ICCES, 2023, vol.26, no.4
DOI: 10.32604/icces.2023.09169

PROCEEDINGS

Self-Driving Behavior and Pinning Effect of Droplets on Graphene-Covered Functional Textured Surfaces

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ABSTRACT

Biological features such as the bumps on the back of desert beetles and the spikes of cacti enable the directional transport of water droplets, creating conditions for their survival in nature. Inspired by the interesting natural phenomenon, a novel design of nanopillared surface with a gradient density of structural pillar matrix covered by a monolayer graphene is proposed to realize ultrafast self-driving of water droplets. The droplet can move spontaneously at ultrahigh speed of 75.7 m/s (272.52 km/h) from sparsest to densest regions of pillars while a wettability gradient is created by the gradient distribution density of pillar matrix relying on the wetting transparency of monolayer graphene. In particular, the gradient short pillared texture triggers an opposite self-driving regularity in which the water droplet moves from densest to sparsest regions of pillars, intrinsically because the gradient short-pillared surface leads to a wetting transition from hydrophobic to hydrophilic since the monolayer graphene can be adsorbed into the sparsest short-pillared texture. Furthermore, a monolayer graphene-covered nanocone (GNC) is proposed to realize ultrafast water droplet transport from the tip to the end of the GNC. The rule of energy change during the droplet self-driving process indicates that the potential energy of the droplet and the interaction energy between the droplet and the GNC undergo cooperation and competition successively, resulting in the droplet first speeding up and then slowing down to a steady moving state. Continuum theory in the self-driving of a droplet at a microscale is used to describe the steady moving process, in order to further understand the rule in GNC-based water transport. However, the pinning effect induced by surface defects usually restrain the self-driving of droplets on functionalized surfaces. Thus, the mechanism of pinning effect in droplet self-driving is further revealed based on the molecular dynamic simulations for motion behaviors of droplet on copper substrate with different shaped defects. The results show that the monolayer graphene covered on the defected solid surface can remarkably reduce the pinning effect in droplet self-driving processes. A large damping force will appear when the droplet initially approaches and finally moves away from the defects on pure copper substrate, whereas a tiny damping force can be observed for the droplet moving across the defects covered by a monolayer graphene. Particularly, a consequent extra-damping force appears because the nano-configuration of the droplet is changed after passing the defects on pure copper substrate induced by the large deformation in pinning process. These findings explore the role of graphene in reducing resistance and pinning in droplet self-driving, and have theoretical significance for the design of graphene-covered functional surfaces in droplet transport.

KEYWORDS

Droplet self-driving; pinning effect; monolayer graphene; functional Surface; molecular dynamics

Acknowledgement: This work was supported by the National Natural Science Foundation of China (NSFC) with Grants (Nos. 12272151, 11872192, 52005222).

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.