Artificial microswimmers work together like bacteria

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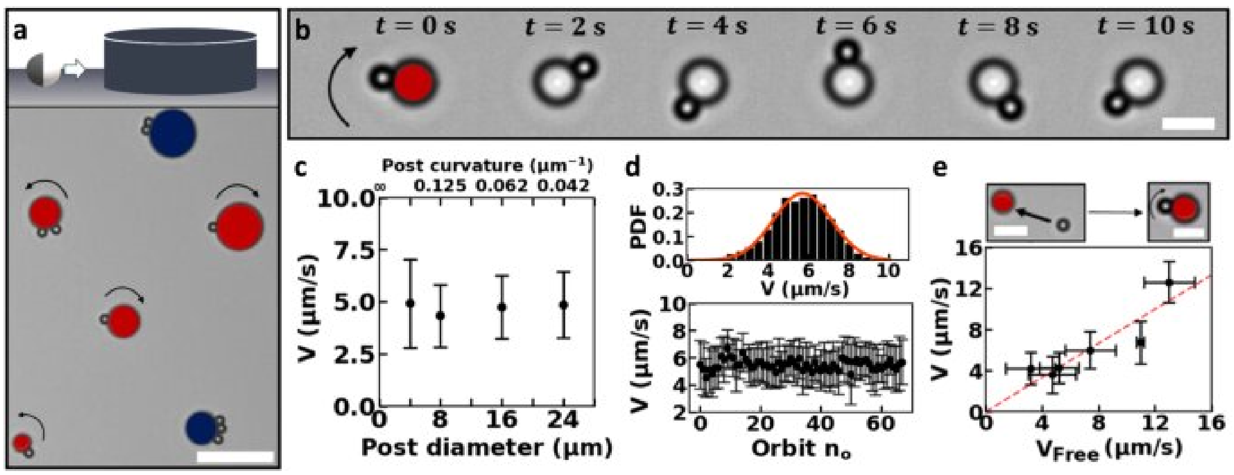

Catalytic microswimmer motion along circular posts: single-particle orbiting. a Schematic of the experimental setup (top) and light microscopy image (bottom) of the corresponding experiment: catalytic microswimmers orbit circular 3D posts, microprinted on planar substrates. Scale bar is 20 μm. Coloring is used to distinguish the stationary posts from our swimmers, and indicates whether the attached swimmers were mobile (red posts) with the arrow denoting their direction in orbit, or immobile (blue posts) due to the swimmers initially orbiting toward opposing directions. b Time series of light microscopy images of a (2.00 ± 0.05) μm diameter swimmer orbiting a 4 μm diameter post, with the arrow denoting its constant direction of motion. Scale bar is 5 μm. c Propulsion speed along the post as a function of post diameter. All data were taken at otherwise fixed experimental conditions. d Top: propulsion speed of an individual swimmer in orbit follows a Gaussian distribution. Measurement duration was 4 min. Bottom: same propulsion speed data plotted as a function of number of orbits. e Propulsion speed for the swimmers before orbiting, i.e., free speed on the planar substrate, plotted against their speed in orbit. The dashed line is a least-squares fit with y = ax and a = 0.83 ± 0.08, in line with Ref. Credit: *Nature Communications* (2022). DOI: 10.1038/s41467-022-29430-1

Microscopic swimmers such as bacteria do not always swim alone. There are advantages to exchanging information and cooperating. Stefania Ketzetzi and colleagues now show in *Nature Communications* that human-made microswimmers, too, can cooperate.

Cooperative motion lies at the heart of some of the truly complex behavior shown by microorganisms. For example, bacteria cooperate to capture nutrients, cancer cells communicate to accelerate the growth of tumors, and spermatozoa can assemble into trains to move faster toward the egg cell. These collaborations are made possible through the exchange of information between these microorganisms.

Microscopic swimmers made by humans

In the lab, scientists can make similar swimmers. These artificial microswimmers, have become a powerful tool for studying, understanding, and harnessing motion at a microscopic scale. Intriguingly, they as well can work together in the presence of other swimmers or surfaces.

"In our work, we were interested in how artificial microswimmers behave when they encounter specific surfaces," says Ketzetzi, who researched this topic for her Ph.D. at Leiden University. Together with her colleague Melissa Rinaldin, she studied the motion of microscopic spheres near confining surfaces.

Just keep spinning

By partly coating the spheres with platinum and putting them in water with hydrogen peroxide, the spheres will start to move because of a chemical reaction taking place on the platinum side. Ketzetzi: "We then put these self-moving spheres in a container with microscopic 3D-printed posts. When a swimmer comes across one of the posts, it attaches to it and keeps moving around it for a very long time."

This is something that had already been observed by others. But the researchers noticed something interesting when multiple spheres were moving around the same pole: if they moved in the same direction, they worked together to move faster. A collective speed-up just like the collaborations found in nature.

Or, if the swimmers were moving in the opposite direction around the same pole, they stopped each other. A pair of these could remain stationary for a long time, creating a traffic jam for other orbiting swimmers. After a tug of war, the chain would start to move again. But only if there were at least two extra swimmers pushing from one side or the other.

Cooperative motions like these could be relevant in future applications, where artificial swimmers would need to perform tasks while moving within and interacting with a confining environment. Ketzetzi: "In biomedical applications, for example, where artificial microswimmers are expected to play a big role, cooperative behaviors could enable faster drug delivery."

More information: Stefania Ketzetzi et al, Activity-induced interactions and cooperation of artificial microswimmers in one-dimensional environments, *Nature Communications* (2022). DOI: 10.1038/s41467-022-29430-1

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