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TiO2/Silane Coupling Agent Composed Two Layers Structure: A Novel Stability Super-hydrophilic Self-cleaning Coating Applied in PV Panels

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Abstract

In order to improve the properties of anti-dust and self-cleaning for PV panels, self-cleaning has been proposed. But traditional self-cleaning coatings are unstable in nature environment, so it limited the application in the PV panels. Based on the above discussions, this study aims to design a novel super-hydrophilic coating with high stability and corrosion resistance which would be very advantageous for applying in the PV panels. The super-hydrophilic self-cleaning coating is composed by 3-triethoxysilylpropylamine (KH550) and TiO2. KH550 is a kind of surface modification agent which creates more active group on surface of glass. Due to the water as the solvent, the coating is environmental friendly and the material coast is low. This coating can be applied with spraying technology and roller coating by changing the coating's viscosity. The composition was measured by Fourier transform infrared spectroscopy (FTIR), particle size distribution and the surface structure was characterized by Scanning Electron Microscope (SEM). The water contact angle (WCA) was measured by contact angle instrument. It was found that the static water contact angle on the surface of super-hydrophobic coating was as lower than 5°, which show an excellent super-hydrophilic property.

Keywords: Self-cleaning, Super-hydrophilic, double-layers

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1. Introduction

The application of photovoltaic power station was increase rapidly during the 2001. With the development of technology and economic, the cost of the photovoltaic power station is lower than 2 dollars per watt, and the life time of the photovoltaic panel is longer than 25 years. The efficient of the PV panel is effected by its design and also the dust. There have two ways for the dust to effect the efficient of PV panel which are the reduction of the transmittance and the hot pot effect of the PV panels which can reduce the electric energy production and cause fire. When the particle size of the dust is small, the main effect is blocking the passage of light. When the leaves, bird droppings and great heaps of earth on the surface of PV panels, the main effect is hot pot.

The research of the effect for the dust-fouling on PV panel has been studied all around the world for many years. Due to the different air quality in different area, the effect of the dust-fouling on PV panels are great difference. In dry and less of rainfall area, the dust has a great effect to the PV panels. Nimmo and Said [1] discovered that reduction is 26%~40% in Saudi Arabia after 6 mouth without washing. Sayigh [2] showed another result that the efficient of solar thermal collector decreased 30% after 3 days without washing. In 1981, Wakin proposed that 17% degradation of efficient for the PV panel occurred after 6 days in Kuwait. EI-Nashar [3] who comes from The United Arab Emirates showed that the dust reduced 70% of the transmittance for glass in the summer. A simple way to reduce the dust on the PV panel is a research focus. Thus, self-cleaning coating is applied.

When a surface water contact angle greater than 150°, it is referred to as super-hydrophobic. On the contrary, surface with water contact angel of lower than 10° is typically referred to as super-hydrophilic. All these surfaces are often observed in nature on lotus leaves [4] and common nepenthes [5]. These two kinds of surfaces have the self-cleaning properties with different ways. Water on surface became water film while washing away contamination. This phenomenon renders materials with super-hydrophilic surfaces self-cleaning. The observed self-cleaning property of nature super-hydrophilic surfaces has stimulated extensive research interest in the fabrication of artificial super-hydrophilic surface as well as in understanding the fundamental mechanisms underlying the behaviour of a liquid on such surfaces [6].

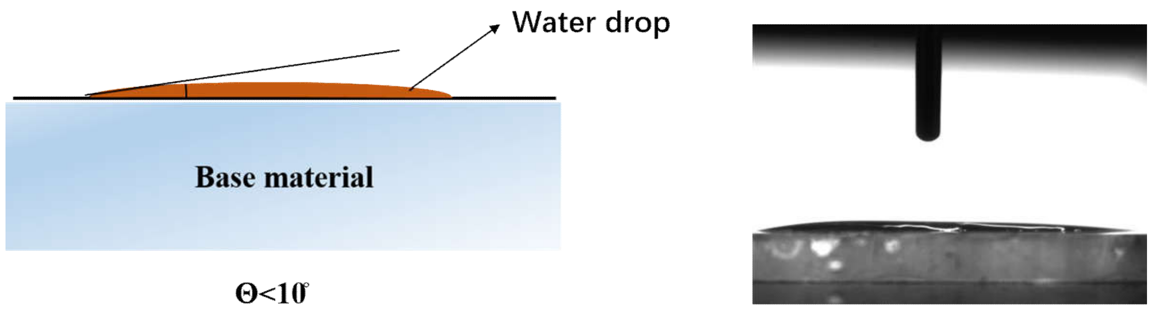

Fig. 1. Super-hydrophilic surface

In generally, Super-hydrophobic surfaces are composited by some organic materials with micro- and nano-structure. However, most of the super-hydrophobic surfaces will failure, when they are exposed in the air. Because they can be damaged by some environmental factors which include chemical reaction with some solution and air, ultraviolet aging, erosion by some particles and germs, even mechanical wear, which limits the application of the super-hydrophobic coating in PV panels.

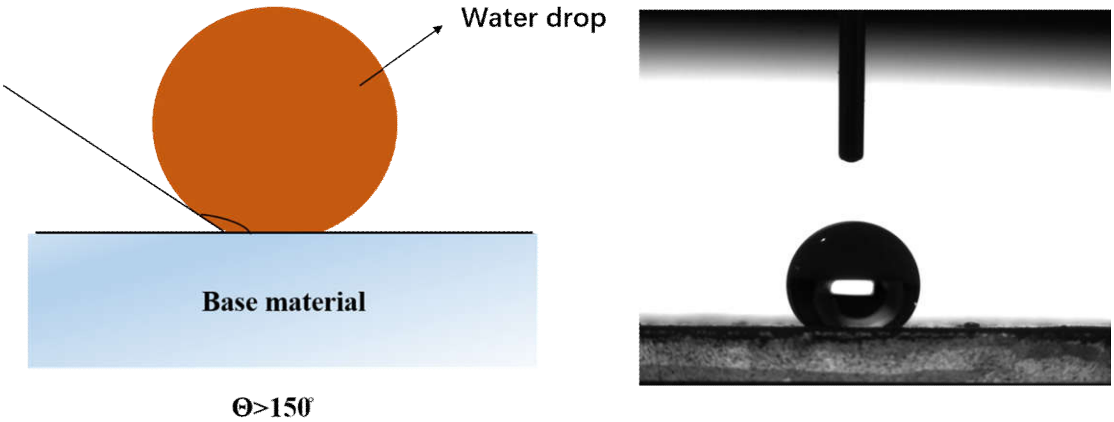

Fig. 2. Super-hydrophobic surface

Most of super-hydrophilic self-cleaning coatings are composited of TiO2 which is a kind of photocatalyst [7]. These coatings chemically break down dirt when exposed to light. However, with the poor dispersion and adhesion, this coating show a short life time and low transmittance. Despite the commercialisation of a hydrophilic self-cleaning coating in a number of products, the field is far from mature. Also there have many other materials to process a super-hydrophilic surfaces. Hu Yan [8] showed a controllable water contact angle of super-hydrophilic coating with TEOS and Silane coupling agent. But the lifetime of this coating is not very long which limited its application in the PV panels.

In this paper, a novel super-hydrophilic coating is prepared with KH550 and TiO2, which show excellent super-hydrophilic. The TiO2 which has a small particle size is synthesized by TiCl4 with ethanol by water thermal reactor (WTR). Also this coating shows a high stability and corrosion resistance which can be applied in the PV panels.

2. Experiment

KH-550 comes from the Sigma-Aldrich. The TiCl4 and ethanol are purchased from Alfa-Aesar. The glass sheets come from Sail Brand Company.

The TiCl4 is firstly dissolved in the alcohol, then the mixture solvent is reaction in WTR at 150℃ with 8 hours. The TiO2 is obtained after final product in the WTR dried in the vacuum drying oven. The synthetic process of TiO2 is shown in the Fig.4.

The glass sheets are cleaned with cleaning compounds to instead of PV panels. The glass sheets are merged into KH-550 solution, then sprayed with TiO2 coating (the concentration of TiO2 is 5‰). The glass sheet treated by KH550 and coated by TiO2 are shown in the Fig.5 and Fig.6 respectively.

The surface structure of glass sheet is observed by SEM (JEOL Model JSM-6490). The dispersion of TiO2 coating is measured by laser particle analyzer (Malven 3000) and the WCA of the surface is measured by Contact Angle Goniometer Sindatek Model 100SB.

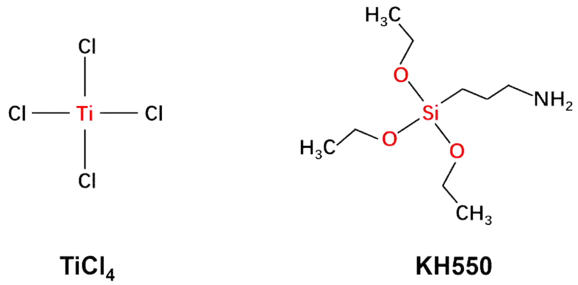

Fig. 3. The structure of TiCl4 and KH550

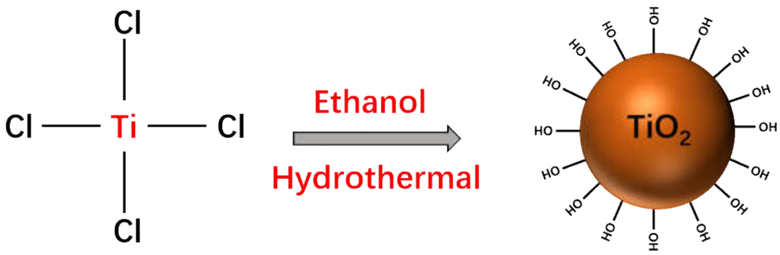

Fig. 4. The synthetic process of the TiO2

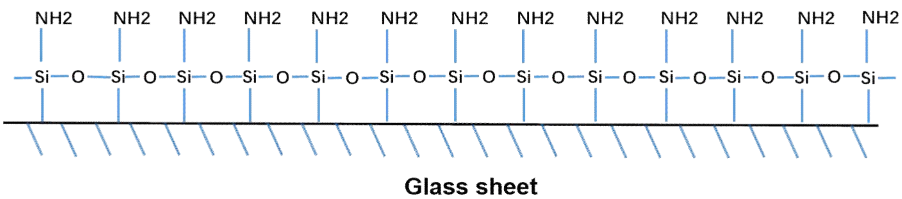

Fig. 5. The glass sheet treated by KH550

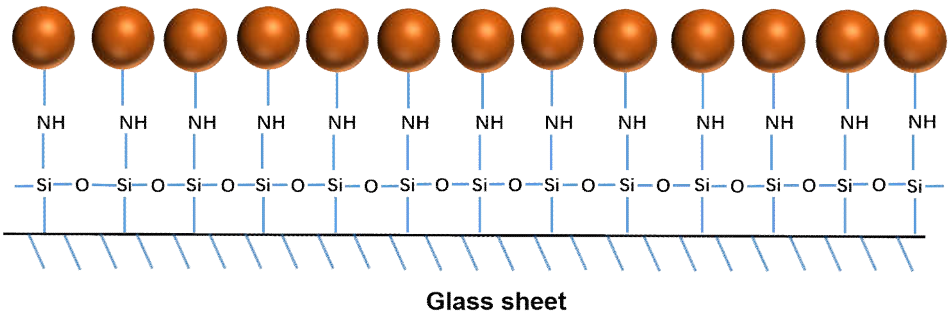

Fig. 6. The glass sheet coated by TiO2

3. Results

The surface structure of the coated glass sheet is shown in Fig 7. The TiO2 is evenly distributed in the glass sheet. And the primary particle size of TiO2 is very small.

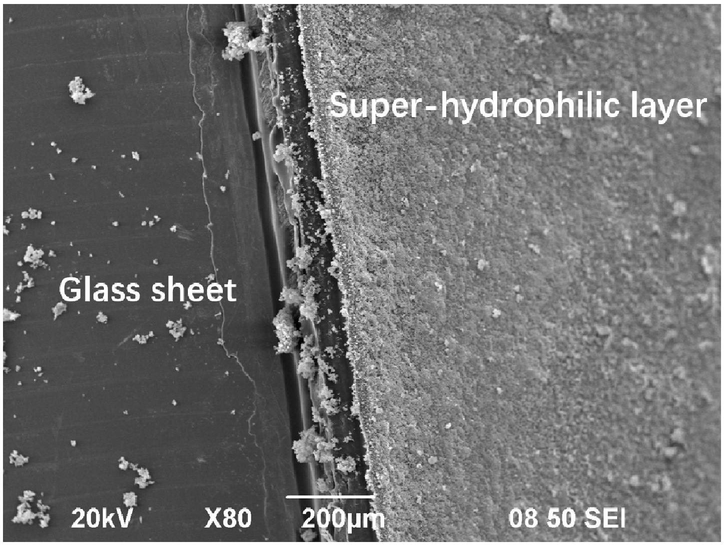

Fig. 7. Super-hydrophilic surface

The secondary particle size of TiO2 coating is shown in Fig 8. It could be seen that the average secondary particle size of TiO2 coating is only about 15nm, and it show a narrow distribution, which provide the excellent transmittance of the coating.

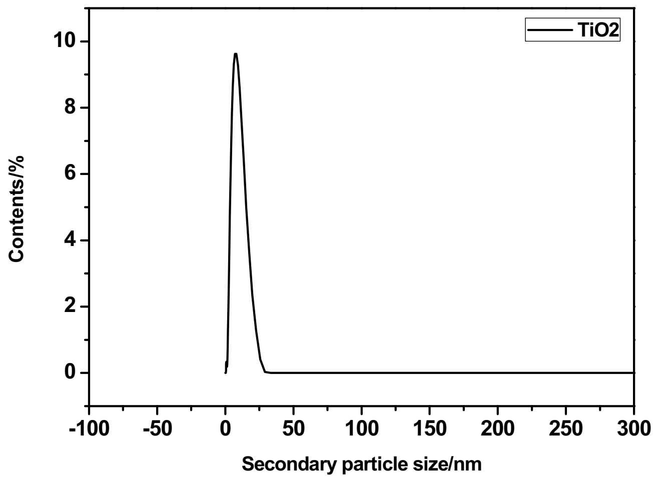

Fig.8. Secondary particle size of the TiO2 coating

The comparison of the WCA about the original glass sheet and coated glass sheet are shown in the Fig 9. The WCA of original glass sheet is 43.7^{o}, while the WCA of coated glass sheet is 4.6^{o} which show a super-hydrophilic self-cleaning surface.

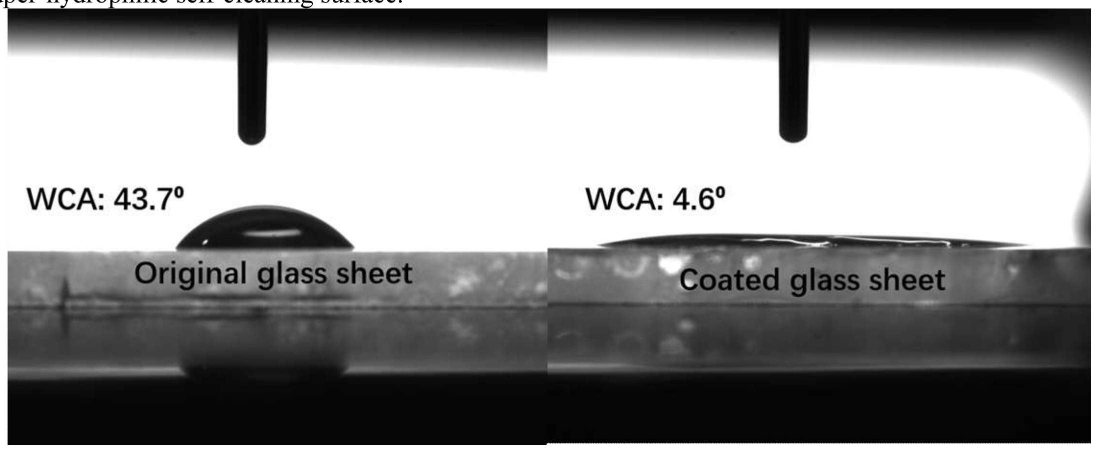

Fig. 9. WCA of the original glass sheet and coated glass sheet

4. Conclusions

From the SEM image, the TiO2 layer is coated on the surface of glass sheet. The TiO2 coating has a excellent transmittance, due to the low secondary particle size of the coating. From the picture of WCA data, the coated glass have a perfect super-hydrophilic self-cleaning performance.

5. Copyright

Acknowledgements

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