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Shape transformations and propulsion due to an elastic filament rotating in a viscous fluid BIAN QIAN, THOMAS POWERS, KENNETH BREUER, Brown University — The deformation of an elastic filament in a viscous liquid is central to the mechanics of motility in cells ranging from *E. coli* to sperm. We use experiments and theory to study the shape transition of a flexible rod rotating in a viscous fluid and set at an angle to the axis of rotation. In the experiments, two modes of operation are studied: constant torque and constant speed, and the shape of the filament is measured using stereoscopic imaging. At low applied torque, the rod bends gently, while at high torque, the rod adopts a helical shape with the tip close to the axis of rotation. At constant torque, the transition from the splayed form to the helical form is abrupt, accompanied by a sharp increase in the rotational speed. As the torque is decreased, the shape change exhibits hysteresis, transitioning back to the splayed form at a lower torque. At constant speed, the shape transition is continuous characterized by a region of decreasing torque that persists until the transition to the helical form is complete. Calculations based on slender body and resistive force theory predict the torque-speed relationship and the filament shape throughout the entire operating range, and show excellent agreement with the experiments. The propulsive force is predicted to increase sharply after the shape transformation, at which point the efficiency is also predicted to reach a maximum.

Kenneth Breuer
Brown University

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