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An effective temperature theory coupling structural evolution and viscoplastic deformation of glassy polymers THAO NGUYEN, Department of Mechanical Engineering, Johns Hopkins University, RUI XIAO, Department of Engineering Mechanics, Hohai University — Glassy polymers are amorphous polymers that have been driven out of equilibrium below the glass transition temperature. In the nonequilibrium state, the polymer chains continue to slowly rearrange towards a lower entropy state, which causes physical properties to change with time in a process referred to as physical aging. Physical aging can be reversed by plastic deformation, which moves the material further away from equilibrium. Though structural evolution and viscoplasticity are interdependent, they have been treated as separate processes and described by different theoretical approaches. Here, we introduce a new theory that strongly couples viscoplasticity and structural evolution through an effective temperature thermodynamic framework and a constitutive model for the dependence of the relaxation time on the configurational structure. The theory can describe a wide range of nonequilibrium behaviors, including viscoplasticity, physical aging, mechanical rejuvenation, and the glass transition, using a common set of parameters. We will show comparisons of theoretical predictions and experimental measurements of the effect of cold work and aging on the viscoplastic stress response and energy storage as measured by dynamic scanning calorimetry.

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