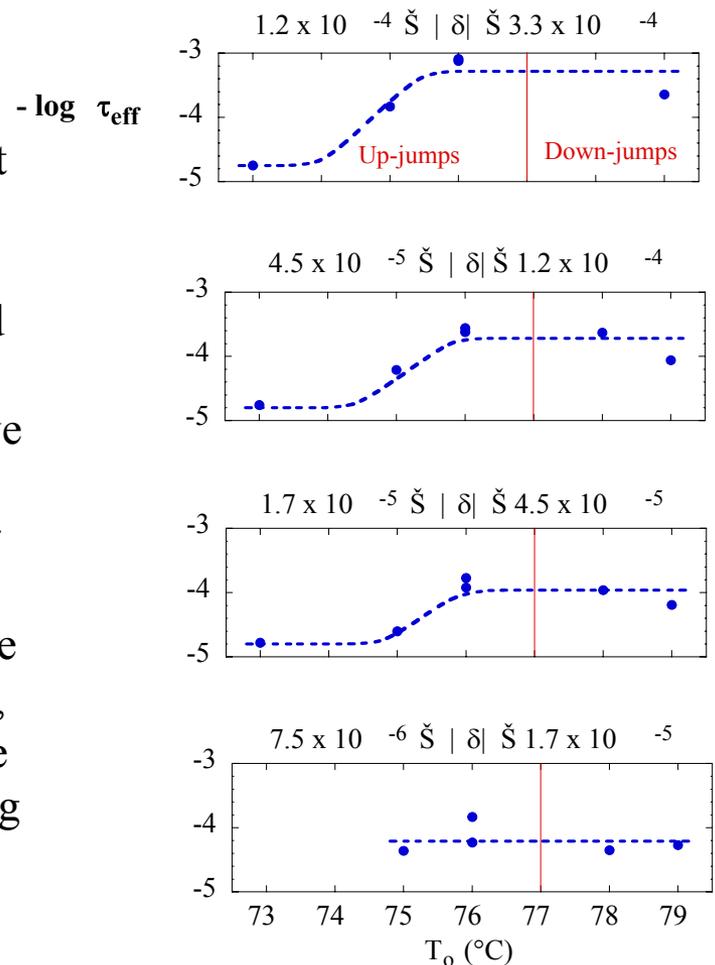


# A Fundamental Study of the Bulk Modulus in Polymers and its Dependence on Chemical Structure

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The time-dependent bulk modulus and bulk compliance are important viscoelastic properties, for which there is very little data because making such measurements is difficult. Our aim is to examine these properties as a function of chemical structure for linear and network polymers. To that end, volume recovery measurements, which had been reported to yield the bulk compliance, were made for an epoxy/amine material. In our analysis of the data, we found that the entire dispersion for the bulk compliance could not be obtained. More importantly we found that the  $\tau$ -effective paradox, first described by Kovacs in the early 1960s, was resolved very near equilibrium. As shown on the right, our data conclusively demonstrate that the  $\tau$ -effective paradox exists for 2 and 4 K up-jumps made to  $77^\circ\text{C}$  (very near the nominal  $T_g$  for this material) at  $\delta$  values as low as  $1.7 \times 10^{-5}$ , where  $\delta$  is the departure from equilibrium. At smaller  $\delta$ , the paradox is resolved. These findings are important for testing models of structural recovery and indicate that assumptions underlying current models are not valid.



## **Education:**

Two students and one post-doctoral researcher have worked on this project since its inception. Srinivas Kolla, completed his M.S. degree in spring 2004, and performed the state-of-the-art volume recovery experiments leading to resolution of the  $\tau$ -effective paradox. Yan Meng, a Ph.D. student, is calibrating the pressurizable dilatometer and preparing for bulk modulus measurements. Postdoctoral researcher, Qingxiu Li, is characterizing a series of polycyanurate network materials with different crosslink densities using FTIR and DSC, in addition to obtaining the shear viscoelastic response with rheometry. The students and post-doctoral researcher participate in weekly polymer group meetings and present their results to one another on a regular basis.

## **Outreach:**

Outreach has included presentations by the PI on the findings of this project at various national and international meetings, including the Gordon Research Conference on Polymer Physics and the “Times of Polymers” Conference in Italy. In addition, the results on the  $\tau$ -effective paradox have been submitted for publication. With the coming fall semester, we anticipate that an undergraduate researcher will participate in the project.