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Microfluidic one-way streets for algae JORN DUNKEL, VASILY KANTSLER, MARCO POLIN, RAYMOND E. GOLDSTEIN, DAMTP, University of Cambridge — Controlling locomotion and transport of microorganisms is a key challenge in the development of future biotechnological applications. Here, we demonstrate the use of optimized microfluidic ratchets to rectify the mean swimming direction in suspensions of the unicellular green alga Chlamydomonas reinhardtii, which is a promising candidate for the photosynthetic production of hydrogen. To assess the potential of microfluidic barriers for the manipulation of algal swimming, we studied first the scattering of individual C. reinhardtii from solid boundaries. High-speed imaging reveals the surprising result that these quasi-spherical "puller"-type microswimmers primarily interact with surfaces via direct flagellar contact, whereas hydrodynamic effects play a subordinate role. A minimal theoretical model, based on run-and-turn motion and the experimentally measured surface-scattering law, predicts the existence of optimal wedge-shaped ratchets that maximize rectification of initially uniform suspensions. We confirm this prediction in experimental measurements with different geometries. Since the mechano-elastic properties of eukaryotic flagella are conserved across many genera, we expect that our results and methods are applicable to a broad class of biflagellate microorganisms.

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