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The Instability Mechanism of Moving Contact Line on the Surface of Soluble Solids

Xudong Chen[1,2] and Quanzi Yuan[1,2,*]

[1] State Key Laboratory of Nonlinear Mechanics, Institute of Mechanics, Chinese Academy of Sciences, Beijing, 100190, China

[2] School of Engineering Science, University of Chinese Academy of Sciences, Beijing, 100049, China

[*] Corresponding Author: Quanzi Yuan. Email: yuanquanzi@lnm.imech.ac.cn

ABSTRACT

The wetting and instability of liquids on the surface of soluble solids is a problem of interface stability at multiple scales, which is coupled by mechanics and chemistry. This problem is crucial to application fields such as micro-nano processing and microscopic observation. In this work, the instability process of moving contact lines on the surfaces of soluble solids is investigated in experiments, theories, and simulations. Based on the unique shapes of the surfaces of soluble solids caused by instability in experiments, the concept of pagoda instability is proposed. Then the Cahn-Hilliard interfaces are developed to establish the evolution model of solid-liquid and liquid-gas interfaces in the instability process, obtaining the mathematical expressions of the final shapes of soluble solids. The stability of the liquid-gas interfaces and the evolution of capillary forces are analyzed when the dissolved shapes are characterized by power functions, revealing that the unique shapes caused by instability can effectively eliminate capillary adhesion. Furthermore, the key role of contact angle hysteresis in this problem is introduced to the developed Cahn-Hilliard interface theory. The effect of contact angle hysteresis on the solid-liquid and liquid-gas interfaces during the dissolution process is analyzed to clarify the mechanism of the formation of pagoda instability, which is in great agreement with the experiment results. It is hoped that the control of the instability process of the moving contact line in the experiments with the help of the theoretical model will guide for the relevant design of shapes in practical applications.

KEYWORDS

Wetting; dissolution; capillary forces; contact angle hysteresis; interfacial effects

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