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Full Length Article

Co-solvent induced self-roughness superhydrophobic coatings with self-healing property for versatile oil-water separation

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ABSTRACT

Despite of the extensive effort made to construct a superhydrophobic surface in labs, achieving a short processing time and via a sustainable production route remains a challenge for practical applications. Here, with tetrahydrofuran and n-hexane as co-solvent, we demonstrate that roughness can be induced on polydimethylsiloxane (PDMS) coatings to achieve superhydrophobic coatings on different types of substrates including woven fabrics, non-woven fabrics, and melamine sponge. The sample constructed without adding particles exhibited excellent performance for versatile oil-water separation of mixtures of heavy oil and water, light oil and water, as well as oil-water emulsion. Due to the good solubility of the PDMS in the co-solvent, the dipping solution exhibited a long-time stability. Moreover, the abundant CH_3 provided by the self-roughness PDMS coating helped the substrates recover its superhydrophobic property even after destroyed by plasma for 10 times. We believe that this extremely easy dipping-curing method would open up a new direction for fabricating a series of self-roughed superhydrophobic surface with self-healing property. Besides, the developed strategy is fast and easily scalable for industrial applications.

1. Introduction

In the past decades, superhydrophobic surface with static contact angle (CA) larger than 150° and the dynamic slide angle (SA) smaller than 10° has drawn enormous attention due to its potential application in multifarious fields such as oil-water separation [1–5], self-cleaning [6–9], liquid drag-reduction [10–12], anti-icing [13–17], and so on [18–25]. There is an inherent demand for creating surface roughness combining with low surface energy materials to achieve the superhydrophobic state. However, the property was easily damaged during use. Three methods have been proposed to solve this problem. One is to find harder materials to withstand the mechanical friction during the daily use. For example, Liu et al. fabricated superamphiphobic fabrics with the treatment of argon-plasma. The as-prepared cotton fabrics displayed robust mechanical strength and excellent durability after 3500 abrasion cycles [26]. However, since plasma treatment and nanoparticles are used, this strategy obviously increased the cost of materials and processing. The second is simplifying the processing steps and decreasing the cost. Therefore, when the surface is damaged, the property could be easily repaired by repeating the fabrication process with minimum time and cost involved [27,28]. Based on the second strategy, methods like dip coating and spaying coating, using low-cost materials like $CaCO_3$ and soot have been introduced to reduce the processing time and cost [29,30]. Qahtan et al. fabricated superhydrophobic films by spraying coating of candle soot dispersion. The as-prepared surface was endowed prominent water jet resistance and thermally stability. But how to keep the dipping solution stable for a long duration remained as a big challenge. The last was to endow the surface with self-healing property through adding self-healing component. Xue et al. fabricated superhydrophobic surface by spraying coating of polystyrene/SiO_2 nanoparticles and polydimethylsiloxane. While, within limited two heat-healing cycles, long healing time was needed [31].

Though prefect superhydrophobic surface can be obtained through the above mentioned strategies, adding nanoparticles potentially poses a risk to human health [32,33]. Alternative materials and methods with

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no nanoparticles should be explored. Levkin et al. put forward a versatile porous polymer coating to fabricate superhydrophobic surfaces, while the complex raw materials and complicated procedures have restricted the practical usage [34].

Effort has been ongoing to search for ways to create superhydrophobic surface without the use of nanoparticles or fluorine-contained agent [35,36]. For example, by taking THF as solvent, water as non-solvent and PDMS as binder, a superhydrophobic surface was built

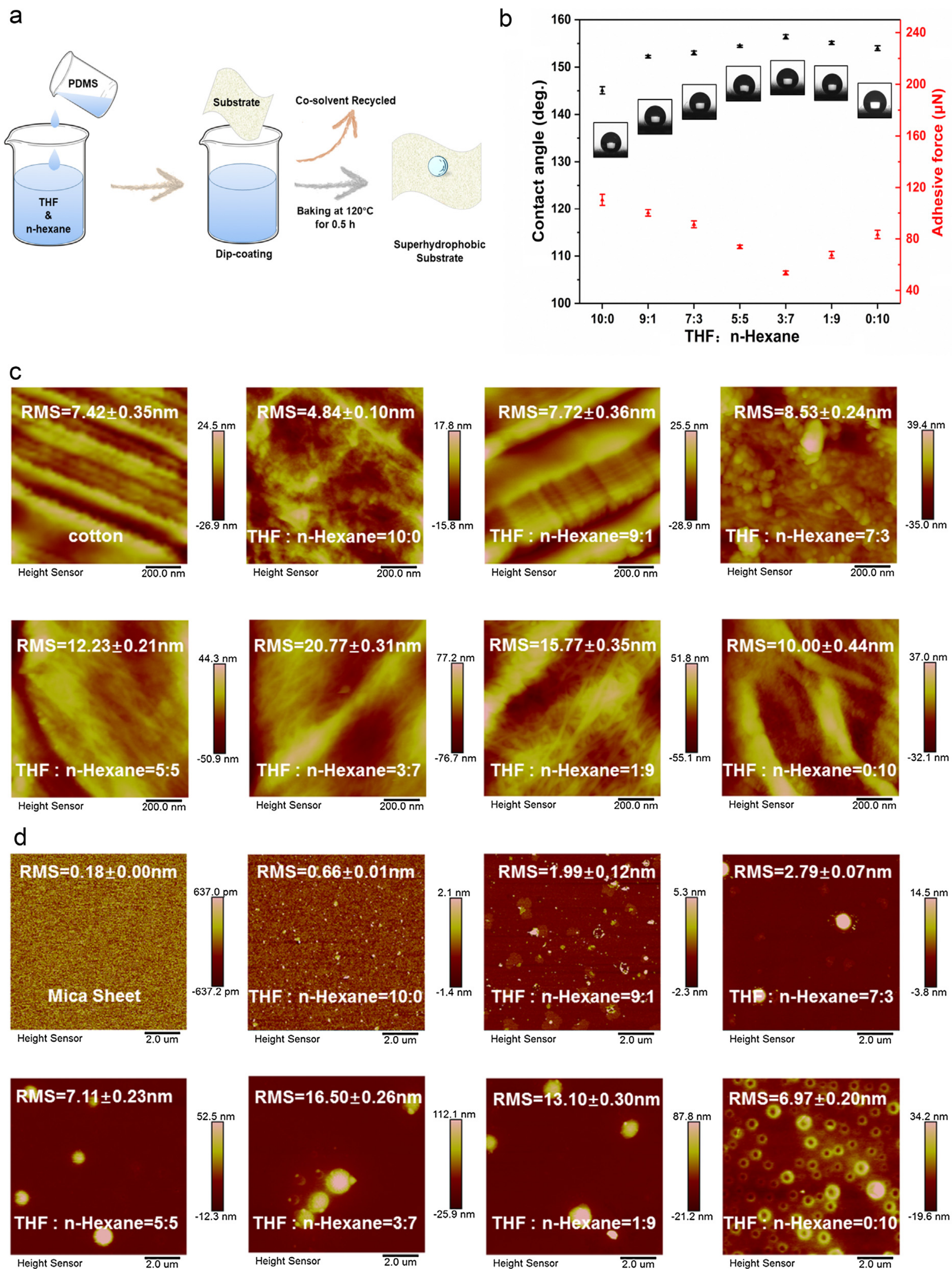

Fig. 1. (a) Schematic illustration of the procedures used to construct superhydrophobic substrates. (b) CA and adhesive force for fabric modified under different volume ratio of THF and n-hexane. (c) AFM roughness images under different conditions on cotton fabrics. (d) AFM roughness images under different conditions on the mica sheets.