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Nonlinear flow response of soft hair beds[1] JOSE ALVARADO, JEAN COMTET, Massachusetts Inst of Tech-MIT, EMMANUEL DE LANGRE, Ecole Polytechnique, A. E. HOSOI, Massachusetts Inst of Tech-MIT — We are hairy inside: beds of passive fibers anchored to a surface and immersed in fluids are prevalent in many biological systems, including intestines, tongues, and blood vessels. Such hairs are soft enough to deform in response to stresses from fluid flows. Fluid stresses are in turn affected by hair deformation, leading to a coupled elastoviscous problem which is poorly understood. Here we investigate a biomimetic model system of elastomer hair beds subject to shear- driven Stokes flows. We characterize this system with a theoretical model which accounts for the large-deformation flow response of hair beds. Hair bending results in a drag-reducing nonlinearity because the hair tip lowers toward the base, widening the gap through which fluid flows. When hairs are cantilevered at an angle subnormal to the surface, flow against the grain bends hairs away from the base, narrowing the gap. The flow response of angled hair beds is axially asymmetric and amounts to a rectification nonlinearity. We identify an elastoviscous parameter which controls nonlinear behavior. Our study raises the hypothesis that biological hairy surfaces function to reduce fluid drag. Furthermore, angled hairs may be incorporated in the design of integrated microfluidic components, such as diodes and pumps.

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