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Investigation of the strain behavior of amorphous polyurethane elastomers

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Abstract

The strain behavior of two series of amorphous polyurethane elastomers on the base of olygoetherdiols and oligodienediols under stretching with a constant rate was investigated. Samples of the each series being varied in the network density value only demonstrated high-elastic behavior with some hardening effect in the final stage of the strain process. The stress versus strain dependence of investigated objects was described using the early proposed approach, taking into account high-elastic properties of elastomers and relaxation properties as well. A significant feature of the mentioned approach was separate accounting contributions to the stress value of stabile (chemical) cross-linking bonds and labile ones; this allowed taking into account the hardening effect on the total stress value in strained material. This accounting was provided using the transformation function which type depended on the type of considered polymer chains. The use of the mentioned function provided an adequate accounting varying in the polymer chains elasticity within the strain process. It was experimentally found that the chemical network density of investigated samples did not vary with the strain process up to the rupture allowing use of elements of basic equations of modern approaches in the framework of high-elasticity theory. The closeness of the experimental values of relaxation parameters for elastomers for the same series of samples allowed using average values of these parameters that lead to significant simplification of the applied calculations. Thus, bases for developing an engineer-theoretic approach to predict strain behavior of elastic materials under non-equilibrium conditions were created. The obtained parameters allowed adequately describing stress versus strain relationships for all investigated objects.

References

[1] H.W. Greensmith. Rupture of Rubber. VII. Effect of Rate of Extension in Tensile Tests. *Journal of Applied Polymer Science*. **1960**. Vol.3. P.175-182.
[2] M. Cheng, W. Chen. Experimental investigation of the stress-stretch behavior of EPDM rubber with loading rate effects. *International Journal of Solids and Structures*. **2003**. Vol.40. P. 4749-4768.
[3] A.A. Shergold, N.A. Fleck, D. Radford. The uniaxial stress versus strain response of pig skin and silicone rubber at low and high strain rates. *International Journal of Impact Engineering*. **2006**. Vol.32. P.1384-1402.
[4] V.V. Tereshatov, V.Yu. Senichev. On the deformation behavior of spatially crosslinked polybutadieneurethanes. *High-Molecular Compounds. Ser. A*. **1995**. Vol.37. P.1166-1169. (russian)
[5] S.S. Sarva, S. Deschanel, M.C. Boyce, W. Chen. Stress-strain behavior of a polyurea and polyurethane from low to high strain rate. *Polymer*. **2007**. Vol.48. P. 2208-2213.
[6] S.S. Sarva, A.J. Hsieh. The effect of microstructure on the rate-dependent stress-strain behavior of poly(urethane urea) elastomers. *Polymer*. **2009**. Vol.50. P. 3007-3015.
[7] C.M. Roland, J.N. Twigg, P.H. Mott. High strain rate mechanical behavior of polyurea. *Polymer*. **2007**. Vol.48. P. 574-578.
[8] J. Yi, M.C. Boyce, G.F. Lee, E. Balizer. Large deformation rate-dependent stress–strain behavior of polyurea and polyurethanes *Polymer*. **2006**. Vol. 47. P. 319-329.
[9] D.A. Doman, D.S. Cronin, C.P. Salisbury. Characterization of polyurethane rubber at high deformation rates. *Experimental Mechanics*. **2006**. Vol.46. P. 367-376.

[10] C. Prisacariu. Polyurethane Elastomers from Morphology to Mechanical Aspects. *Wien, New York: Springer-Verlag*. **2011**. 255p.
[11] T. Thomson. Polyurethanes as Specialty Chemicals: Principles and Applications. Boca Raton: *CRC Press*. **2005**. 99p.
[12] D. Randall, S. Lee. The Polyurethanes Book. *New York: Wiley*. **2003**. 494p.
[13] I. Yilgor, E. Yilgor, G.L. Wilkes. Critical parameters in designing segmented polyurethanes and their effect on morphology and properties: A comprehensive review. *Polymer*. **2015**. Vol.58. P.A1-A36.
[14] M. Szycher. Szycher's handbook of polyurethanes. Boca Raton: *CRC Press*. **1999**. 269p.
[15] V.V. Tereshatov, M.A. Makarova, V.Yu. Senichev, A.I. Slobodinyuk. Interrelation between ultimate mechanical properties of variously structured polyurethanes and poly(urethane urea)s and stretching rate thereof. *Colloid and Polymer Science.* **2012**. Vol.7. P. 641-651.
[16] V.V. Tereshatov, M.A. Makarova, V.Yu. Senichev, E.R. Volkova, Zh.A. Vnutskikh, A.I. Slobodinyuk. The role of the soft phase in the hardening effect and the rate dependence of the ultimate physico-mechanical properties of urethane-containing segmented elastomers. *Colloid and Polymer Science.* **2015**. Vol.293. P.153-164.
[17] Valery Yu. Senichev, Vasily V. Tereshatov, Marina A. Makarova, and Alexey I. Slobodinyuk. Describing strain behavior of cross-linked elastomers under stretching with constant rate. *Butlerov Communications*. **2016**. Vol.45. No.2. P.97-102. DOI: 10.37952/ROI-jbc-01/16-45-2-97
[18] V.V. Tereshatov, V.Yu. Senichev. Stress-Strain Dependence of Cross-Linked Single-Phase Polyether Urethane. *Journal of Macromolecular Science, Part B: Physics*. **2014**. Vol.53. P.575-587.
[19] G.M. Bartenev, N.M. Lyalina. Relaxation of stress in mesh rubber-like polymers. *High-molecular Compounds. Ser. A.* **1970**. Vol.12. No.2. P.368-384. (russian)
[20] V.V. Tereshatov, V.Yu. Senichev. Stress-Strain Dependence of Segmented Polyurethanes and Polyurethane Ureas. *Journal of Macromolecular Science, Part B: Physics*. **2015**. Vol.54. P.365-380.