Salinity Effects on the Degree of Hydrophobicity and Longevity for Superhydrophobic Fibrous Coatings

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Received 13 July 2011; accepted 9 September 2011
DOI 10.1002/app.35615
Published online in Wiley Online Library (wileyonlinelibrary.com).

ABSTRACT: Previous studies on submerged superhydrophobic surfaces focused on performance variables such as drag reduction and longevity. However, to use such surfaces for practical applications, environmental factors such as water salinity must be investigated and understood. In this work, experiments were carried out to investigate the impact of salt (sodium chloride, NaCl) concentrations in aqueous solutions on the hydrophobicity and longevity of polystyrene (PS) fibrous coatings. Rheological studies using salt water as a test fluid were performed to determine the effect of salt concentration on drag reduction. Contact-angle measurements were used to validate the results from the rheometer. *In situ* noninvasive optical reflection was used to measure the longevity of the coating—time-dependent loss of entrapped air within the coating—as a function of salinity. The superhydrophobic coating used herein consisted of PS fibers that were deposited using DC-biased AC-electrospinning. Electrospinning is scalable and far less expensive than conventional methods (e.g., microfabrication), bringing the technology closer to large-scale submerged bodies such as submarines and ships. © 2011 Wiley Periodicals, Inc. J Appl Polym Sci 000: 000–000, 2011

Key words: biomimetic; superhydrophobic coatings; fibers; interfaces; polystyrene; drag reduction

INTRODUCTION

Surfaces with static contact angle (CA) greater than 150° are typically classified as superhydrophobic. Superhydrophobicity is exhibited in materials with a combination of low surface free energy and micro and/or nanoscale surface roughness. Natural superhydrophobic surfaces are exemplified by lotus leaves, which allow rain drops to roll off of them, carrying dirt away and creating a self-cleaning effect (lotus effect). When fully submersed in water, such a surface can entrap air between the micro/nanostructures resulting in a surface with both air–water and solid–water interfaces. The presence of the air–water interface is responsible for the slip effect, which results in a reduction in the skin-friction drag exerted on the surface.[1]

Synthetic superhydrophobic surfaces have been produced using the same microfabrication techniques developed for the computer industry and typically consist of a regular array of microposts or microridges etc.[2–7] The orientation (with respect to the flow), spacing, and aspect ratio of the microposts or microridges can be adjusted to optimize the generated drag reduction and the stability of the air–water interface (meniscus) against transition from dewetted (Cassie) to wetted (Wenzel) state.[7–9] Many synthetic strategies and materials have been reported for obtaining superhydrophobicity, including sol–gel processing[10] and solution casting,[11] chemical vapor deposition,[12] laser/plasma/chemical etching,[13] lithography,[14] electrical/chemical reaction and deposition,[15] layer-by-layer and self-assembly,[16] and electrospinning.[17] Except for the electrospinning, all of these methods are complicated and require special equipment, high temperature or vacuum conditions, or low-surface-energy material modification involving multiple steps, which makes it difficult for practical applications in large-scale coatings. Electrospinning is a simple, low-cost method that can be used to deposit micro- to nanotextured coatings of a hydrophobic polymer onto substrates of arbitrary geometry. The resulting superhydrophobic surfaces can be applied in diverse applications, including self-cleaning glasses and clothes, protection against corrosion of metallic parts (in bridges, under water constructions etc.), anti-snow sticking, and reducing skin-friction drag in underwater vessels such as submarines. Superhydrophobic coatings can be utilized as a passive method of flow control and may potentially become a viable

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Contract grant sponsor: Defense Advanced Research Projects Agency (DARPA); contract grant number: W91CRB-10-1-0003.