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Dynamics of polymer glasses under active deformation.[1]

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Polymer glasses can often be deformed significantly without breaking. What microscopic mechanism allows this "flow" under conditions where mobility is otherwise absent? We utilize an optical photobleaching technique to measure the segmental mobility of polymer glasses and nanocomposites during active deformation. It has been previously established that the reorientation of dilute dye molecules (on the time scale of thousands of seconds) can monitor the segmental dynamics of a polymer melt. Here we utilize this method to measure mobility during tensile deformation of a free-standing poly(methyl methacrylate) glass. We have observed increases in mobility during deformation from Tg-10 K to Tg -30 K, with larger changes at lower temperatures. At Tg-18 K, with a strain rate of 0.00001/s, segmental mobility increases slowly at first and then dramatically, so that the increase in mobility during deformation reaches a factor of about 200. After removing the stress, we observe that the enhanced mobility disappears slowly. These measurements are compared to continuum and mesoscopic models of polymer glass dynamics and rheology.

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