Jiangtao Cheng, J Nanomater Mol Nanotechnol 2017, 6:4 (Suppl)
DOI: 10.4172/2324-8777-C1-008

16th World Nano Conference

June 05-06, 2017 Milan, Italy

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Contact line dynamic of Cassie-state wetting on ultrahydrophobic nano-structured surfaces

We report a molecular dynamics (MD) study on the wetting dynamics of Cassie-state water droplets on ultrahydrophobic nano-structured surfaces. The surface materials were selected to be the amorphous polytetrafluoroethylene (PTFE). Our analysis in the framework of molecular kinetic theory (MKT) indicates that nano-droplets of water exhibit a constant unit displacement length of ~6.05±0.48Å regardless of the surface topography. The contact line friction (CLF) originates from the solid-liquid retarding Gw and viscous damping Gvis, and is also influenced by the fraction of solid-liquid contact. Gw is related to the work of adhesion and is independent of the surface structure. The effects of Gw become manifest in the orderly packing of water molecules at the droplet base. As a result of the solid-liquid retarding, a thin depletion layer of ~2.852 Å thick is formed at the droplet base on smooth PTFE surfaces. However, such depletion phenomenon is mitigated on nanostructured surfaces owing to the sagging of the droplet base. The potential of mean force analysis ascribes Gvis to the fluctuations of relationship of~sin 20 (θ0 is the static contact angle) is derived In liquid density in the vicinity of solid-liquid interface. A heuristic essence, the non-sticking feature of ultrahydrophobic structured surfaces (smaller CLF and larger θ0) indeed roots in the reduced solid-liquid contact. On a smooth PTFE surface, the static friction coefficient, which characterizes the static frictional force exerted on the contact line, was found to be on the same order of magnitude as the dynamic viscosity and increase with the droplet size. A non-dimensional number, which signifies the strength of the inherent contact line fluctuation, was put forward to unveil the mechanism of enhanced energy dissipation in nanoscale, whereas such effects would become unapparent in micro scale. Moreover, regarding a liquid droplet on hydrophobic/super hydrophobic surfaces, an approximate solution to the base radius development was derived by an asymptotic expansion approach.

Biography

Jiangtao Cheng completed his Bachelor's degree in Applied Physics at Peking University in 1991; Master's degree in Computer Science at Purdue University in 2002 and; Doctorate degree in Physics in 2002. In 2007, he accepted an offer from the Teledyne Scientific Company (formerly Rockwell Science Center) as a Research Scientist III for the next four years. He returned to academia in 2011 as an Associate Professor at University of North Texas. In 2015, he joined Department of Mechanical Engineering at Virginia Tech as an Associate Professor. His areas of expertise include: "Sustainable energy and renewable energy; optofluidics and electrofluidics; microfluidics and nanofluidics; thermal-fluid science and heat transfer; thermal management and microelectronics cooling". Recently, he introduced surface plasmon resonance and terahertz technology in his research in thermal-fluid science.

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