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Impacts of yield-stress fluid drops on permeable mesh substrates

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Abstract

Viscoplastic fluids, also known as yield-stress fluids, can stick and accumulate where they impact. Here we experimentally study conditions for open surfaces to be impermeable to impacting yield-stress fluid drops, and the dynamic conditions for these drops to permeate and coat internal aspects of a complex topography. We experimentally study drops of model yield stress fluids (Carbopol microgel particles in water) impacting open solid meshes (rigid surfaces with small, evenly spaced openings). High speed video reveals dynamics across a range of behavior, from 0% to 100% transmittance, by varying drop size, impact velocity, mesh geometry, and rheological material properties. When inertial stresses are sufficiently high compared to the yield stress, a drop can pass through a mesh, breaking into smaller fluid particles with varying shapes, sizes, and velocities in the process. In contrast, when inertial stresses are sufficiently low compared to the yield stress, a drop can stick to the mesh as though it were a solid surface, inhibited from passing through the holes by the yield stress. Layers of multiple meshes are also examined, demonstrating a range of behaviors and the ability to coat internal aspects of complex topography. Dimensional analysis is performed to characterize material transmittance and velocity of transmitted droplets as a function of dimensionless input parameters.

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