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Pressure-driven flow across a hyperelastic porous membrane.[1]

RYUNGEUN SONG, Sungkyunkwan University, HOWARD STONE, Princeton University, KAARE JENSEN, Technical University of Denmark, JINKEE LEE, Sungkyunkwan University — We report an experimental investigation of pressure-driven flow of a viscous liquid across thin polydimethylsiloxane (PDMS) membranes. Our experiments revealed a nonlinear relation between the flow rate Q and the applied pressure drop Δp, in apparent disagreement with Darcy's law, which dictates a linear relationship between flow rate, or average velocity, and pressure drop. These observations suggest that the effective permeability of the membrane decreases with pressure due to deformation of the nanochannels in the PDMS polymeric network. We propose a model that incorporates the effects of pressure-induced deformation of the hyperelastic porous membrane at three distinct scales: the membrane surface area, which increases with pressure, the membrane thickness, which decreases with pressure, and the structure of the porous material, which is deformed at the nanoscale. With this model, we are able to rationalize the deviation between Darcy's law and the data. Our result represents a novel case in which macroscopic deformations can impact the microstructure and transport properties of soft materials.

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