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Computational Characterization of Micro- to Macroscopic Mechanical Behavior of Carbon Black-Filled Rubber

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The deformation behaviors of rubber under macroscopically uniform tension, and of a plane-strain rubber unit cell containing cylindrical carbon black were investigated by computational simulation with the nonaffine molecular-chain network model. The results revealed the mechanisms of the enhancement of deformation resistance and hysteresis loss, i.e., Mullins effect, occurring in stress-stretch curves under cyclic deformation processes. The increase of volume fraction and of the heterogeneity of the distribution of carbon black substantially raises the resistance to deformation and hysteresis loss. The concentration of deformations and orientation hardening in the rubber phase are responsible for these characteristic behaviors.

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