Research progress of nano self-cleaning anti-fouling coatings

Y Liu¹,², Y J Zhao¹,², J L Teng¹,², J H Wang¹,², L S Wu¹,², Y L Zheng¹,²
1Nari group corporation (state grid electric power search stitute), Naijing, 211106, China
2Beijing Guodian Futong science and technology development corporation, Ltd, Beijing, 100070, China
E-mail: caser825@163.com

Abstract. There are many methods of evaluating the performance of nano self-cleaning anti-fouling coatings, such as carbon blacking method, coating reflection coefficient method, glass microbead method, film method, contact angle and rolling angle method, organic degradation method, and the application of performance evaluation method in self-cleaning antifouling coating. For the more, the types of nano self-cleaning anti-fouling coatings based on aqueous media was described, such as photocatalytic self-cleaning coatings, silicone coatings, organic fluorine coatings, fluorosilicone coatings, fluorocarbon coatings, polysilazane self-cleaning coatings. The research and application of different kinds of nano self-cleaning antifouling coatings are analysed, and the latest research results are summed.

1. Introduction
It is an effective way to ensure the normal operation of the equipment in harsh environments by preparing nano high self-cleaning coating materials with special functions on the surface of the equipment shell and parts. In the ceramic, glass, metal and other equipment shell surface coated self-cleaning paint, the establishment of super-hydrophobic or sparse surface, thus changing the shell material material surface function. The small water droplets, dust, grease, icing and other dirt adhered on the surface of the shell can fall off automatically so as to achieve the purpose of self-cleaning.

For the study of nano self-cleaning antifouling coatings, it has been widely concerned by the domestic and international coatings industry for a long time. In this paper, the performance evaluation methods of nano self-cleaning antifouling coatings and the research progress of self-cleaning antifouling coatings are mainly discussed.

2. Study on evaluation method of nano self-cleaning coatings
There are many measures to evaluate the performance of nano self-cleaning coatings. It is very important to select suitable self-cleaning performance evaluation methods for different kinds of coatings.

2.1. Carbon black collection method [1]
Carbon black collection method is a simple and relatively close to the actual method of pollution assessment of natural environment.

The process of carbon black collection is to spread the carbon black powder evenly on the surface of the nano self-cleaning anti-fouling coating; then, a certain amount of water is loaded into the injector and drops on the surface of the coating. At the same time, in order to allow the water droplets to roll
away from the surface of the coating, the test device must be tilted to a certain Angle. Schematic diagram of the principle of Carbon black collection method. The state of the water droplets on the surface of the coating reflects the self-cleaning ability of the nano self-cleaning anti-fouling coating. Song Zhenyu et al [1] using carbon black collection method to characterize the surface coating agent on the PVC substrate before and after treatment in the self-cleaning performance. The results showed that PVC substrate after nano self-cleaning coating, can effectively improve the surface of the substrate self-cleaning effect.

The carbon black collection method can only characterize the self-cleaning of the coating, and can not quantify the self-cleaning of the paint.

2.2. Coating reflection coefficient method [2-3]

The coating reflection coefficient method is suitable for the evaluation of nano self - cleaning performance of solvent - based exterior wall paint. Reflective coefficient test, the fly ash mixed with water as a source of pollution, brushing in a paint on the model. After the fly ash layer coated on the template is dried, the reflection coefficient of the surface of the paint sample is measured after the rinsing of the water flow for a specified number of times. The decrease rate of reflection coefficient is calculated to investigate the self-cleaning performance of the coating surface. The specific operation is as follows: The first step, mixed; The second step, measuring the reflection coefficient. The entire testing process needs to be repeated five times.

The coating reflection coefficient method is close to the natural pollution situation and can be quantitatively analyzed, but because of its complex operation and large working cycle of the limitations, it can not quickly determine the coating coating self-cleaning level.

2.3. Glass microbeads method [4]

The glass microbeads method is a common method used to characterize the self-cleaning properties of the anti-fouling of silicone rubber used for insulators. The self-cleaning of the coating is measured by glass microbeads method, which can be tested by special test bed or special self-cleaning coefficient tester. Weigh 3g glass beads as a source of pollution. Remove the sample and collect the glass beads that naturally fall from the surface of the sample and weigh it, and weigh the mass as m (unit: g). Calculate the self-cleaning coefficient η:

\[ η = \frac{m}{0.3} \times 100\% . \] (1)

The advantages of glass microbeads are simple test operation, short work cycle, and can be used to analyze the self-cleaning properties of coatings. However, this method is different from the natural fouling situation, which can not explain the self-cleaning performance of coatings in natural fouling environment.

2.4. Film method [4]

The film method is also a method for characterizing the self-cleaning properties of RTV silicone rubber antifouling coatings. Unlike the glass bead method, the film method is a qualitative test.

2.5. Contact angle and rolling angle method [5-7]

At the level of solid on the surface of a drop of water, when the gas liquid solid three-phase solid surface contact balance, tangential gas liquid interface and the solid-liquid interface formed by the tangent to the folder in which the liquid phase angle is called contact angle \([0-6]\). According to the size of contact angle formed by water and interface on solid surface, the wetting degree can be divided into 2 kinds: hydrophilic material and hydrophobic material.

The rolling angle is the critical angle formed by an inclined surface and a horizontal surface when the droplet is just rolling on the inclined surface. Zhang Zhiqiu and other[7] people in the study repeated 7 times the sample surface rolling angle and its average value, to verify this conclusion. When the static
contact angle value is greater than 150 degrees and the rolling angle value is less than 5 degrees, the coating can be considered as a surface with super hydrophobic properties.

2.6. Organic degradation method [8-9]
The organic degradation method is generally used for the characterization of photocatalytic self-cleaning coatings. The self-cleaning properties of the coatings are evaluated according to the amount of photodegradation organic compounds. The organic compounds in degradation include alizarin red, methylene blue, formaldehyde and benzene compounds, etc. Organic matter degradation method is simple but only applicable to the performance characterization of photocatalytic self-cleaning coatings. In fact, the pollution in the actual environment is not only single organic matter, but also solid dust, inorganic pollutants and so on. Therefore, the structure of the degradation material and the actual pollution of the composition are different, and it is not sufficient to prove the self-cleaning performance of the coating in practical application.

3. Research progress of nano self-cleaning antifouling coating

3.1. Nano photocatalytic self-cleaning coating [10-12]
The nano photocatalytic self-cleaning coating can be applied to the outer walls of equipment and facilities, and can effectively degrade organic pollutants such as adhesion, pollution and corrosion that are adhered to the outer surface of the equipment. Photocatalytic self-cleaning coatings are currently widely used in glass, ceramic and some metal surface. It is widely used in building exterior anti-fouling, can be effective anti-bacterial mold, to prevent the surface caused by microbial degradation of paint and other phenomena occur.

3.2. Silicone self-cleaning antifouling coating [13]
Lee et al. used sol-gel method to prepare the compact structure and can be applied to the silicone insulating coating of electronic devices. However, the curing temperature of silicone coating is high, which is suitable for factory prefabrication and has limitations in site construction.

3.3. Organic fluorine self-cleaning antifouling coating [14-16]
Organic fluorine coatings have excellent corrosion resistance, wear resistance, insulation and pollution resistance. They are widely used in various fields. They are excellent coatings with many advantages. Organic fluorine coating has the name of "coating king". Its film-forming substances are mainly organic fluorine resin and organic fluorine modified resin / modified organic fluorine resin.

3.4. Fluorine silicon self-cleaning antifouling coating [17]
The physical modified fluorine silicon self-cleaning antifouling coating mainly uses the modified florosilicone resin itself as water repellent, oil repellent and other excellent characteristics. Zhang Jinghai uses tetrafluoroethylene, vinyl acetate, allyl alcohol and eleven acid four monomers to obtain organic fluorine resin, then after copolymerization of organic fluorine resin and silicone resin copolymer, adding fillers and additives mixing, self-cleaning and anti fouling coatings for silicon fluoride. It is found that the paint has excellent hydrophobic, hydrophobic and aging resistance up to 20 years, and can be used in marine antifouling coatings.

3.5. Fluorocarbon self-cleaning antifouling coating [18]
C-F-containing paint collectively referred to as fluorocarbon coating, fluorocarbon coating material for the fluorocarbon resin. Fluorocarbon materials are widely used in construction, petrochemical, railway and road traffic, and military and many other fields. Fluorocarbon coating as a durable protective coating, can withstand blooming, cracking, corrosion and air pollution, chemical erosion, etc. Commonly used fluorocarbon materials, such as polytetrafluoroethylene, polyvinylidene fluoride and other melt-type fluorine resin, with the same silicone coating similar to the need to film at high temperatures, it is only applicable to the factory coating.
3.6. Self cleaning antifouling coating of Poly [19-20]

The dry film thickness of varnish developed from poly (urethane) material is usually between 10 nm~2μm. Compared with the alkyd alkyd varnish system and the two-component polyurethane varnish system, two types of varnish show better gloss and weather resistance. In comparison with the silicone modified polyester varnish system, the performance of silicone varnish is superior to that of. If the polysilazane based self-cleaning coatings by certain means for power system, its high hardness will greatly increase the insulator surface coatings, such as the use of electrical equipment for outer wall coatings such as paint the length of time, reduce maintenance costs, is an important direction for the development of electric power industry coatings.

4. Conclusion

The evaluation method of nano self-cleaning antifouling coating has been continuously improved with development for many years. The antifouling effect of nano self-cleaning coating has been evaluated more accurately by using of various methods. With the progress of science and technology, the type of self-cleaning costing increases and the effect is gradually increasing at the same time. Different types of coatings also have a variety of problems, such as higher curing temperature, high cost, poor environmental adaptability and so on. Choosing proper self-cleaning antifouling paint is the key to practical application. I believe that with the continuous optimization of technical means, the development of a comprehensive performance of self-cleaning anti fouling paint is just around the corner.

5. Reference

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