Preparation and Friction Performance Research of a Translucent Hydrophobic Film

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Abstract. Alumina hydrophobic film is widely used, but there are few studies on its friction performance. Traditional hydrophobic films are self-assembled with a layer of low surface energy compound on the alumina film surface. The surface is in contact with other substances during use, causing the loss of low surface energy substances and reducing the hydrophobic properties of the film. We use organics and alumina alternate coatings to form an organic-inorganic composite layer, and then tested its hydrophobicity and friction performance.

Keywords: Alumina hydrophobic film, friction performance, composite layer.

1. Introduction

Because of its good hydrophobicity, antifouling, visible light transmittance, self-cleaning, etc., transparent super-hydrophobic film has a wide range of application prospects on the glass of aircraft, yachts, automobiles, etc.

Barthlott et al. [1] observed that the surface of the lotus leaf was self-cleaning, and believed that the superhydrophobicity originated from the rough surface of the micro-structured papillae and the presence of surface wax. Jiang Lei [2] further found that there are nanostructures on the papillae of the microstructure on the surface of the lotus leaf, and believes that the double microstructure is the root cause of the self-cleaning.

At present, the construction of superhydrophobic films can generally be achieved in two steps [5]. First, the micro-nano bump structure is made on the surface of the material, and then the molecular layer of low surface energy substance is modified on the surface [6]. The larger the surface roughness, the more beneficial to increase the water contact angle. But the surface contacts with other substances during use, which causing the loss of low surface energy substances and reducing the hydrophobic performance of the film.

A large number of scholars [7] [8] [9] [10] have done work on the research of superhydrophobic films, but there are few reports on the friction performance of superhydrophobic alumina films. Only Wan Yong [11] used the sol-gel method to prepare superhydrophobic films and studied their Friction performance.

2. Model assumption

The Friction performance of superhydrophobic film is undoubtedly related to its special film structure. It has been confirmed that under dry friction conditions, the aluminum oxide film constructed on the
surface of the material by the sol-gel technology has good mechanical strength and can effectively reduce the wear of the material \[^{12}\]. On the other hand, because of softness of Si-C bond, low surface energy organics can play a lubricating and antifriction effect, which adsorbed on the surface of the material. Therefore, a lubricating agent is added to the solid barrier of alumina, low surface energy organics can not only effectively increase the thickness of the hydrophobic film, but also reduce the friction coefficient, which is the main reason for the film to exhibit better friction performance.

![Figure 1](image1.png)

**Figure 1** Model assumption

We used glass as the substrate, and coat the alumina film which is prepared by sol-gel technology. When the low surface energy organic matter and the sol are alternately sprayed on the surface of the alumina film to make a composite hydrophobic layer. This method not only can produce surface roughness of the film, but also the organic matter can be embedded in the alumina to support and reduce the loss of the organic film. Finally, cetyltrimethoxysilane are grafted to produce a surface coating. It is desirable to obtain a friction-resistant hydrophobic film.

3. Experimental part

Prepare boehmite sol by hydrolysis of aluminum sec-butoxide. Coated on clean glass surface (5.5×2.5cm\(^2\)). Naturally dry for one day, place the sample in a muffle furnace, set the initial temperature to 50\(^\circ\)C, the heating rate is 1\(^\circ\)C /min, then keep at 550\(^\circ\)C for 5 hours to obtain an alumina film substrate;

Alternately spray 2.5 g of 10% hexadecyltrimethoxysilane ethanol solution and 2.5 g of boehmite sol on the surface of the aluminum oxide film to produce an organic-inorganic composite layer. Use a heating plate at 120\(^\circ\)C to heat while spraying. Then play the prepared film in 10% ethanol solution of hexadecyltrimethoxysilane for self-assembly of the film surface, and finally heat in a muffle furnace at 120\(^\circ\)C for 30 min to get hydrophobic translucent alumina film.

Make 5 sets of samples in parallel.

4. Characterization of film characterization results

4.1. Infrared absorption

![Figure 2](image2.png)

**Figure 2** Infrared spectrums of film

There are strong peaks at 2930cm\(^{-1}\) and 2850cm\(^{-1}\), which are the asymmetric expansion and symmetric expansion of -CH\(_2\) in hexadecyltrimethoxysilane.
4.2. The wettability of alumina film (DSA30 contact angle measuring instrument produced by Kruss, Germany)

We measured the contact angle with water by the 5 sets of samples, and the results are as follows:

**Table. 1** Contact angle and rolling angle of 5 groups of samples

| sample  | Contact angle (°) | Rolling angle (°) |
|---------|-------------------|-------------------|
| Sample1 | 128.6             | 11.8              |
| Sample2 | 127.8             | 12.5              |
| Sample3 | 126.9             | 13.6              |
| Sample4 | 125.4             | 14.9              |
| Sample5 | 127.3             | 13.5              |
| **average value** | **127.2** | **13.26** |

**Figure. 3** Image of contact angle between film and water (128.6°)

4.3. Friction performance of the film

Measurement conditions for coefficient of friction: friction force: 4.76N; speed: 100 mm/min; temperature: 25°C. (Labthink MXD-01 Friction coefficient measuring instrument)

We performed dry rubbing on 5 groups of samples for different times, and measured the contact angle between the film and water after rubbing. The result is as follows:

**Figure. 4** The friction coefficient and contact angle corresponding to different friction time of the sample

Because of the hexadecyltrimethoxysilane, the friction coefficient is small and the contact angle does not change much when it is rubbed for 100s. As the friction time increases, the organic layer on the surface is damaged, then enter into the composite laye. Due to the aluminum oxide contained in the composite laye, the friction coefficient increases slightly, and the contact angle decreases significantly.
5. Conclusions
(1). The hydrophobic film prepared by the spray method can increase the thickness of the hydrophobic film by increasing the spray amount to increase the lubricating effect, and improve the friction resistance of the film. And it can finish coating any shape and size substrate.
(2). The different location of the jet source can make uneven hydrophobicity
(3). As the amount of spray increases, the light transmittance of the film also decreases.

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