R. Shrout, J. Appl. Phys. 82, 1804 (1997)

3. Q. M. Zhang, V. Bharti, and X. Zhao, Science 280, 2101 (1998)

4. M. Zhenyl, J. I. Scheinbeim, J.W. Lee, and B. A. Newman, J. Polym. Sci. B 32, 2721 (1994)

5. R. Shankar, T.K. Ghosh, and R. J. Spontak, Adv. Mater. 19, 2218 (2007)

6. C. Keplinger, M. Kaltenbrunner, N. Arnold, and S. Bauer, Proc. Natl. Acad. Sci. U.S.A. 107, 4505 (2010)

7. T. Blythe and D. Bloor, Electrical Properties of Polymers (Cambridge University Press, Cambridge, England, 2005)

8. X. H. Zhao and Z. G. Suo, Appl. Phys. Lett. 91, 061921 (2007)

9. X. Zhao and Z. Suo, Phys. Rev. Let. 104, 178302 (2010)

10. J. Heiner, B. Stenberg, M. Persson , Polym. Test 22, 253 (2003)

11. L. Meunier, G. Chagnon, D. Favier, L. Orgeas, P. Vacher, Polym. Test 27, 765–77 (2008)

12. P.B. Liu, D.L. Liu, H.W. Zou, P. Fan, W. Xu, J. Appl. Polym. Sci. 113, 3590 (2009)

13. E.S. Park, J. Appl. Polym. Sci.110, 1723 (2008)

14. M.J. Wang, M.D. Morris, Y. Kutsovsky, KGK-Kaut Gummi Kunst 65, 107 (2008)

15. A. Ghosh, B. Kumar, A.K. Bhattacharya, S.K. De, J. Appl. Polym. Sci. 88, 2377 (2003)

16. A.G. Bejenariu, Boll, M., Lotz, M.R., Vraa, C., Skov, A.L., SPIE Smart Structures, San Diego 7976, (2011)