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HOW LOADING TYPE AFFECTS VISCOELASTIC RESPONSE IN POLYURETHANE STRUCTURES

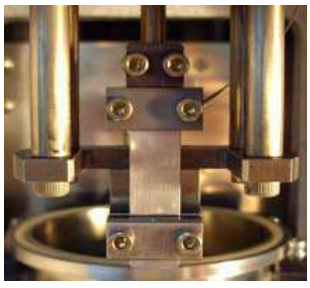
M. Cristea[1], D. Ionita[1], S. Oprea[1] and E. A. Pieczyska[2]
[1]*"Petru Poni" Institute of Macromolecular Chemistry, Iasi, Romania*
[2]*Institute of Fundamental Technological Research, Warsaw, Poland*

1. Introduction

Specialists in polymers have a good understanding of the structure-property relation. They can choose the reactants, modify the synthesis conditions or the processing parameters in order to obtain polymeric materials with appropriate characteristics. However, all the characteristics of the polymeric materials are obtained in quasi-ideal conditions, i.e. the measured parameters are confined in a range wherein they obey some laws. When polymers are materials used in applications, the approaching of their properties should be done in a larger context. Among shape-memory materials, polymers provide a large variety of structures and applications. Polyurethanes are excellent candidates for shape-memory materials due to their segregated structures, with hard and soft domains [1]. The hard domain consists of hydrogen-bonding physical crosslinks that are responsible for the permanent shape structure. The amorphous soft domains represent the temporary shape. Mostly, polyurethanes are glass transition-type shape memory polymers [2]. This means that the variation of the storage modulus during the glass transition (determined by dynamic mechanical analysis-DMA) is the basis for the shape memory effect [3]. The glass transition temperature is regarded as a fingerprint of a polymer. Nevertheless, the analysis of the relation structure-properties only on the basis of a temperature value is not quite compelling [4]. The presentation intends to present the viscoelastic behaviour of polyurethane structures with the same glass transition temperature. The use of different fixtures in the DMA experiment helps in getting information on the structure-property correlation.

2. Experimental procedure, discussion

The DMA experiments were conducted on a Perkin Elmer DMA, in tension, shear and bending (Figure 1, a, b and c).


a)

b)

c)

Figure 1. Fixtures used in the DMA experiments: tension (a), shear (b), bending (c).

It should be mentioned that the characteristics of the samples (stiffness, dimensions) allow for the use of all three loading modes. The single-frequency temperature scanning experiment was run by increasing the temperature in ramp mode with 2 ^{o}C/min, at 1 Hz, starting from -150 ^{o}C. Also, multifrequency experiments were performed to establish the nature of some processes.

In the glassy region, all the samples are rigid, with storage modulus higher than 10^9 Pa. Due to structural specificities the order of rigidity is reversed during the glass transition. The multifrequency experiment indicates the unpacking of some polyurethane networks. Each loading mode features a specific phenomenon.
The tension mode stabilized the sample in the rubbery region, due to stress-induced orientation.
The bending mode revealed the strong effect of melting/crystallization on the stability of the samples.
The shear mode draw attention to enthalpic relaxation phenomena.

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