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Role of enhanced segmental mobility in the deformation of polymer glasses

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The mechanical properties of polymer glasses, including plastic flow, are important for many applications. In contrast to the flow of polymer melts, plastic flow is poorly understood at a fundamental level. One reason for this is that the deformation of polymer glasses typically occurs in a highly nonlinear regime, e.g., doubling the strain rate has little impact on the flow stress. Eyring proposed that stress increases the rate of molecular rearrangements in solids and this is the source of nonlinearity in many models. In this talk, experiments measuring molecular mobility during constant strain rate deformation of a polymer glass will be described for the first time. In these experiments on PMMA, the mobility initially increases in the pre-yield regime, by a factor of up to 160, as compared to the undeformed glass. After yield, the mobility remains constant even as the stress is decreasing; this non-Eyring effect is consistent with the view that the sample is being pulled higher on the potential energy landscape. For the range of strain rates investigated, mobility and strain rate are linearly correlated, consistent with the view that enhanced segmental mobility enables the flow of polymer glasses.