Proceedings IRF2018: 6th International Conference Integrity-Reliability-Failure
Lisbon/Portugal 22-26 July 2018. Editors J.F. Silva Gomes and S.A. Meguid
Publ. INEGI/FEUP (2018); ISBN: 978-989-20-8313-1

PAPER REF: 7060

MECHANICAL BEHAVIOR OF NEW POLYUREA ELASTOMERS: CONSTITUTIVE MODELLING

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ABSTRACT

The elastic properties of new polyurea elastomers with different segmental molecular weight have been studied in order to observe their mechanical behavior and to find a constitutive model that properly describes it. These new polyurea elastomers are polymers composed of hard and soft segments due to the variation in the segmental molecular weight and the degree of polymerization of the end group.

Keywords: mechanical analysis, stress-strain behaviour, new polyureas elastomer, rubber.

INTRODUCTION

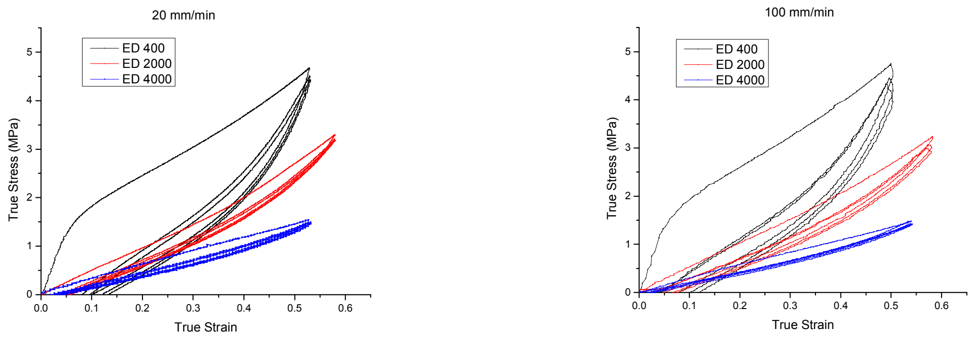
Elastomeric polyurea materials can be found in several day-to-day applications (Hergenrother, 1994). In many applications, elastomeric components are subjected to cyclic deformation and/or multiaxial stress states. This work is concerned with the mechanical evaluation of new polyurea elastomers composed by hard (HS) and soft segments (SS) arisen from the variation in the segmental molecular weight and the degree of polymerization of the end group (Sanchez-Ferrer, 2015).

Herein, stress-strain tensile tests and constitutive models capturing the major features of the stress-strain behavior of new polyurea elastomers, including nonlinear hyperelastic behavior, time dependence, hysteresis, and softening, are presented.

RESULTS AND CONCLUSIONS

Mechanical Testing

Figures 1(a) and 1(b) show the mechanical behavior for the three ED series materials under two different strain rates (100%/min and 500%/min). Depending on the chemical structure of the materials, different behaviors were displayed. For the ED 2000 and 4000 samples, in which the volume percentage of hard domains is lower, a typical elastomeric with moderate hysteresis is observed. On the other hand, for sample ED 400 the loading curves show an initially stiff response, followed by a rollover to a more compliant behavior at a strain of about 0.1, and stiffen again after a strain of 0.4. The unloading path shows a large hysteresis loop with a residual strain. This unusual behavior can be interpreted as a “glass-like” response with a clear yield event followed by a modest hardening consistent with the presence of a relatively large amount of hard domains.

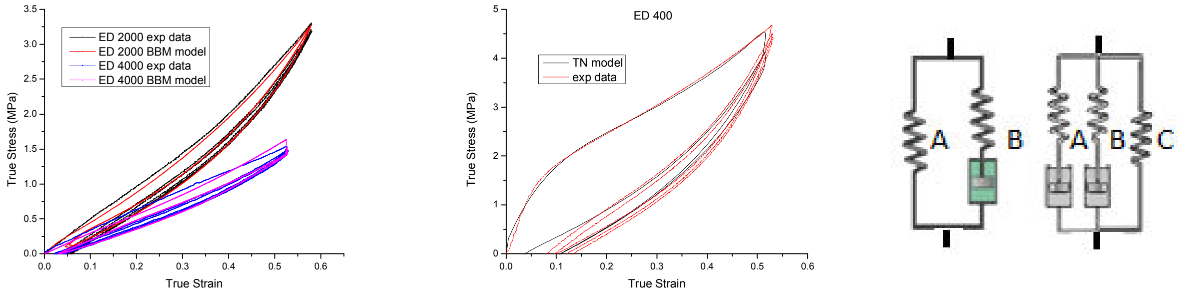


(a) (b)

Fig. 1 - Tensile test for complete ED series with 3 loading-unloading cycles up to a maximum ε = 0.6. (a) strain rate 100%/min; (b) strain rate 500%/min

Constitutive Modelling

It was found that for the ED 4000 and ED 2000, which show a typical elastomeric response, a viscoelastic constitutive model such as Bergström-Boyce with Mullins effect (BBM) (polymerfem.com), accurately fitted the experimental data, Figure 2(a). On the contrary, for the ED 400, which displays a mixed mechanical response with “elastomeric” and “glass-like” features, the use of a more complex visco-plastic constitutive model such as the Three Network (TN), (polymerfem.com), was needed, Figure 2(b), in order to accurately capture material response.



(a) (b) (c) (d)

Fig. 2 - Experimental result vs constitutive model for: (a) ED 4000 and ED 2000; (b) ED 400; (c) BBM scheme; (d) TN scheme

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