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Viscosity at the Nanoscale: Confined Liquid Dynamics and Thermal Effects in Self-Recovering Nanobumpers

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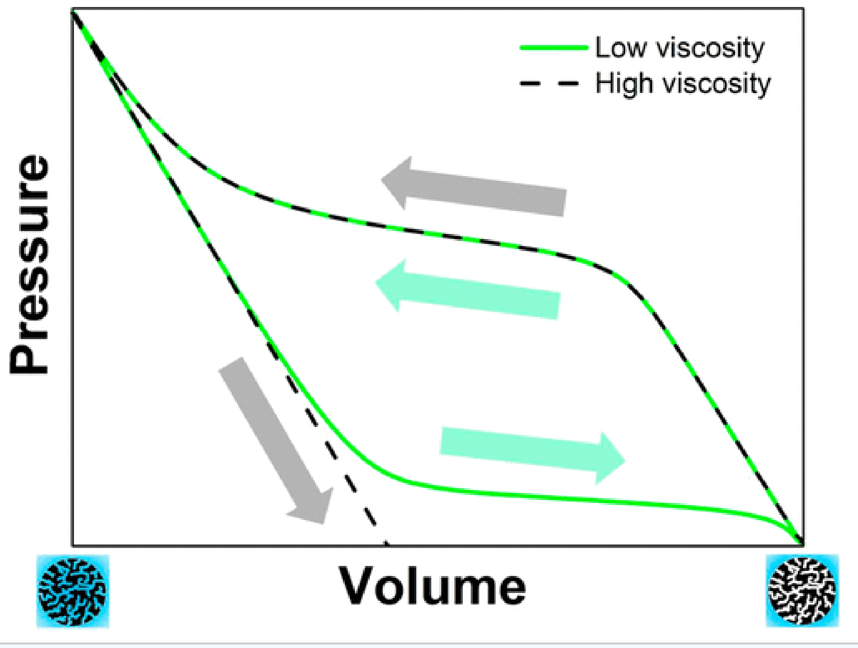
Abstract



Understanding the effect of liquid viscosity in nanoconfinement is of paramount importance from both the fundamental and practical points of view. In particular, unexpected dynamic phenomena are ubiquitous in a broad range of nanofluidic applications. In this work, we used state-of-the-art high-pressure (P,V,T) calorimetry for direct observation of pressure, volume, temperature, and thermal effects during controlled intrusion/extrusion of liquids in nanoporous materials. It was discovered that the liquid extrusion pressure and the accompanying thermal effects can be controlled by changing solely the liquid viscosity. Such knowledge allowed us to propose the {nanoporous material + nonwetting liquid} system as a self-recovering nanobumper and to clarify the parameters for its optimization. Experimental results were interpreted in terms of confined classical nucleation theory as the slowdown of bubble expansion in the nanopores because of the high liquid viscosity. The present results are of practical value for designing energy storage/dissipation devices based on intrusion/extrusion cycles, as well as of fundamental importance for understanding the effect of viscosity in nanoconfined liquids.

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