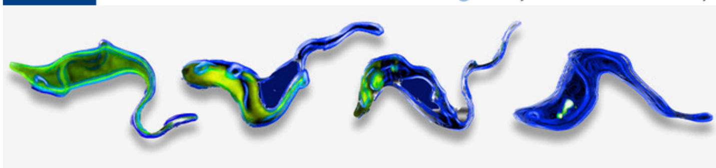

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Microfluidics to emulate the behavior of biological microswimmers using artificial alternatives

A key feature of biological microswimmers is their ability to navigate away from or toward a certain stimuli, and this skill is termed as 'taxis'. Tactic behavior can be induced by physicochemical changes in the environment such as light (phototaxis), chemical (chemotaxis), temperature (thermotaxis) and fluid flow (rheotaxis). In the last few years, a lot of research has been done for mimicking the behavior of the biological organisms in a fully synthetic way. Hence, artificial microswimmers were developed which have the same basic trait i.e. they are able to autonomously move at microscale. While these artificial devices lack any sensing and signaling capabilities, it is worth investigating if they can also mimic the taxis character of the biological organisms. In order to mimic the taxis behavior, one of the most crucial challenge is creating changes in the environment in a controlled manner. Here, microfluidics offers great solutions due to its excellent fluid manipulation abilities at the microscale [1]. Using microfluidics, we were able to create an otherwise technically challenging chemical gradients and fluid flow and study the chemotaxis [2] and rheotaxis [3] response of catalytically active Janus spheres. We also studied the phototaxis response of artificial microswimmers which did not require microfluidic setup and could be built using simple platform [4].

Here, I describe rheotaxis behavior in artificial microswimmers in detail: many motile microorganisms respond to the presence of the water currents by either migrating up or down the flow and this behavior is termed as rheotaxis. Similar to their biological counterparts, artificial microswimmers have also been shown to respond to fluid flows [5]. To deepen the understanding of how different microswimmers behave in an externally imposed flow, it is crucial to understand the influence played by their swimming patterns. Experimentally, pusher-type Pt@SiO2 Janus microswimmers have been shown to exhibit cross-stream migration in flow conditions. Whereas, theoretical studies have predicted an upstream response for puller-type microswimmers. In this work, we introduce Cu@SiO2 Janus spheres that swim towards their catalytic cap, quite differently from Pt@SiO2 which move towards SiO2. Using theoretical flow field calculations, we hypothesize that they behave as a puller-type system. Indeed, when placed in an externally imposed flow, these swimmers show a steady upstream response, which supports our hypothesis. Using a simple squirmer model for puller-type system, we reproduce all the experimental observations. To conclude, our study highlights the relevance of the flow field pattern around the microswimmers to comprehend the rheotactic behavior in motile systems.

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