Effect of intermolecular forces in mechanical behavior of elastomers
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ABSTRACT
Importance of intermolecular forces (interactions of molecular chains) in the characteristic mechanical behavior of elastomers is studied. To focus on the microstructure of sulfur vulcanized rubbers, different network structures of NR/SBR elastomeric blends are investigated. The main difference of these structures comes from the ratio of sulfur to accelerator content in the curing systems. This ratio specifies the proportion of poly-sulfidic crosslinks in comparison with mono or di-sulfidic ones. In this study, three different curing systems (conventional, semiefficient, and efficient systems) are used to vulcanize the NR/SBR elastomeric blends. The vulcanized samples are exposed to uniaxial tensile tests to examine the effect of the curing systems on the material stress-strain behavior. The Exp-Ln hyperelastic model is utilized to formulate the mechanical behavior of the tested elastomers by dividing it into two independent (and also competitive) mechanisms; the entropic conformations of the molecular chains and the interactions of molecular chains. An exponential term is proposed to the former mechanism and a logarithmic term accounts for the latter one. Application of this model to the experimental data obtained from samples cured by different systems makes it possible to relate the material parameters of the model to the physical properties of the material molecular network especially to strength of the intermolecular forces. Furthermore, the curing system may affect the amount of physical entanglements. Therefore, the tube model is used to separate the contributions of chemical crosslinks and physical entanglements in the stress–strain behavior. Because the strength of intermolecular forces is the main difference between rubbery elastomers and thermoplastic elastomers, the results of this study can also be extended to model the mechanical behavior of thermoplastic elastomers.