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Convective flow reversal in self-powered enzyme micropumps HENRY SHUM, University of Pittsburgh, ISAMAR ORTIZ-RIVERA, ARJUN AGRAWAL, AYUSMAN SEN, The Pennsylvania State University, ANNA BALAZS, University of Pittsburgh — It was recently shown that a surface-bound patch of enzymes in a fluid filled chamber can drive large scale flow in the presence of the enzyme's substrate. Evidence suggested that the flow was buoyancy driven but the pumping speed, or even direction, was not always consistent with estimates based on heat released by the reaction. Hence, we develop and analyze a model for density variations due to changes in solution composition as the reaction proceeds. If the reaction causes an increase in solution density, then we intuitively expect the fluid to sink down and spread outward, away from the pump. If the reaction substrate and product have different diffusion coefficients, however, the pump can exhibit much more complex behavior, such as pushing fluid outwards at early times and pulling fluid inwards later on. Two parameters, the ratio of solutal expansion coefficients and the ratio of diffusion coefficients, determine the pump dynamics. The predicted reversal of pumping direction is experimentally verified with a urease pump. We further show that not only the speed but also the direction of pumping varies with the amount of enzyme present on the patch. A better understanding of these pumps will aid in the design of responsive, chemically powered microfluidic flow control.

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