Journal of Macromolecular Science, Part A
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713597274

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To cite this Article Chen, Li Juan , Chen, Miao , Zhou, Hui Di and Chen, Jian Min(2009) 'Preparation of ZnO Film on 2024Al Surface for Hydrophobicity Investigation', Journal of Macromolecular Science, Part A, 46: 2, 202 — 204
To link to this Article: DOI: 10.1080/10601320802595144
URL: http://dx.doi.org/10.1080/10601320802595144

Journal of Macromolecular Science®, Part A: Pure and Applied Chemistry (2009) **46**, 202–204

ISSN: 1060-1325 print / 1520-5738 online
DOI: 10.1080/10601320802595144

Preparation of ZnO Film on 2024Al Surface for Hydrophobicity Investigation

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Received May 2008, Accepted August 2008

A uniform ZnO film with microscale rod-like structure has been obtained on 2024Al surface by the hydrothermal method and perfluorooctanoicacid has been used to enhance the surface hydrophobic performance of the ZnO film. The as-prepared ZnO film was characterized by scan electron microscope (SEM), X-ray diffraction (XRD) and X-ray photoelectron spectrum (XPS). The results indicate that the ZnO film is uniform and the ZnO microrods are 2 um in length. The water contact angle of hydrophobic surface is 146° and the sliding angle is 10°.

Keywords: Wettability, surface texture, super-hydrophobic surface

1 Introduction

Syntheses of water repellent surfaces have attracted considerable interest in fundamental research and potential industrial applications such as frictionless flow through water pipes, transparent and hydrophobic coating on vehicle windshields etc. (1–3). The wettability of solid surfaces is a very important property that is governed by both the chemical compositions and geometrical microstructures of the surfaces (4–8). The wettability of a solid surface is often characterized by the water contact angle measurement. The water contact angle of a hydrophobic surface is usually greater than 90°. In nature, many plant leaves exhibit the superhydrophobicity and their contact angles are greater than 150°, such as lotus leaves. The ability of these surfaces to make water bead off completely and thereby wash off contamination very effectively has been termed as the "lotus effect" (9). However, it is well known that the contact angle of a surface cannot be increased beyond 120° by a purely chemical process (10). Furthermore, the present studies demonstrate that super-hydrophobicity of the lotus leaves results from their low energy wax-like materials and binary structures at both micro- and nanoscales (11). To date, many methods have been developed to mimic lotus leaves to construct the hydrophobic materials with the binary structures at both micro- and nanoscales (12–15). In this paper, we first prepared a uniform ZnO film with microscale rod-like structure on 2024Al surface and then modified the ZnO film with the low surface energy matter of perfluorooctanoicacid to obtain a hydrophobic surface.

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2 Experimental

Aluminum alloy(YL12) is one of the duralumins and widely applied in the aviation industry, and the chemical composition of YL12 consists of 93.5 wt% aluminum, 4.4 wt% copper, 1.5 wt% magnesium and 0.6 wt% manganese. The super-hydrophobic YL12 surface was prepared by a two-step synthetic method. This method is to first texture the YL12 surface by forming a ZnO film on the YL12 surface and then to modify the textured YL12 surface using perfluorooctanoic acid. The specific process is as follows: A sheet of YL12 (20 × 20 × 5 mm) was successively polished using 800, 1000, 1200 emery papers and then ultrasonically cleaned in acetone and deionized water, respectively. The sheet was immersed in a 0.05 mol/L $ZnNO_3$ and 0.01 mol/L NH_4Cl solution with the pH value of 10 at 90°C for 30 min and then ultrasonically rinsed with deionized water. Finally, the sheet was immersed in a 1 mol/L perfluorooctanoic acid-ethanol solution for 24 h and dried at 120°C for 2 h in an oven.

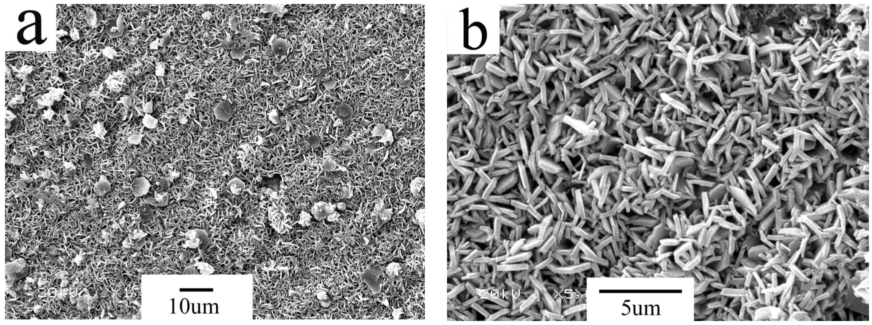

Fig. 1. SEM image of as-prepared ZnO film on 2024Al surface.

3 Results and Discussion

Figure 1 shows the typical morphology of the ZnO film deposited on the 2024Al surface. Figure 1a and 1b exhibit the SEM images with the low and high magnification, respectively. It can be clearly seen that the as-prepared ZnO film on 2024Al surface is uniform and textured by ZnO microrods, and the ZnO microrods is 2 um in length.

The X-ray diffraction pattern of the product shown in Figure 2 indicates that the product is of high crystallinity. All the diffraction peaks in this pattern can be well indexed to a cubic structure of the ZnO phase, which is consistent with the standard data file (JCPDS, No: 80-0075).

X-ray photoelectron spectra of the ZnO film on the 2024Al surface unmodified and modified by perfluorooctanoicacid are shown in Figure 3a and 3b, respectively. The binding energies obtained in the XPS analysis have been corrected by referencing the C1s line to 284.6 eV. XPS analysis of the ZnO film modified by perfluorooctanoicacid gives an elemental composition of 52.134% fluorine and 7.716% carbon, indicating that the ZnO film deposited on 2024Al surface has been covered by the low surface energy groups (-CF_3). Therefore, the as-prepared surface may be super-hydrophobic, which is further confirmed by the contact angle measurement.

Figure 4 shows the profile of the water droplet on the ZnO film deposited on the 2024Al surface modified by perfluorooctanoic acid. The ZnO film on the 2024Al surface is hydrophilic and the water contact angle is 40°, whereas the ZnO film on 2024Al surface modified by perfluorooctanoicacid is the superhydrophobic surface with a water contact angle of 146° and its sliding angle of 10°, implying that the water droplets can be moved upward easily even when the surface is only slightly tilted. These results above reveal that the microstructures and the low surface free energy matter of perfluorooctanoic acid are significantly

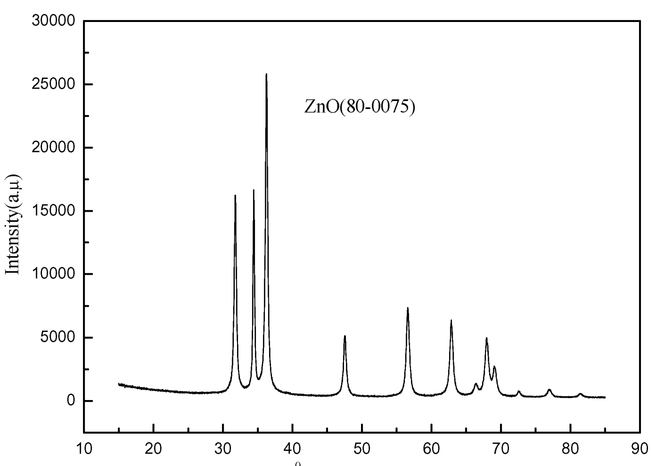

Fig. 2. XRD pattern of as-prepared ZnO film on the 2024Al surface.

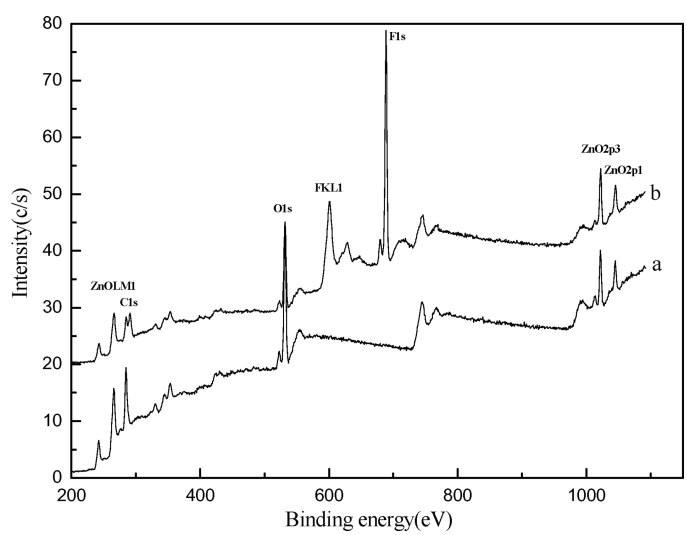

Fig. 3. XPS spectra of the ZnO films deposited on 2024Al surfaces unmodified (a) and modified with perfluorooctanoicacid (b).

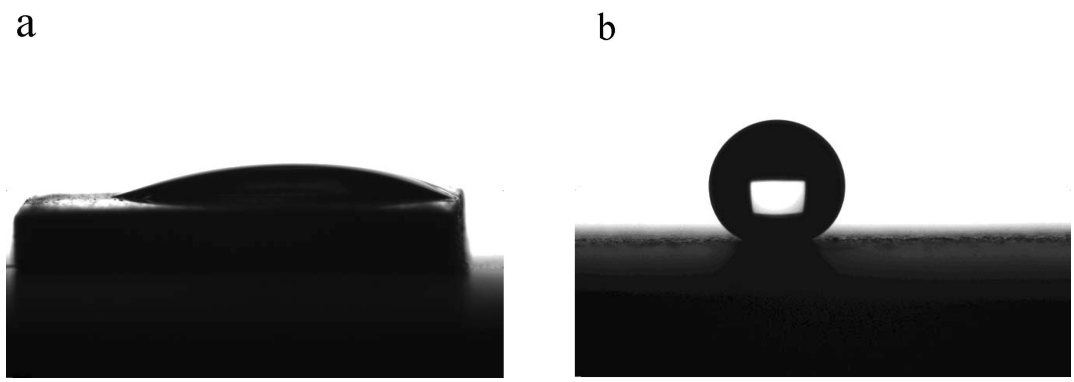

Fig. 4. Profile of the water droplet on the ZnO deposited 2024Al surface unmodified (a) and modified with perfluorooctanoicacid (b).

responsible for the super-hydrophobicity. The samples can be kept for 3 months at temperature in the ambient atmosphere, no decrease in water contact angle was observed, and no contamination was observed.

4 Conclusions

A uniform ZnO film with microscale rod-like structure on a 2024Al surface can be obtained by a hydrothermal method and a super-hydrophobic surface can be prepared by modifying the textured surface with the low surface free energy material of perfluorooctanoic acid. The water contact angle of 146° and the sliding angle of 10° indicate that it may be a good super-hydrophobic engineering material in the industrial applications.

Acknowledgements

The authors are grateful to the National Natural Science Foundation of China (Grant No. 50705094), the Innovative Group Foundation from NSFC (Grant No.50421502) and the National 973 Project (No.2007CB607601).

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