ISSN: 2710-0588

Research on Improving the Performance of Waterborne Surface Insulation Paint

Mingwen Gu, Haifeng Zhang, Xiangmu Hu, Yuanhao Jia, Sizhe Qi, Xiang Xie

Suzhou Vocational Institute of Industrial Technology, Suzhou 215104, China

Abstract

With the rapid development of China's economy, the demand for electric energy in society is increasing, which puts forward higher requirements for the structure and scale of the national power network. High voltage direct current transmission is considered a new technology that can effectively alleviate the problems of power resource allocation and transmission. Insulation technology is an important part of high-voltage DC transmission and transformation technology. Currently, research on external insulation components such as silicone rubber sleeves is relatively mature, and there is relatively little research on DC internal insulation components such as epoxy poured insulators. Under direct current conditions, the surface of insulation materials is prone to charge accumulation effects, resulting in significant differences in insulation and flashover characteristics compared to AC insulation materials.

Keywords

Insulation Paint; Titanium Dioxide; Nanotubes.

1. Introduction

In order to further improve the performance of water-based surface coatings, the method of doping inorganic particle materials is generally used[1,2]. Nano titanium dioxide materials have received widespread attention due to their excellent chemical stability and mechanical properties, while smaller titanium dioxide nanotubes have better dispersibility, which is expected to solve the problem of commonly used silica and aluminum oxide particles being difficult to achieve good composite effects due to the large size and uneven dispersion of doped particles[3-5]. This paper modifies waterborne epoxy resin by modifying nano aluminum oxide/titanium dioxide nanotubes in a specific proportion. Compared to the commonly used nano aluminum oxide/silica particle modified waterborne epoxy resin[6,7]. Titanium dioxide nanotubes replace granular silica to form a stable and dispersed particle/nanotube mixed system in insulation paint. The nanotubes separate the aggregated aluminum oxide particles, thus avoiding the uniformity of nanoparticles in traditional nano aluminum oxide/silica particle systems the difficulty in controlling dispersion in insulation paint and the high inconsistency with the surface interface of the insulation paint result in unsatisfactory modification[8-11]. In addition, under the premise of excellent hydrophilicity, the surface paint of this paper introduces titanium dioxide nanotubes with higher chemical stability and mechanical properties, which can simultaneously possess excellent heat resistance, corrosion resistance, wear resistance, and arc resistance.

The selected raw materials for waterborne surface paint include titanium dioxide nanotubes, waterborne epoxy resin, film forming aids, dispersants, curing agents, curing accelerators, and water. The selected raw materials also include nano aluminum oxide particles. The selected modified nano alumina and modified titanium dioxide nanotubes are mixed in a mass ratio of 10-20:1, The mass ratio of the selected modified nano alumina and modified titanium dioxide nanotubes to the selected waterborne epoxy resin is 0.04-0.20:1. The selected raw materials

ISSN: 2710-0588

also include one or more combinations of emulsifiers, wetting agents, defoamers, rust inhibitors, leveling agents, and thickeners.

2. Sample Preparation and Analysis:

The selected modified nano alumina and the selected modified titanium dioxide nanotubes were obtained by grafting with silane coupling agents, which accounted for 0.5-1.0% of the total mass of the selected nano alumina and nano silica. The selected waterborne epoxy resin is made by reacting bisphenol A, compounds containing hydrophilic groups, and epichlorohydrin. The selected compound containing hydrophilic groups is diethanolamine; The mass ratio of selected bisphenol A, selected compounds containing hydrophilic groups, and selected epichlorohydrin is 1:2:0.1-0.2:1; In the process of preparing the selected waterborne epoxy resin, the selected reaction is controlled at a temperature of 70-90 ℃. The selected curing agent is made by reacting diethylenetriamine with propylene glycol diglycidyl ether to form an adduct, which then reacts with a composite of epoxy resin E-20 and epoxy resin E-12 to form the selected curing agent. The feed mass ratio of the selected diethylenetriamine, the selected propylene glycol diglycidyl ether, and the selected composite is 1:5:0.4-0.6:1; The mass ratio of the selected curing agent to the selected water-based epoxy resin is 0.3-0.4:1; In the method of preparing the selected curing agent, each step of the reaction is controlled to be carried out at 60-70 ℃. The feeding mass ratio of epoxy resin E-20 selected in the selected composite to epoxy resin E-12 selected is 2-5:1; The selected film-forming agent is 2,2,4-methyl-1,3-pentanediol monoisobutyric acid, and the selected dispersant is a block copolymer containing pigment affinity groups. The selected block copolymers include BYK-163 from Germany and MOK-5032 from Germany; The selected curing accelerator is Japanese flavor element PN-23; The selected emulsifier is SYNTHRO-COR 609 B, a French pioneer; The selected wetting agent is polyether modified siloxane copolymer, which includes BASF Hydrogalat875 and Dow HW-1000; The selected defoamer is a defoamer polymer that does not contain organic silicon, and the selected defoamer polymer includes BYK-A500 from BYK Chemical in Germany; The selected anti rust flashing agent is water-based silane coupling agent, and the selected water-based silane coupling agent is one or more combinations selected from KH450, KH566, and KH578; The selected leveling agent is BYK380 from Bike Chemical of Germany; The selected thickener is a non ionic polyurethane type associative thickener, which includes Nantong Hantai Chemical HT-820 and Nantong Hantai Chemical MA-2.

1) Preparation of titanium dioxide nanotubes: Add anatase phase titanium dioxide powder (with a particle size of about 50 nanometers) and a 10M concentration NaOH solution in a high-pressure reactor at a mass ratio of 1:5, seal, and react under hydrothermal conditions at 140 ℃ for 72 hours; After the reactor cools down, remove the white solid from the high-pressure reactor and wash it with 0.1M hydrochloric acid (HCl) solution, then rinse with a large amount of deionized water until the pH value of the effluent solution is neutral. Finally, dry the titanium dioxide nanotube product at 80 ℃.

2) Preparation of modified nano aluminum trioxide/titanium dioxide nanotubes or modified nano aluminum trioxide/titanium dioxide particles: Add the mixture of titanium dioxide nanotubes and aluminum trioxide nanoparticles (or anatase phase titanium dioxide powder and aluminum trioxide nanoparticles) obtained from the previous reaction to a mixture of silane coupling agent and anhydrous ethanol (volume ratio 1:10) at a mass fraction of 10% - 20%, And ultrasonic dispersion treatment for 10 minutes; Subsequently, treat in an oil bath at 400 ℃ for 4 hours; After the oil bath is completed, the flocs obtained from the reaction are repeatedly washed with anhydrous ethanol and deionized water, filtered, and naturally dried at room temperature.

ISSN: 2710-0588

3) Preparation of modified nano aluminum oxide/silica: Add the nano silica particles and a mixture of aluminum oxide nanoparticles at a mass fraction of 10% -20% to a mixed solution of silane coupling agent and anhydrous ethanol (volume ratio 1:10), and ultrasonic dispersion treatment for 10 minutes; Subsequently, treat in an oil bath at 400 ℃ for 4 hours; After the oil bath is completed, the flocs obtained from the reaction are repeatedly washed with anhydrous ethanol and deionized water, filtered, and naturally dried at room temperature.

4) Preparation of waterborne epoxy resin: Dissolve bisphenol A and compounds containing hydrophilic groups in a 5-15% concentration of NaOH aqueous solution, quickly add epichlorohydrin at a temperature of 70-90 ℃, react, control the temperature, and let stand after the reaction is completed; After removing the upper layer of alkaline water, wash the remaining substances with hot water until neutral to remove alkali residues and by-products from the resin. Vacuum dehydrate the resulting product to obtain a light yellow transparent viscous liquid, which is the selected water-based epoxy resin.

5) Preparation of curing agent: Under dry nitrogen protection conditions, diethylenetriamine is added to a four necked bottle containing a thermometer, reflux condensing tube, mechanical stirring, and drip funnel, at a temperature of 60-70 ℃ (preferably 63-68 ℃). Then, slowly add polyethylene glycol diglycidyl ether and maintain the reaction temperature to obtain the diethylenetriamine polypropylene glycol diglycidyl ether adduct; In the later stage of distillation, a certain amount of diethylene glycol butyl ether is added, and then diethylene glycol butyl ether and a small amount of diethylenetriamine are distilled together; Under nitrogen protection at 60-70 ℃ (preferably 63-68 ℃), a composite solution of epoxy resin E-20 and epoxy resin E-12 dispersed in propylene glycol methyl ether was added dropwise to the diethylenetriamine propylene glycol diglycidyl ether adduct, and the selected curing agent was prepared through reaction.

6) Preparation of waterborne epoxy surface paint: Mix waterborne epoxy resin, film forming agent, and some water, and selectively add emulsifier to prepare a mixture; Add modified nano aluminum oxide/titanium dioxide nanotubes to the mixture under stirring conditions; Then add curing agent, dispersing agent, selectively adding wetting agent, selectively adding defoamer, selectively adding leveling agent, curing agent promoter, selectively adding anti flashing rust agent, selectively adding thickener and remaining water, and mix to obtain the selected water-based epoxy surface paint.

Table 1. Performance Comparison

	Example 1	Example 2	Example 3	Pair ratio 1	Pair ratio 2	Pair ratio 3	Pair ratio 4
Arc resistance time/s	342	333	321	343	352	321	322
Neutral salt spray resistance/h	346	346	321	321	342	287	342
Heat resistance/℃	132	123	125	123	162	123	124
Water resistance/h	≥240	≥240	≥240	≥240	≥240	≥240	≥240
Impact strength Kg/cm	56	55	59	52	54	52	52
hardness	H	H	H	H	H	F	F

3. Summary

This article proposes a preparation method of insulating paint for electric vehicle motors doped with titanium dioxide nanotubes. The resulting breakdown or discharge consequences are also severe, which can affect the stability of DC transmission and transformation systems.

ISSN: 2710-0588

Reasonably designing the insulation structure of the device and optimizing the performance of insulation materials are currently two commonly used methods to improve the internal insulation flashover characteristics of insulation components. The former adjusts the distribution of the electric field by adjusting the thickness distribution of the insulation layer and optimizing the electrode shape. Although this technology has some improvement in the stability of DC transmission and transformation systems, there are many limitations in the component manufacturing process. The chemical modification of insulation matrix can also effectively regulate the degree of charge accumulation on the surface of materials, while also changing its electrical resistivity, mechanical strength, and electrical strength parameters.

Acknowledgments

This work was supported by Suzhou Industrial Vocational and Technical College Innovation and Entrepreneurship Project (PTXM0171).

References

[1] XIE J, PAN X B, WANG M Y, et al. The role of surface modification for TiO2 nanoparticles in cancer cells [J]. Colloids and Surfaces B-Biointerfaces, 2016, 143: 148-155.

[2] HUANG C, HUANG Z X, LV X S, et al. Surface modification of hollow glass microsphere with different coupling agents for potential applications in phenolic syntactic foams [J].Journal of Applied Polymer Science, 2017, 134(4): 14.

[3] SILVEIRA-HORNUNG P, ÁVILA S, APEA-BAH F B, et al.Sustainable use of ilex paraguariensis waste in improving biodegradable corn starch films'mechanical, thermal and bioactive properties [J]. Journal of Polymers and the Environment, 2020, 28(6): 1696-1709.

[4] KHATTAK N S, AHMAD A S, SHAH L A, et al. Thermal and rheological study of nanocomposites, reinforced with Biphase ceramic nanoparticles [J]. Zeitschrift Für Physikalische Chemie, 2019, 233 (9): 1233-1246.

[5] AHMED N, FAN H, DUBOIS P, et al. Nano-engineering and micromolecular science of polysilsesquioxane materials and their emerging applications [J]. Journal of Materials Chemistry A, 2019, 7(38): 21577-21604.

[6] ZHENG W, TANG C, XIE J, et al. Micro-scale effects of nano-SiO2 modification with silane coupling agents on the cellulose/nano-SiO2 interface [J]. Nanotechnology, 2019,30(44): 445701.

[7] NAKAMURA T, TABUCHI H, HIRAI T, et al. Effects of silane coupling agent hydrophobicity and loading method on water absorption and mechanical strength of silica particle-filled epoxy resin [J]. Journal of Applied Polymer Science,2020, 137(17): 48615.

[8] QING Y Q, YANG C N, YU N N, et al. SuperhydrophobicTiO2/polyvinylidene fluoride composite surface with reversible wettability switching and corrosion resistance [J].Chemical Engineering Journal, 2016, 290: 37-44.

[9] YANG D, RUAN M N, HUANG S, et al. Improved electromechanical properties of nbr dielectric composites by poly(dopamine) and silane surface functionalized TiO2 nanoparticles [J]. Journal of Materials Chemistry C, 2016,4(33): 7724-7734.

[10] SHI Y, ZHANG Q, LIU Y, et al. Preparation of amphiphilic TiO2 janus particles with highly enhanced photocatalytic activity [J]. Chinese Journal of Catalysis, 2019, 40(5): 786-794.

[11] ZHONG H, HU Y, WANG Y H, et al. TiO2/silane coupling agent composed two layesrs structure: A novel stability super-hydrophilic self-cleaning coating applied in PV panels [J]. Applied Energy. 2017, 204: 932-938.