A cost-effective method for preparing anti-corrosive and fireproof super hydrophobic coating

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Abstract. In this research, a cost-effective method for preparing anti-corrosive and fireproof super hydrophobic coating was presented. By simply painting the mixture of aluminum hydroxide, stearic acid, and polydimethylsiloxane, the self-similar structure was obtained. Thus, this coating maintained super hydrophobicity after sandpaper abrasion. Moreover, this coating could withstand the chemical and fire attack without losing super hydrophobicity.

1. Introduction
The safety of the system transmission line has always been jeopardized by icing, oil, and corrosion [1]. The safety factor of power transmission in power system is determined by the performance level of external insulation material. With the research of silicone rubber (PDMS), researchers have found that silicone rubber has unmatched weather resistance, chemical resistance, corrosion resistance and excellent anti-sticking properties in contrast to other materials [2-4]. The excellent water repellency and hydrophobic migration of room temperature vulcanized silicone rubber (RTV) make it have perfect anti-fouling performance and many characteristics [5-7]. Meanwhile, the super hydrophobic coating has broad application prospects in anti-icing, anti-fouling, oil-water separation, self-cleaning, etc. [8-12]. However, the problem of the poor stability has not been better changed, which cannot conform the needs of transmission lines. Probably, the poor durability of super hydrophobic coating will be solved by combined with organic and inorganic materials.

The super hydrophobic surfaces are typically super hydrophobic with water contact angles (CA) greater than 150° and sliding angles (SA) less than 10°. The wetting of solid surface droplets depends on surface chemistry and surface roughness. On a flat surface with a low surface energy, the maximum CA of the water droplets can reach 120° [13]. In order to increase the contact angle, roughness can be utilized on the flat surface of low surface energy [14-16]. There are two wetting states on a rough surface: The Wenzel regime and the Cassie-Baxter regime. In the Wenzel state, the liquid completely penetrates into the surface roughness characteristics, resulting in complete wetting of the solid interface [17]. In
the Cassie-Baxter state, the liquid droplet sits on top of the roughness asperities with bubbles trapped in between, resulting in a composite solid-air-liquid interface [18]. The wetting behavior in the Cassie-Baxter state is preferred for liquid-repellent surfaces due to droplets are completely suspended above the air pockets hided in the surface pit.

In this paper, RTV was made super hydrophobic simply by aluminium hydroxide nanoparticles and stearic acid. The RTV acted as a binder to interconnect the aluminum hydroxide nanoparticles with each other and to the substrate. The character of super hydrophobic was provided by super hydrophobic aluminum hydroxide nanoparticles and low surface energy modified by stearic acid (STA). A super hydrophobic coating with excellent durability, fire resistance and corrosion resistance was successfully prepared. It is expected to solve the effects of icing, fire, water droplets and air pollution in the natural world on the insulation of the transmission line.

2. Materials and method

2.1. Materials
Room temperature vulcanized silicone rubber (RTV) was purchased from Hebei Lvmeng Co., Ltd. (China). Stearic acid (STA), and Aluminum hydroxide (ATH) was purchased from Sinopharm Chemical Reagent Co., Ltd. (China). All chemicals were analytical grade reagents and were used as received.

2.2. Preparation of coating
In this research, 1.2g of ATH were added to 10ml of absolute ethanol containing 0.4g of STA. Then, the mixture was ultrasonically oscillated for 4h. After drying in air for 8h, the aluminum hydroxide super hydrophobic nanoparticles modified with STA were obtained. The sufficient grinding made the particles into tiny powders. In the next step, 1.5 g of powders were thoroughly stirred with 3 g of RTV, and the mixture was applied to the surface of rubber insulator. Subsequently, it was placed in a 50 °C dry box for 6 hours.

2.3. Characterization
The morphologies of the RTV coating were characterized by SEM (Zeiss, Merlin compact) with an acceleration voltage of 5 kV. JC2000D (Shanghai Zhongchen, China) apparatus measured the drops CAs and SAs.

3. Results and discussion
The super hydrophobicity described in this research was made by the uniform mixing of RTV and aluminum hydroxide nanoparticles modified by STA. In this work, data for the super hydrophobic coating is offered on glass slide. However, the same coating properties were achieved on different substrates by following a similar coating procedure [19]. RTV is a kind of refractory fire-resistant silicone rubber. This coating has also been successfully applied to the surface that can be glued by RTV such as thermoplastic polyurethanes (TPU), polycarbonate (PC), polypropylene (PP), polyethylene terephthalate (PET), and so on.

The super hydrophobic aluminum hydroxide nanoparticles provided surface roughness and low surface energy. The RTV also acts as a binder to interconnect the aluminum hydroxide nanoparticles with each other and to the substrate. As is shown in Fig. 1, RTV contained a large amount of methyl groups and hydroxyl groups can wet aluminum hydroxide nanoparticles. Compared with the content of aluminum hydroxide nanoparticles, the low content of silicone rubber will result in too low adhesion, but the excessive content of silicone rubber will reduce surface roughness and hydrophobicity. Therefore, the content of silicone rubber must be strictly controlled.

The super hydrophobicity of the coating can be attributed to the dual effect: the rough ATH micro-nanoparticle surface and the low surface energy of the STA. In order to understand the surface morphology of the ATH/RTV coating, SEM images of the glass slide sample with the coating were taken as shown in Fig. 2. Irregular modified aluminum hydroxide (STA+ATH) nanoparticles were
observed which resulted in the formation of micro-nanostructures on the surface. In addition, micro-nano particles are visible at the scratches, which together with the RTV silicone rubber constituted a rough surface structure. Nanoparticle-induced surface roughness is an important origin of the super hydrophobic coating.

![Diagram of aluminum hydroxide nanoparticle and silicone rubber composite coating.](image1)

**Figure 1.** Diagram of aluminum hydroxide nanoparticle and silicone rubber composite coating.

![SEM images of the microstructure of coatings under different multiples.](image2)

**Figure 2.** SEM images of the microstructure of coatings under different multiples. The surface morphology image of the coating is shown, indicating surface morphology at different multiples.

We measured the contact angle (CA) and sliding angle (SA) of droplets on the surface of the glass slide coated the RTV coating. The super hydrophobic surfaces are typically super hydrophobic with water contact angles (CA) greater than 150° and sliding angles (SA) less than 10° [19]. In this coating, the CA and SA of the droplets with the surface are showed in Fig. 3(a, b). The CA of 154.5° and SA of 4° demonstrate the excellent super hydrophobic properties of the coating. The droplets appear perfectly spherical when droplets stationary on the coating as shown as Fig. 3(c). In order to verify the resistance of the coating to high temperatures, we measured the CAs of different temperatures. Surprisingly, the super hydrophobic lossing of the coating is not achieved by high temperatures. Instead, the CA increase
s with increasing temperature. The CAs affected temperatures summarized in Fig. 4(I). Compared to many other coatings whose super hydrophobicity gradually loses with increasing temperature, the RTV coating has a great advantage in thermal stability due to its fire resistance of RTV silicone rubber. The excellent thermal stability of the coating indicates that the coating can be applied to harsh temperatures (>180°).

The acidic environment of nature also tests the durability of the coating. All gaseous pollutants or particulate pollutants fall to the ground with precipitation patterns such as rain, snow, fog or haze. Corrosion-resistant super hydrophobic coatings should remain super hydrophobic under the presence of acidic or alkaline contaminants. Here, we tested the corrosion resistance of the coating by contaminants simulated with different pH (1–13) solutions. After immersing the RTV coating in the corrosive liquids for 24 hours, it was rinsed with water and dried at room temperature for the following CA measurements. As shown in Fig. 4(II), all the CAs were still larger than 150. Thus, the RTV coating retained super hydrophobicity after chemical immersion.

Figure 3. Wetting behavior of droplets on the coating. (a) CA of the droplet on the coating. (b) SA of the droplet on the coating. (c) Spherical droplets above the surface.

Figure 4. (I): CAs vs the temperature of RTV coating. (II): CAs vs the RTV coating with treatment of different pH solutions.
4. Conclusion
In summary, we made a super hydrophobic, fireproof and anti-corrosion coating with the use of aluminium hydroxide (ATH), stearic acid (STA) and polydimethylsiloxane (PDMS). This RTV super hydrophobic coating shows a robust resistance to oil contamination, sandpaper abrasion, heat treatment and corrosive liquid attack. Thus, the insulation of the transmission line can be effectively protected by covered with this coating.

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