TEXAS TECH UNIVERSITY
Edward E. Whitacre Jr.
College *of* Engineering™

Mechanical Engineering Department: Faculty Candidates Seminar Series

Monday, February 24; 11:00-12:00 ME Conference Room – ME 106

A Tale of Two Droplets – Exploiting Coalescence and Non-Coalescence

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Abstract: For conventional dropwise condensation on a vertically-oriented hydrophobic surface, condensate droplets are gravitationally removed at millimetric length scales. Condensation heat transfer would be enhanced if the droplets could be removed from the surface at smaller sizes or at any surface orientation, but to date gravity has been the only practical removal mechanism. Here, I show that dropwise condensation forming on a nanostructured superhydrophobic surface spontaneously jumps off the surface independently of gravity at micrometric length scales (Fig. 1A). The spontaneous droplet jumping results from the surface energy released upon droplet coalescence. Using the jumping-droplet condensation as a novel fluid return mechanism, a planar thermal diode was invented that conducts over 250 times more heat in the forward direction compared to the reverse direction at any orientation. When amphiphilic phospholipids are introduced into an oil reservoir containing water droplets, droplet interface bilayers (DIBs) can form between adjacent water droplets. DIBs are versatile model membranes useful for synthetic biology and bio-sensing; however, to date they have always been confined to oil reservoirs. Here, I demonstrate that when two or more water droplets in an ambient environment collide on an oil-infused substrate, they exhibit non-coalescence due to the formation of a thin oil film that gets squeezed between the droplets from the bottom-up (Fig. 1B). When phospholipids are included in the system, an air-stable bilayer forms between the non-coalescing water droplets that can detect single-channel currents. These findings reveal that DIBs can function in ambient environments, which could potentially enable the stochastic bio-sensing of airborne molecules.

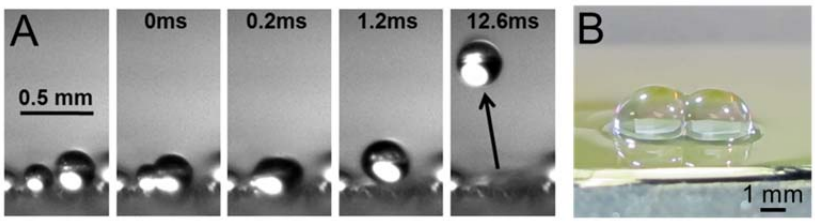

Figure 1: (A) Condensate droplets spontaneously jump off nanostructured superhydrophobic surfaces upon coalescence. (B) Water droplets exhibit non-coalescence on oil-infused surfaces.

Short Bio

In 2012, Jonathan received his Ph.D. in Mechanical Engineering and Materials Science at Duke University. Currently, he is a postdoc at the Oak Ridge National Laboratory in the Center for Nanophase Materials Sciences. His research lies at the intersection of fluid dynamics, phase-change heat transfer, materials science, and synthetic biology, and has been featured by *The New York Times*, *Science*, *Discovery Channel*, and on the cover of *Physical Review Letters*. In his free time, Jonathan enjoys hiking, playing classical piano, and reading the works of Dostoyevsky.