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Robust and muti-repaired superhydrophobic surfaces via one-step method on copper and aluminum alloys

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ABSTRACT

Facile preparation, mechanical durability, and fast regeneration are superior factors to expand the application of superhydrophobic surfaces. In this letter, a one-step immersion process was explored to construct a mechanically and chemically durable superhydrophobic surface on copper and aluminum alloy, respectively, which can also be used when the surfaces were destroyed by mechanical stress or chemical damage. By immersion of the wrecked surfaces in the one-step regenerative solution or by the spray method and air dried, the substrates could be easily repaired, regaining the durable superhydrophobic properties.

1. Introduction

Copper and aluminum alloys, which are subsistent abundantly in nature with superior properties, have been widely used as important engineering materials. However, most of metallic materials or constructions are chemically reactive and liable to suffer severe damage during service in harsh environments, which seriously limits their applications [1]. Surface treatments are hence indispensable for improving performance and elongating service-life of industrial metallic materials [1–3]. Among current industry strategies for combating these problems, transforming the hydrophilic nature of metal surface to be superhydrophobic is viewed as excellent candidate for protection against mechanical and chemical attacks. Generally, the way to fabricate an artificial superhydrophobic surface is combining the approach of multiscale roughness along with low surface energy [2–4]. However, most of these methods are complex operations; environmentally unfavorable, expensive and time consuming. To overcome the inherent disadvantage, several one-step solution immersion processes have been developed to eliminate the complexity of creating superhydrophobic surfaces [5–7].

In regardless of numerous techniques to construct superhydrophobic surfaces, practical applications of the prepared surfaces are usually restricted by their weak mechanical and poor chemical stabilities. How to regenerate the superhydrophobic performance of a surface after being damaged becomes a key concern. Self-healing has been used to improve the durability of superhydrophobic surfaces [8,9]. However, this restoration will be limited when the healing agents exhausted after multiple damage-restoration processes. Furthermore, the healing behavior always depends on external stimuli, like UV irradiation, humidity and heating [10,11]. Therefore, the alternative way would be to prepare superhydrophobic surfaces with simple fabrication and easy repairability.

In this work, a facile and low-cost one step solution immersion method is used to construct robust and multi-repairable superhydrophobic surfaces on copper and aluminum alloys. The wettability, morphology, and composition of the as-prepared samples are characterized and the obtained superhydrophobic surfaces have strong resistances to abrasion, UV irradiation and high stabilities whether in acidic or alkali medium. In addition, the damaged superhydrophobic surface can be easily repaired by dipping the wrecked surfaces in the as-prepared solution or by the spray method and soft heating.

2. Experimental section

Aluminum and copper sheets (20 mm × 20 mm × 1 mm) were used as substrates, which were mechanically abraded and

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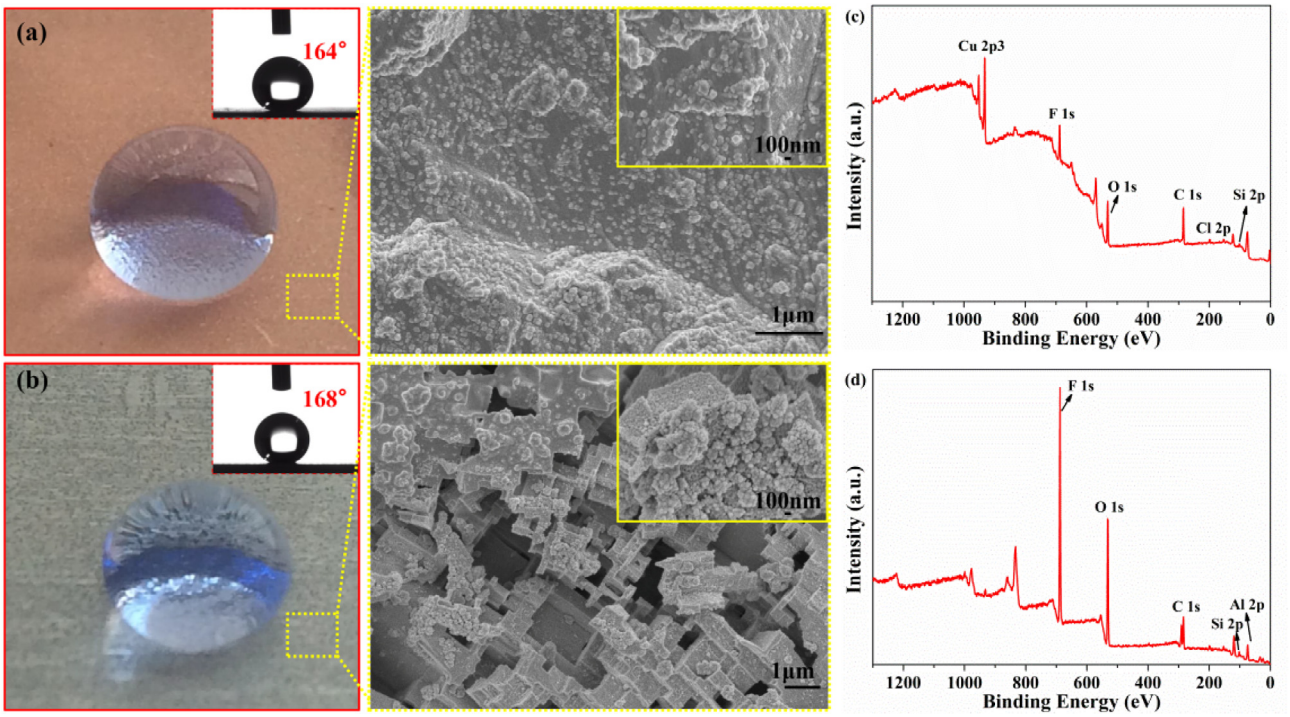

Fig. 1. The photos, SEM images, CA images and XPS spectra of as-prepared Cu (a, c) and Al alloy (b, d) surfaces.

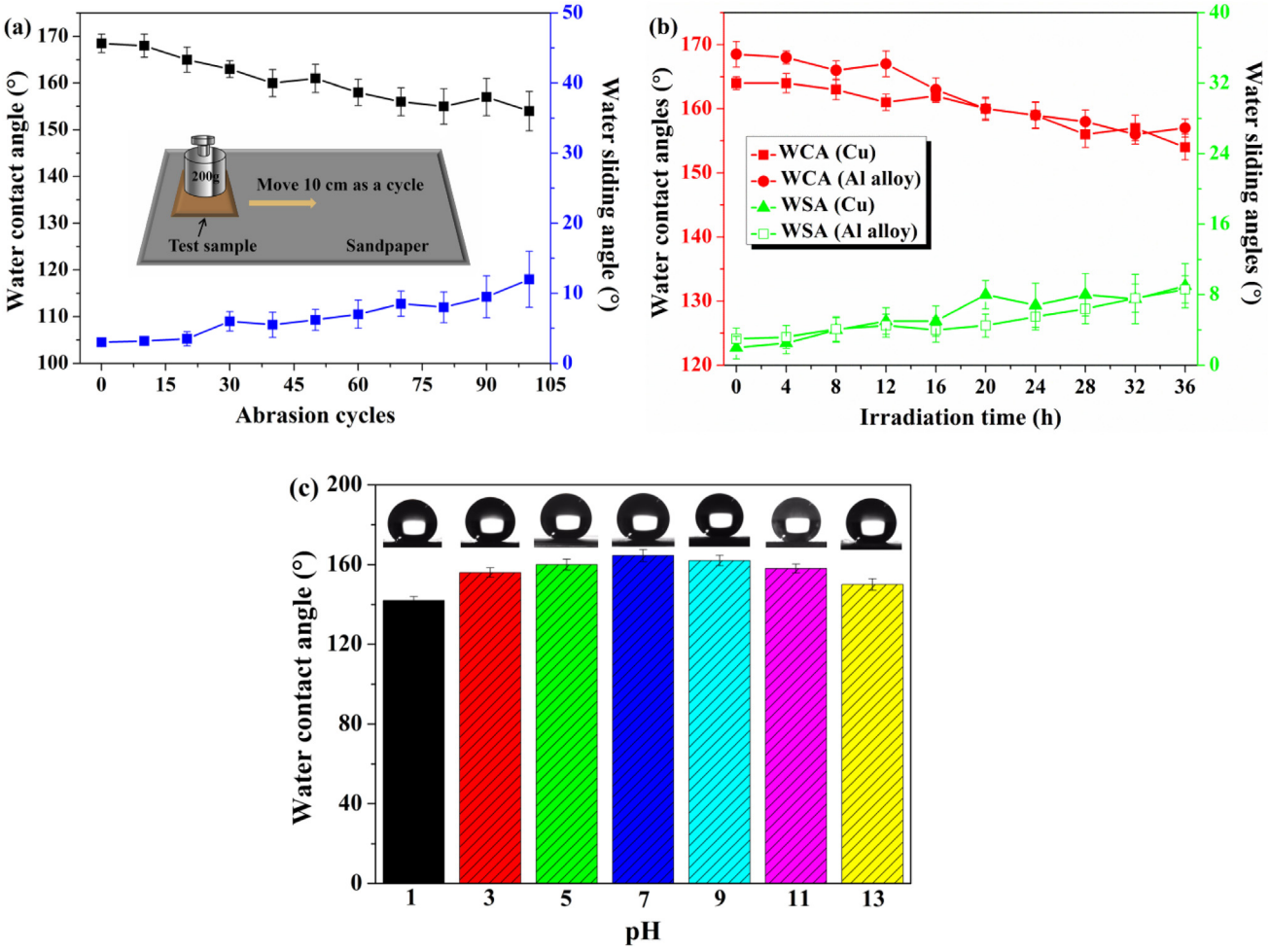

Fig. 2. (a) The WCAs and WSAs of Al alloy after 0–100 repeated abrasion tests. (b) The WCAs and WSAs of Cu and Al alloy upon UV irradiation. (c) The WCAs of acidic and basic aqueous solutions with different pH values on Cu substrates.