CHEMICAL ENGINEERING

DISTINGUISHED YOUNG SCHOLARS SERIES

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Monday, July 2, 2018

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Curvature-mediated assembly in confined nematic liquid crystals

ABSTRACT: The ability to control particles motion on micron-scale goes far beyond scientific novelty and has implication in manufacturing new materials, distributed sensing, drug delivery and designing intelligent systems. Towards that goal, chemotactic particles, bacteria-particle hybrids, external fields have been used to define colloid assemblies and trajectories. In my work, I exploit migration of particles in confined nematic liquid crystals (LCs). LCs consist of rod-like molecules that tend to co-align with their neighbors, which gives rise to elasticity by penalizing the distortion. Under confinement, the anchoring, or the orientation of the molecule at the surface, balances the bulk elasticity. Controlling the boundary gives us a mean to control both the arrangement of the LC molecules and the inclusion inside.

My experimental platform consists of a wavy wall sandwiched between two glass coverslips (Fig. 1a), which allows for easy fabrication and visualization of colloid trajectories, yet powerful in its simplicity to explore a large range of geometries. My study focuses on two aspects: assembly and directed motion of particles. In the first aspect, I have shown that particles are driven by elastic forces created by the LC to dock and assemble on boundaries with features of complementary shape. This interaction is analogous to the "lock-and-key" interaction in enzymes (Fig. 1b). The docking behavior is driven by matching regions of the same kind of distortion ("splay" and "bend") on both the colloid and the wavy wall (Fig. 1c). The same mechanism accounts for instances where the particle stop at an equilibrium position at a distance away from the wall when the

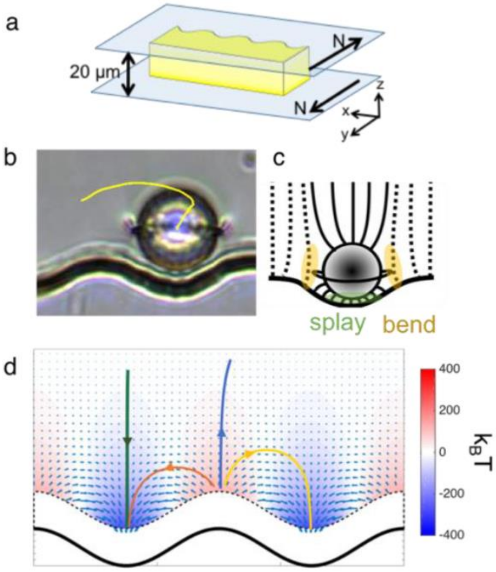

Figure 1. (a) Schematic of the experimental setup (b) "Lock-and-key" interaction where yellow denotes colloid's trajectory (2a = 15 µm). (c) Particle docking facilitated by favorable splay and bend matching. (d) Energy landscape with force field superimposed and calculated trajectories.

wavelength of the well increases. Therefore, I establish a method to position particles by modulating the wavelength of the wall. Building on this concept, I use topographical features to guide particle assembly into nontrivial shapes. In the second aspect, I study and control the dynamics of this process. By shaping the geometry of the surfaces that bound the LC, I can embed an energy landscape (Fig. 1d). For example, I can define stable points, attractors in phase space, within the LC domain. I can also embed unstable points. The attractive, stable points induce long-range attraction; particles migrate along paths defined by the energy gradients, i.e. force, within the domain. These could inspire new self-healing strategies that exploit this ability to find boundary imperfections, dock, and then deliver materials. On the other hand, the repulsive, unstable points force particles away from those loci. In some cases, particles can diverge along multiple paths, with potential application in distributed sensing. I demonstrate the reconfigurable LC field can be combined with flow, electrical and magnetic field to realize multi-degree control.

I have contributed to the field of self-assembly by expanding the repertoire of particle manipulation not through direct intervention, rather, through a reconfigurable soft matter field cued by tunable boundary conditions. Although the experiments have been performed in a model system, the rules are expected to be applicable to generic systems, e.g. many biological entities such as cells and bacteria are known to form LC phases, and their arrangement and disorder have important biological implications.

BIOGRAPHY: Yimin Luo is soft matter scientist, studying aerosols, emulsions, and complex fluids, widely used in areas such as consumer product, pharmaceuticals and oil and gas. She has obtained her Bachelor of Science from Rice University (2013), and Master of Science from University of Pennsylvania (2014), both in Chemical Engineering. She is currently pursuing her Doctor of Philosophy from University of Pennsylvania. Her research focuses on designing complex topography using microfabrication tools to steer the motion and direct the assembly of particles in liquid crystals.

Prior to joining Penn, she was an undergraduate researcher at Rice University, fabricating high-quality films and fibers from carbon nanotubes via solution processing. She has also worked several internships. In summer 2012, she worked as a chemical engineer intern with Schlumberger Oilfield Service, investigating coalescence behaviors of droplets and analyzed the feasibility of in-situ curable liquid proppants in a microfluidics platform. In summer 2013, she traveled to Singapore on a grant to study enhanced photostability of fluorophores for bioimaging at Nanyang Technological University.

Her passions range from traveling to outdoor activities, but also in communicating science at all levels. She teaches sophomore math weekly for Minds Matter, a national organization that does college prep for students from low-income families. In addition, she gives public lectures, TED-style talks, to bridge the gap between a general audience and the forefront of scientific research.

She has published 8 papers in scientific journals and given over 10 talks at international conferences. She is a member of Phi Beta Kappa, Society of Women Engineers, and American Physical Society.

LECTURE 4:00 - 5:00 (PAA) A110
Happy Hour in Benson Hall Lobby Following