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Ultrasonic Studies of Polyurea Elastomer Composites with Inorganic Nanoparticles

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Abstract : Inorganic nanoparticles are used for fabrication of various composites based on polymer materials because they exhibit a good homogeneity and solubility of the composite material. Multifunctional materials based on composites of a polymer containing inorganic nanotubes are expected to have a great impact on industrial applications in the future. An emerging family of such composites are polyurea elastomers with inorganic MoS2 nanotubes or MoSI nanowires. Polyurea elastomers are a new kind of materials with higher performance than polyurethanes. The improvement of mechanical, chemical and thermal properties is due to the presence of hydrogen bonds between the urea motives which can be erased at high temperature softening the elastomeric network. Such materials are the combination of amorphous polymers above glass transition and crosslinkers which keep the chains into a single macromolecule. Polyurea exhibits a phase separated structure with rigid urea domains (hard domains) embedded in a matrix of flexible polymer chains (soft domains). The elastic properties of polyurea can be tuned over a broad range by varying the molecular weight of the components, the relative amount of hard and soft domains, and concentration of nanoparticles. Ultrasonic methods as non-destructive techniques can be used for elastomer composites characterization. In this manner, we have studied the temperature dependencies of the longitudinal ultrasonic velocity and ultrasonic attenuation of these new polyurea elastomers and composites with inorganic nanoparticles. It was shown that in these polyurea elastomers large ultrasonic attenuation peak and corresponding velocity dispersion exists at 10 MHz frequency below room temperature and this behaviour is related to glass transition Tg of the soft segments in the polymer matrix. The relaxation parameters and Tg depend on the segmental molecular weight of the polymer chains between crosslinking points, the nature of the crosslinkers in the network and content of MoS2 nanotubes or MoSI nanowires. The increase of ultrasonic velocity in composites modified by nanoparticles has been observed, showing the reinforcement of the elastomer. In semicrystalline polyurea elastomer matrices, above glass transition, the first order phase transition from quasi-crystalline to the amorphous state has been observed. In this case, the sharp ultrasonic velocity and attenuation anomalies were observed near the transition temperature TC. Ultrasonic attenuation maximum related to glass transition was reduced in quasicrystalline polyureas indicating less influence of soft domains below TC. The first order phase transition in semicrystalline polyurea elastomer samples has large temperature hysteresis (> 10 K). The impact of inorganic MoS2 nanotubes resulted in the decrease of the first order phase transition temperature in semicrystalline composites.

Keywords : inorganic nanotubes, polyurea elastomer composites, ultrasonic velocity, ultrasonic attenuation
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