Photo-Chemopropulsion
Light-Stimulated Movement of Microdroplets

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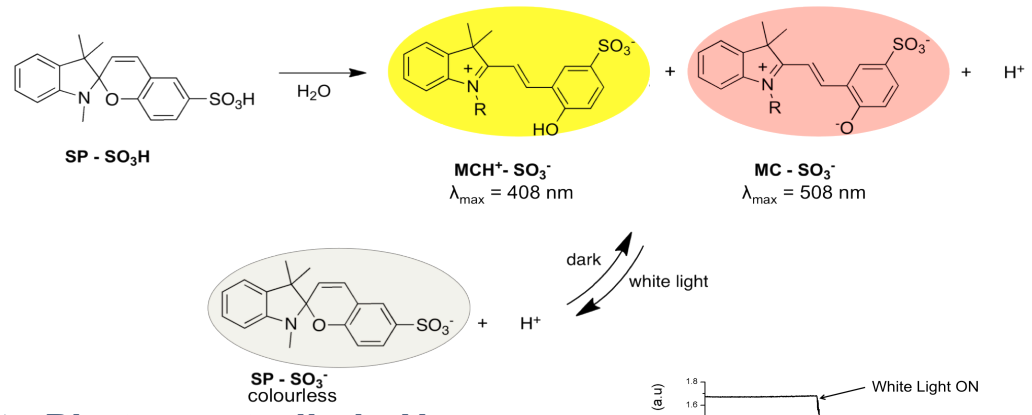
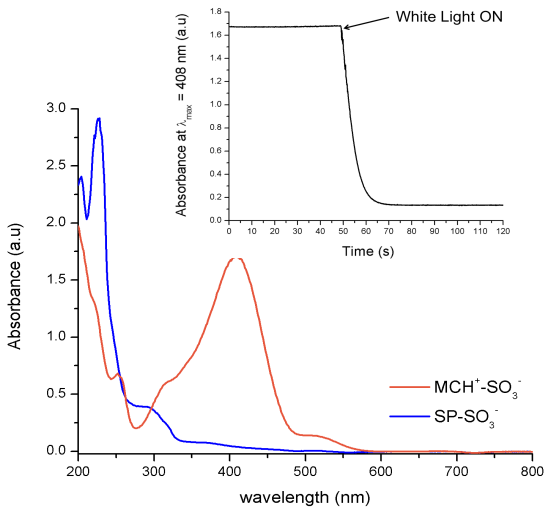
➢ Introduction

The ability to selectively transport chemical species in a controlled fashion, typically against chemical and electrochemical gradients, has been the cornerstone of the development of complex natural systems. While transport over short distances (*e.g.* intracellular) is typically achieved by cargo-carrying motor proteins acting like conveyor belts in a factory, active transport through natural fluids requires a biological "motor" to drive a carrier through the fluid resembling a miniature submarine. Emulating this latter approach in synthetic fluidic systems, we developed an inanimate/chemical system in which an organic droplet is self-propelled in response to a photo-stimulus. The centimetre-scale directional movement of the organic droplet on the aqueous solution is powered by the combination of photo-induced pH change and surface tension effects[1].



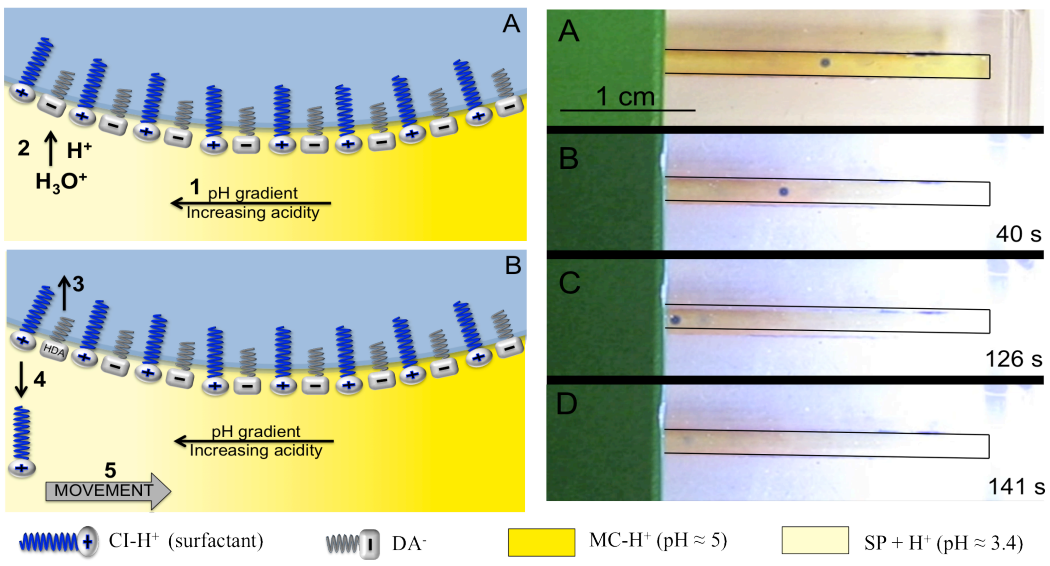
➢ Photo-controlled pH

Dissolution of SP-SO_3H in water leads to dissociation of the sulfonic acid and ring opening of the SP to form an equilibrium mixture of yellow MCH^+-SO_3^- (predominant) and red MC-SO_3^- (pH≈5). Upon white light irradiation, the equilibrium shifts as the open forms of the molecule (MCH^+-SO_3^- and MC-SO_3^-) are predominantly converted to SP-SO_3^- resulting in an increase in H^+ conc. (pH≈3.4).

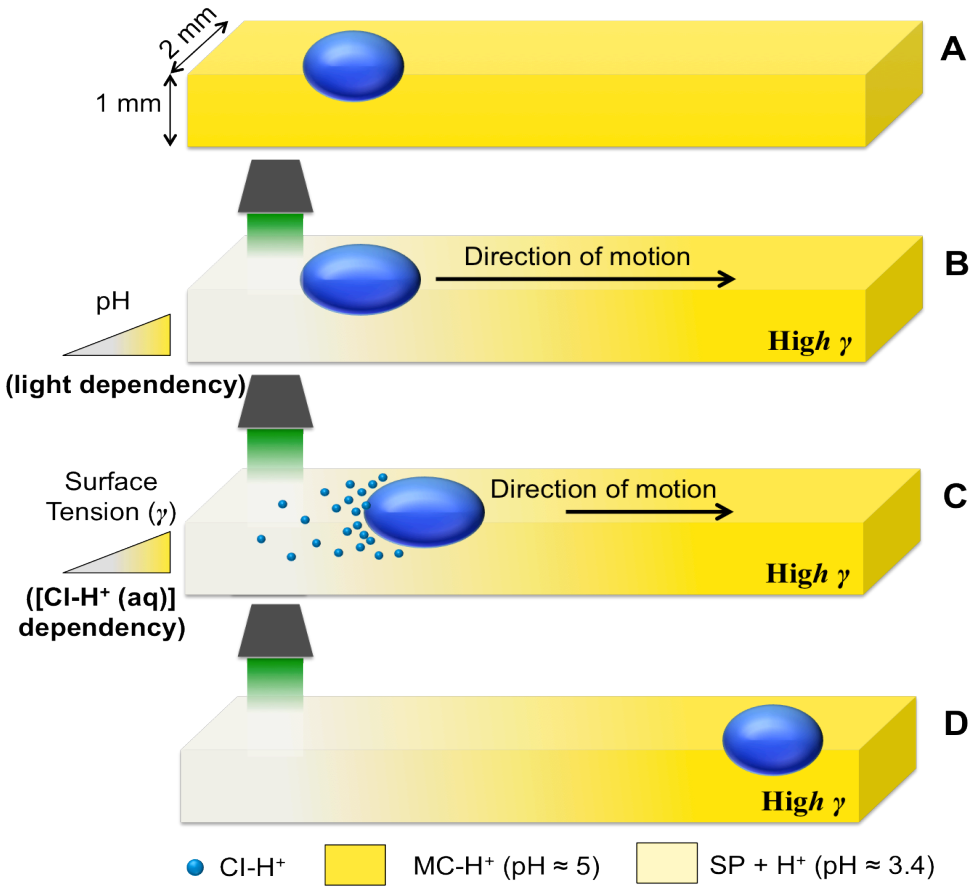


➢ Photo-chemopropulsion

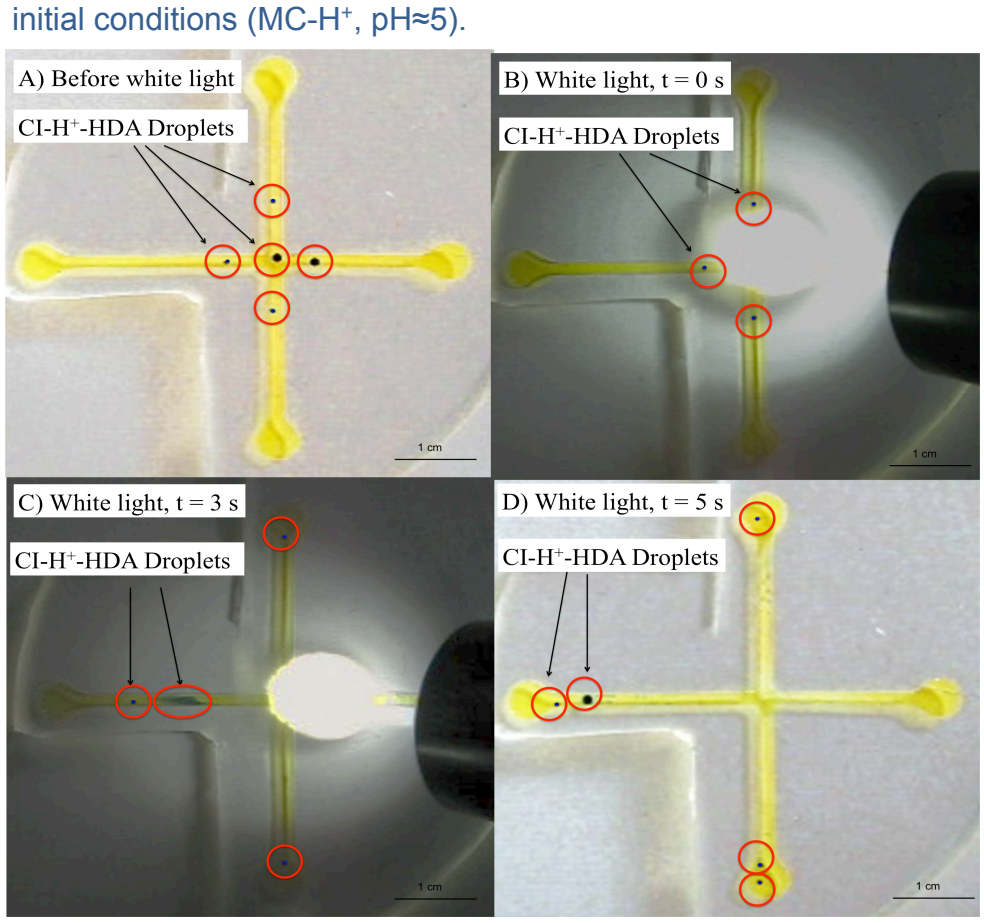
The principle of photo-chemopropulsion offers new possibilities to employ light as an external stimulus for controlling droplet motion at the liquid-air interface. This new concept is generic and can be applied to various organic/ aqueous systems, making photo-manipulation of microliter-size droplets relatively easy to implement. Here, depending on the intensity of the light source, movement of droplets with speeds in the range of 100 to 4000 μm s^{-1} can be achieved.



➢ Powered by Light



(A) Droplet is stable in the initial pH conditions (pH≈5, MC-H^+ solution). (B) Upon irradiation with white light, MC-H^+ reverts to SP, causing the generation of free H^+ (pH≈3.4). (C) Under these acidic conditions, the DA^- ion at boundary region becomes protonated, and migrates back into the bulk droplet region. Simultaneously, to preserve charge neutrality, the CI-H^+ ion (surfactant) migrates into the aqueous phase; as soon as this happens, the surface tension of the solution dramatically drops, causing the droplet to spontaneously move to the opposite direction of the light source. (D) The droplet stops in the region of high surface tension, where it encounters the initial conditions (MC-H^+, pH≈5).



[1] Florea, L., Wagner, K., Wagner, P., Wallace, G. G., Benito-Lopez, F., Officer, D. L., Diamond, D. *Advanced Materials (2014)*, DOI: 10.1002/adma.201403007.

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