The research on Surface charge of super-bihydrophobic nano-coating materials

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Abstract. Using high bonding energy, low surface energy of polymer-based insulation materials, blending modification of nanoparticles, the composite material surface and internal building "micro -nano" super hydrophobic structure, realization of polymer-based the preparation of nano super hydrophobic insulation materials, to make it break the super hydrophobic material only on the surface to construct "micro-" hydrophobic structure, improve its wearability and applicability, realize "existence is effective" super hydrophobic properties. The surface charge characteristic test and internal mechanism of polymer-based nano-composite super-hydrophobic insulating materials were studied. The conductance transformation mechanism of nano-composite super-hydrophobic insulating materials under different temperature and high field intensity curves was used. Combined with the study of surface charge, the effects of electric field intensity, electrode material, temperature, humidity and doped particles on surface charge of nano-composite super-hydrophobic insulating materials are analyzed.

1. Introduction
The super hydrophobic surface is defined as a surface whose contact angle with water exceeds 150 and whose rolling angle is less than 10. This was proposed by Cassie and Baxter in 1944. The breakthrough in the understanding of super-hydrophobicity of materials began with the observation on the microstructure of leaf surface by W.Barthlott, a famous professor of botany at Bonn university in Germany (Fig. 1).

![Figure 1: The micro-nano structure of lotus leaf surface](image-url)
It is found that super-hydrophobic plants had a roughness on the surface of their leaves, and that the presence of micron structures on rough surfaces and the presence of wax on the surface increased hydrophobicity, and this work was published in the “Nature”[1].

1.1. The key problems of super-hydrophobic coatings are facing at present
(1) the micro rough structure and the combination of the base, micro rough structure between each other fastness is not enough, the rough structure is easy damaged, make preparation of super hydrophobic surface is not durable, so the research has abrasion resistance and can repair the super hydrophobic surface are powerful guarantees for solving this problem.

(2) the method is simple and effective, low cost, environment friendly preparation with room temperature self-healing function of intelligent super hydrophobic surface, obtain lasting good super hydrophobic surface is the inevitable trend in the industrial production.

2. Review on the advances in electrical properties study of nano-super-bihydrophobic materials

2.1. The modification research of super-bihydrophobic materials
At present, the ultra thin research focus on the surface of the water meter, is the use of materials to the workpiece surface coating construction of super hydrophobic coating. Yu-qing zhang [2] with modified SiO2 particles filled to the poly (vinylidene fluoride in the casting solution, preparation of the composite membrane has good resistance to pollution. Sethupathy [3] using electrostatic spinning preparation of the PVDF/SiO2 composite fiber membrane, by changing the SiO2 content in the membrane liquid, super hydrophobic surface are obtained. The influence of illumination on the super hydrophobic coating performance. Her to the primitive PVDF (polyvinylidene fluoride) coating, PMSF (benzyl sulfonyl fluoride) modified hydrophobic PVDF coating and compares the super hydrophobic PVDF coating results as shown inFigure 2.

![Figure 2](image)

**Figure. 2** Different corner of the hydrophobic PVDF coating along with the change of aging time

Visible by the figure, the ultraviolet aging 300 h experiments, unmodified PVDF coating and modification of hydrophobic coatings hydrophobic PMSF no obvious change, and super hydrophobic PVDF coating within 100 h, hydrophobic Angle decreased slowly. More than 100 h, hydrophobic Angle falling fast. PMSF is added in the original super hydrophobic PVDF coating for its super hydrophobic PVDF coating modification, again through the contrast test, you can see the super hydrophobic modified PMSF PVDF coating durability obviously improved, in the 350 h after aging test, contact Angle has remained at more than 140 DHS.
2.2. The development of super-bihydrophobic materials

In 1972, the university of Tokyo, Japan Fujishima and Honda [5] will be introduced to the light and electricity at the same time in the catalytic reaction system, on the TiO2 rutile type semiconductor single crystal electrode photoelectric catalytic decomposition of water production of H2 and O2, the findings, published in the journal Nature, extremely innovative papers, created the heterogeneous photocatalytic basic research and applied research in the new era. Due to the inability of TiO2 biological inert and chemical inertness, light corrosion and chemical corrosion, and cheap [6, 7], the TiO2 photocatalyst curing at high voltage insulator surface inorganic antifouling flash film, through comparing the high voltage insulator coating photocatalytic film before and after the change of electrical properties and actual product pollution situation of bolt, showing the insulator electrical properties changed little after plating TiO2, and the net six months after ash secret value of coating on the surface of the sample before 1/35. Coated insulator has good light self-cleaning capacity and antifouling performance.

Blending method is the preparation of mixed with organic polymer nanoparticles through various ways. SiO$_2$ added to the casting PVDF membrane liquid, the roughness of the surface of the hydrophobic. In situ polymerization is mixed polymer and soluble inorganic molecules before body dissolved in appropriate solvent, organic and inorganic components in the solvent composition combined with some kind of force, through the metal alcohol saline solution condensation, double decomposition reaction, REDOX reaction and so on in situ generated inorganic polymer nanoparticles. In-situ polymerization of the prepared polyurethane acrylate/nano-SiO2 composite emulsion and the coating made of hydrophobic effect is good.

In the epoxy/nanoparticle complex, the effects on the properties of the surface charge of the compound are also different due to different types, shapes and mass percentages of the doped nanoparticles, but in the nano composites significantly lower breakdown voltage, so in general, doping nano SiO2 compounds has the best dielectric performance [8].

3. The research on Surface charge of nano-super-bihydrophobic materials

3.1. Surface charge test

In the research of surface charge, polyethylene has been the most studied material for its application in high voltage dc cable insulation. With more and more applications of epoxy and its compounds in HVDC equipment, more and more attention has been paid to the study of surface charge. A large number of experiments have shown that the surface charge in epoxy is affected by many factors, such as curing agent type, electric field strength, electrode materials, temperature, humidity, doped particles, etc. [9].

![Figure. 3 Electrode configurations for PD measurement. (a) Details of the area around void. (b) Top view of measuring impedance.](image)
3.2. The discussion on the test review of Surface charge

The nano-super-bihydrophobic materials show different charging current waveform in the transient peak current, under different temperature, different sample of current peak appearing time difference is not obvious, different sample may be calculated by type of mobility of basic in $10^{-14}$ to $10^{-13}$ m$^2$/(v), and in measuring the discharge current waveform, appear different to the discharge current, therefore with double logarithmic coordinates represent the current change process [10]. Can be seen from figure 7 for different samples, the higher the temperature, turn point time $t_d$ appeared earlier, the migration rate increases with the rising of temperature.

![Figure 4](image)

**Figure. 4** PD due to an ac 2.7 kV peak value of applied voltage over two cycles. (a) surface charge distribution obtained by the difference of surface charge distribution between two continuous frames; (b) positive direction of coordinate; (c) test voltage waveform with symbols indicating the phases corresponding to the frames in (a); (d) index of surface charge density.

Under the temperature gradient of surface charge measurement results can be seen that low temperature (20°C) side of the low resistivity is advantageous to the electrons to move toward the anode, the opposite side of high temperature (60°C) is not conducive to the cathode electron in a sample, the temperature gradient of the benefit to the reducing of sample negative charges in the body. In particular, for the nano particle mass fraction of 1% polyethylene nanocomposite, at 20°C and 60°C under the volume resistivity of the biggest difference, that is the effect of temperature gradient is the most significant [11,12], so the temperature gradient, the nano particle mass fraction of 1% composite material has almost no surface charge accumulation in the body.
3.3. **The discuss non the test review of Surface charge**

Study of polymer-based nano super hydrophobic insulating materials of space charge, partial discharge, electrical aging test and breakdown characteristic and internal mechanism; Test under different temperature gradient, nano super hydrophobic insulating materials of polarization/go to, the average charge body parameters such as density, apparent migration and trap depth and features; To employ a variety of electric conduction mechanism and electric field, current density curve under different temperature and the high field strength nano super hydrophobic insulation conductance transition mechanism; Combining with the study of space charge, try from the electric field intensity, the electrode material, the respect such as temperature, humidity, doped particle analysis of nano super hydrophobic insulating materials the influence of space charge.

At present, the research focus of super-hydrophobic surface is to build super-hydrophobic coating on workpiece surface by using material coating. It is a research direction to prepare the composite membrane with good pollution resistance by filling the modified SiO$_2$ particles into the polyvinylidene fluoride casting solution.

![Figure 5 PD sequence for (a) and typical pulse current waveforms for (b), (c), (d) and (e) [13].](image)

Through polymer-based nano super hydrophobic insulating materials of electrical performance study, clear micro-hydrophobic structure on the influence of the insulation dielectric performance, develop nano super hydrophobic hydropower medium materials application in power system.
4. Conclusion
In combination with surface charge characteristics and testing and internal mechanism theory. Through different temperature gradient, the polarization of the insulating material depolarization, average charge density, apparent migration and trap depth of characteristic parameters such as test method, from the electric field intensity, the electrode material, the respect such as temperature, humidity, doped particle analysis of nano super hydrophobic insulating materials the influence of surface charge. Clear "micro -" hydrophobic structure influence on dielectric insulation performance, develop nano super hydrophobic hydropower medium materials application in power system.

Acknowledgments
This work was financially supported by State Grid Shandong Electric Power Company science and technology project fund (520628180019).

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