Facile Method for Fabricating Superhydrophobic Surface on Magnesium

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In recent times, technologies based on the imitation of nature have attracted considerable attention. Lotus leaves are known for their self-cleaning effect. The micrometer-scale papillae structure and the epicuticular wax on the lotus leaf contribute to this effect. In a manner similar to the self-cleaning property of lotus leaves, the wettability of solid surfaces is of great interest in daily life and industry. Wettability is controlled by both the geometrical structure of a surface and a low surface energy material coating. A superhydrophobic surface is satisfied with a water contact angle of more than 150° and a sliding energy material coating. A superhydrophobic surface is satisfactorily spherical shape and it easily rolls off and removes deposited contaminants. A superhydrophobic surface thus protects a material from contamination, fogging, and snow deposition.

A material coating with a lower surface energy on a flat surface has a water contact angle of less than 120°. This implies that a flat surface will be changed into a rough surface upon impact with the contact interface. Many methods have been reported for constructing micro- and nanostructures on a surface. For example, the sol-gel method, anodization and plasma treatment, microfabrication with photolithography, solidification of an alkylketene dimer, and application of a polymer have been used to obtain a superhydrophobic surface. The presence of micro- and nanometer-scale structures on a surface involves trapping a large amount of air. This causes a reduction in the contact area between water and a solid surface. In addition to the micro- and nanostructures, a material coating with a low surface energy contributes to the superhydrophobicity of the surface. Fluorine-containing compounds have been commonly coated on solid materials in order to fabricate an artificial superhydrophobic surface. Recently, the self-assembly of n-alkanoic acids on a metal surface has been used to prepare a superhydrophobic surface. Au clusters on an ITO glass substrate were modified with n-dodecanethiol to obtain a water contact angle of 173°. A series of n-alkanoic acids was used to prepare a superhydrophobic surface. Depending on the chain length of the n-alkanoic acids, the contact angle on a flat surface was changed from 68° to 113°. A wet chemical etching surface of an aluminum alloy was treated with stearic acid and N,N′-dicyclohexylcarbodiimide (DCCD) to obtain a superhydrophobic surface. Further, the superhydrophobic surface of a polyethyleneimine-coated aluminum wafer was obtained by its reaction with stearic acid and DCCD. DCCD was used as a dehydration reagent to form either an ester bond or an amide bond.

Most methods for fabricating a superhydrophobic surface are either complicated or require the use of a special instrument. In this study, we have used a chemical deposition process to deposit metal clusters on a magnesium plate and have simply modified the plate with stearic acid.

Experimental Section

The preparation method was as follows. (1) A piece of magnesium was rinsed in ethanol and then cleaned in distilled water in an ultrasonic bath for 5 min. (2) After drying, the magnesium piece was immersed in 5% HCl solution for 2 min, rinsed with distilled water and then dried at 80 °C for 1 h. (3) The magnesium piece was immersed in a mixed chemical solution (1.3 g of NiSO₄·6H₂O and 0.62 g of N₂H₄ in 100 mL of H₂O) at 80 °C for 4 h and then dried overnight at room temperature. (4) The magnesium piece was immersed in aqueous stearic acid solution (1 g in 100 mL of distilled water) for 50 min and then dried at room temperature for 24 h.

The magnesium surface modified with 5% HCl was still a hydrophilic surface with a water contact angle of 20°. A scanning electron microscope (SEM) was used to study the geometrical nano- and microstructures of the superhydrophobic surface.

Fig. 2 shows the typical morphology of a superhydrophobic surface of a Ni-coated magnesium plate. A porous structure and Ni particles were observed on the surface. The metal clusters deposited on the surface exhibited an interesting structure with nanoscale protuberances. The micro- and nanometer-scale structure and cavity on the surface played an important role in trapping...
Table 1. Water contact angle on surfaces

<table>
<thead>
<tr>
<th>Surface</th>
<th>Untreated magnesium</th>
<th>Mg surface treated with 5% HCl</th>
<th>Ni deposited Mg surface</th>
<th>Ni deposited Mg surface treated with stearic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water contact angle (°)</td>
<td>CW; 58.4°</td>
<td>CW; 20.4°</td>
<td>CW; 12.1°</td>
<td>CW; 144.5°</td>
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(a) SEM image of Ni deposited on Mg surface. (b) SEM image of Ni deposited on Mg surface modified with stearic acid.

Fig. 2. (a) SEM image of Ni deposited on Mg surface. (b) SEM image of Ni deposited on Mg surface modified with stearic acid.

Fig. 3. XPS pattern of stearic acid coating on Ni deposited Mg surface.

Fig. 4. Relationship between pH and water contact angle on superhydrophobic surfaces of Mg block.

In conclusion, we have developed a simple and inexpensive method for fabricating a superhydrophobic surface of magnesium by metal deposition and stearic acid coating. We fabricated a superhydrophobic surface on magnesium by nickel deposition and surface coating of stearic acid. The fabricated surfaces were stable against acidic and basic solutions.

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References