Collective behavior of free enzymes and enzyme-attached particles

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Abstract: From large-scale organisms to microscopic entities, the phenomenon of collective behavior is ubiquitously observed in the natural world. Inspired by nature's ability to coordinate collective behaviors, scientists are studying active particles to mimic group coordination and communication. Enzymes, traditionally recognized for their catalytic functions in biochemical processes, can function as nanoscale machines that convert chemical energy into mechanical action at the molecular dimension. In this research, we study the collective behavior of enzymes and enzyme-coated nanoparticles during catalysis. While adding dye-tagged urease into urea solution, we observed urease concentrated at the periphery of the dye-covered region, resulting in an anisotropic distribution of the enzyme. In addition, utilizing confocal microscopy, we observed an enhanced mobility of a group of ureases at the microscopic scale when suspended in a urea solution. By exploring the collective motion of enzymes driven by catalysis, we can better understand the essential mechanisms that regulate cellular transport in metabolism and expand the potential uses of micro/nanomotors.