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Superhydrophobic ZnO Nanocoatings for Different Substrates†

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Much attention has been paid to the superhydrophobic nanocoatings due to their many advantages, such as low adhesion, low friction and high restitution coefficient. Herein, we introduce a facile approach for the fabrication of superhydrophobic nanocoating using functional ZnO nanocrystals on the different substrate materials. Through a simple dipping and coating method, the resulting coatings display a remarkable superhydrophobic property with high contact angle.

Key Words: Superhydrophobic, ZnO, Nanocoatings.

INTRODUCTION

In the recent years, zinc oxide (ZnO) as an important functional semiconductor material possesses various kinds of applications in the field of electronic components, sensors, photocatalytic degradation of pollutions and field emission display fields because of its excellent physical and chemical properties[1-4]. Researches have showed that superhydrophobic nanocoatings using ZnO nanoparticles have good superhydrophobic property and photocatalytic activity beyond the ordinary function of coating[5]. The coating can decomposes effectively organic pollutants in the air, kill bacteria and purify air. At the same time, it can also make rain droplets free roll and remove contamination and dirt on the surface to achieve the self-cleanning effect. Superhydrophobic ZnO nanocoatings with this property can be widely used for technical biological field and chemical industry, such as the prevention of contamination and the adhesion of snow to antenna, self-cleaning utensils, suppression of surface oxidation and corrosion[6-10].

However, few studies have been demonstrated for superhydrophobic ZnO nanocoatings. Moveover, the coating methods reported need a repetitive layer-by-layer process and require tedious template removal step *via* chemical etching or calcinations. According to it, herein we report a convenient dip-coating and subsequent chemical modification for remarkable superhydrophobic ZnO nanocoatings on various substrate materials surface, including glass, paper, cotton fabric and metals, which will be benefit to expand to the application of newtype superhydrophobic self-cleaning coating.

EXPERIMENTAL

All reagents were of analytical grade and used as received without further purification. Firstly, dry ZnO nanopowders (0.2 g) dissolved in 30 mL of absolute ethanol were vigorously stirred at room temperature for 0.5 h. The resulting colloidal suspension was continuously stirred prior to its use to prevent agglomeration of the particles. The solution was dip-coated onto the prepared substrate surface for 10 min and dried on a hot plate for 1 min. This process was repeated 7 times. After deposition, the previously prepared substrate was immersed into a 0.1 g solution of stearic acid dissolved in ethanol for 0.5 h. inducing the formation of a thin layer of water insoluble stearate on the sample surface. After surface modification of stearic acid, the samples were dried in a vacuum oven at 60 ºC.

The X-ray diffraction were recorded with Philips X'Pert Pro Super diffract meter with CuKα radiation ($\lambda = 1.54178$ Å). The field emission scanning electron microscopy (FESEM) was performed on JEOL JSM-6700F. The contact angles of the coatings were measured with a contact angle meter C_{20} (Kono, America).

RESULTS AND DISCUSSION

In the current work, we applied the dip-coating of ZnO nanopowders as the main deposition method to fabricate superhydrophobic surfaces. Fig. 1(a) shows an SEM image of ZnO nanopowders used for coating. It is found that micro/nano-structured ZnO nanopowders ranged in size from

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hundreds of nanometers to several micrometers. The distribution of particle sizes produces a rough and open substrate surface, which will provide the structural groundwork for its superhydrophobicity. XRD pattern is shown in Fig. 1(b), revealing that all diffraction peaks could be assigned to the hexagonal wurtzite structured ZnO, in consistent with the values in the standard card (JCPDS 36-1451).

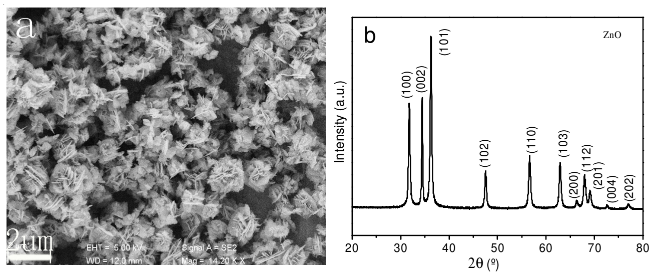

Fig. 1. (a) SEM image of the ZnO nanopowder; (b) XRD pattern of the ZnO nanopowder

In order to study the surface characteristics, non-modified and stearic acid-modified ZnO nanopowders were analyzed by floating test measurements. The floating test was used to measure the ratio of the floated product to the overall weight of the sample after it was mixed in water and stirred vigorously. The ratio above was called the active ratio. Without modification, the ZnO particles obtained were hydrophilic and the active ratio was 0.0 %. When the ZnO powders were treated with stearic acid, the active ratios of all the samples were above 95 %. The floating test demonstrates that the hydrophobic organic stearic acid molecules had been bonded to the surfaces of the obtained modified ZnO particles. Fig. 2 shows the diagram of the hydrophobic modification with stearic acid.

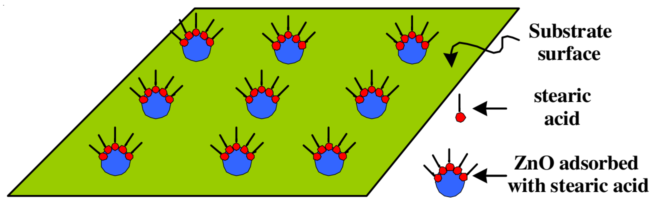

Fig. 2. Diagram of the hydrophobic modification with stearic acid

In order to extend its application, we study the surface wettability of superhydrophobic ZnO nanocoatings on the different substrate surface. Fig. 3 shows photographs of water droplets on the surface of superhydrophobic ZnO nanocoatings for different substrates: glass, copper film, cotton fabrics and paper. From these photographs, we can see that regardless of the substrate materials, the superhydrophobic ZnO nanocoatings obtained by dip-coating and subsequent chemical modification result in a stable and excellent superhydrophobic state of surfaces with high water contact angles. At the same time, the water droplets would roll down if the film was slightly tilted, indicating its small contact hysteresis. Therefore, the substrate materials with superhydrophobic ZnO nanocoating will have an excellent self-cleanning property which can removes effectively contamination and dirt on the surface.

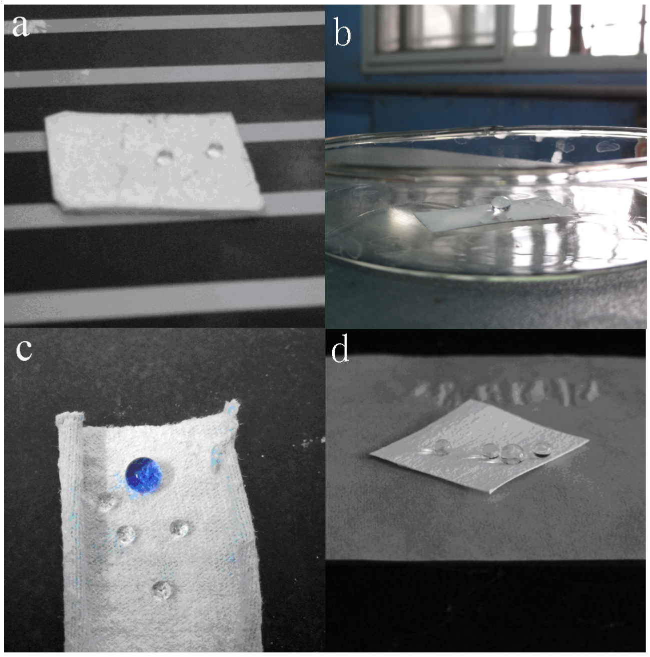

Fig. 3. Photographs of water droplets on the surface of superhydrophobic ZnO nanocoatings for different substrates: (a) glass; (b) copper film; (c) cotton fabrics; (d) paper

Conclusion

A facile fabrication method of superhydrophobic ZnO nanocoatings for various substrates was investigated involving a simple dip-coating step and subsequent chemical modification with stearic acid. All of the resulting coatings showed a stable and good superhydrophobic property. Therefore, this newtype superhydrophobic self-cleaning coating is expected to have extensive application prospects on various substrate materials surface.

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