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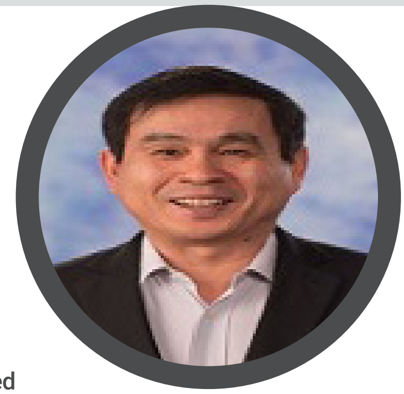
MICROFLUIDICS ENABLED STRUCTURES FOR MANIPULATING LIQUIDS



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Nature has always been our inspiration source of innovations. Chinese Kung Fu developed effective moves from hunting skills of powerful beasts like snakes, eagles, and tigers; airplanes mimic the skillful flight of birds; legged robots imitate legged animals such as dogs and spiders. Nowadays, state-of-the-art technology enables us to unveil mysteries of the microscopic world and thus invent at microscale with precision. We have been using the precision of microfluidics in manipulating liquids at nano-/subnano-liters and engineering nano-/micro- structures to mimic evolutionarily-optimized nano/microstructures in insects that interact with liquids, and thus developed a series of techniques for manipulating liquids precisely: water collecting, liquids repelling, and droplets manoeuvring. The breakthroughs have yielded three articles in Nature Communications. Unique structural and topological features of spider-silks and their web enable them being a super water collector witnessed by a large number of water droplets handing on them in the early morning. With the microfluidic technology, we have precisely fabricated robust microfibers with spindle cavity-knots and different topological fiber-networks in mimicking these features. These microfibers are endowed with unique surface roughness, mechanical strength, and long-term durability, thus enabling a super performance in collecting water. The maximum water volume collected on a single knot is almost 495 times the knot volume; the water collection is even more efficient and scalable with their networks. These light-weighted yet tough, low-cost microfibers offer promising opportunities for large-scale water collection in water-deficient areas. Liquid-repellent surfaces repel liquids instead of allowing droplets to adhere. These surfaces are important in many fields including self-cleaning clothes and kitchenware, enhanced heat transfer, and anti-fouling, anti-corrosive and drag reduction coatings. The dream of research and development on liquid-repellents is a structure that has robust liquid repellency, strong mechanical stability, and is inexpensive to produce on a commercial scale. However, the functional outcomes of existing liquid-repellent surfaces have not been satisfactory, because of inadequacies of conventional structural design and fabrication approaches in engineering microstructures and properties of such surfaces. We developed a low-cost scalable approach for the fabrication of well-defined porous surfaces with robust liquid repellency and strong mechanical stability. The design of the liquid-repellent surfaces is inspired by structures on springtail cuticles, which can effectively resolve the longstanding conflict between the liquid repellency and the mechanical stability. Springtails are soil-dwelling arthropods whose habitats often experience rain and flooding. As a consequence, springtails have evolved cuticles with strong mechanical durability and robust liquid repellency to resist friction from soil particles and to survive in watery environments. We design the porous surfaces to be composed of interconnected honeycomb-like microcavities with a re-entrant profile: the interconnectivity ensures mechanical stability and the re-entrant structure yields robust liquid repellency. The cuticle-like porous surfaces are fabricated by self-assembly using microfluidic droplets, which takes full advantage of the capabilities of microfluidics in terms of scalability and precise-handling of small fluid volumes. The generation of these cuticle-like porous surfaces using microfluidics has led to precise, controllable, scalable, and inexpensive fabrication. Some semiaquatic insects can readily walk on water and climb up menisci slope due to the dense hair mat and retractable claws of complementary wettability on their tarsi. Inspired by this, we created a mechano-regulated surface whose adhesive force to liquid droplets can be simply switched through mechanical regulation. The mechano-regulated surface functions as a "magic hand" that can capture and release multiple tiny droplets precisely in a loss-free manner, and works for both water and oil droplets down to nano-litre scale. These surfaces are relevant and crucial in various high-precision fields such as medical diagnosis and drug discovery where the precise transferring of tiny liquid is a must. Learning from nature paves the way for creating nano/microstructures with unique features to interact with liquids on-demand. Small yet powerful, these structures can manipulate liquids effectively and precisely. With these techniques, water may be gathered directly from the air in deserts, no more laundry may become true, and liquids can be conveniently handled like solids

Biography

Prof. L. Q. Wang received his PhD from University of Alberta (Canada) and is currently a full professor in the Department of Mechanical Engineering, the University of Hong Kong. He is also the Qianren Scholar (Zhejiang) and serves as the Acting Executive Director for the Zhejiang Institute of Research and Innovation (HKU-ZIRI), the University of Hong Kong and as the Director and the Chief Scientist for the Laboratory for Nanofluids and Thermal Engineering at HKU-ZIRI. Prof. Wang has over 30 years of university experience in thermal & power engineering, energy & environment, transport phenomena, materials, nanotechnology, biotechnology, and applied mathematics in Canada, China/Hong Kong, Singapore and the USA, and 2 years of industrial experience in technology and IP development/management/transfer as the Chief Scientist & the Global CTO.

Prof. Wang has secured over 80 projects funded by diverse funding agencies and industries including the Research Grants Council of Hong Kong, the National Science Foundation of China and the Ministry of Science and Technology of China, totaling > US$ 20m. Prof. Wang has published 10 books/monographs and over 390 book chapters and technical articles including 3 in the Nature Communications, 1 in the PNAS and 12 in the Physical Review Letters, many of which have been widely used by researchers all over the world, and been ranked amongst the top 1% of most-cited scientists (ESI). Prof. Wang has also filed 36 filed patents/SoftwareCopyrights and led an international team in developing a state-of-the-art thermal control system for the Alpha Magnetic Spectrometer (AMS) on the International Space Station. The AMS project is headed by Professor Samuel C. C. Ting (Nobel laureate in Physics, MIT, USA) and is to search for antimatter, dark matter and spectra of cosmic rays.

Prof. Wang has received various awards, including the recent TechConnect Global Innovation Award at the TechConnect World Innovation Conference & Expo (TCWI) 2018 (Anaheim, CA, USA; May 13-16, 2018), the Silver Medal at the 46th International Exhibition of Inventions of Geneva (Palexpo, Geneva, Swiss; April 11-15, 2018), the Innovation Award by the Optical Society (Singapore; July 25-28, 2017), and the First Outstanding Achievement Award of Hangzhou Oversea Scholars (Hangzhou Municipal Government, China; 2016). His research has been widely featured by local, national and international media.

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