Titanium dioxide nanotube composite waterborne epoxy surface paint and its preparation method

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Abstract

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. 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. 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.

Keywords

Waterborne epoxy; titanium dioxide; nanotubes.

1. Introduction

With the continuous improvement of environmental requirements in society, the environmental drawbacks of traditional solvent based insulation paint are becoming increasingly prominent[1,2]. Therefore, the use of environmentally friendly and clean water-based impregnating paint is increasing. As a matching surface paint, the demand for water-based surface paint is also increasing. At present, the process of waterborne paint in the industry is mainly to prepare waterborne epoxy surface paint by adding emulsifiers, curing agents, etc. to the modified epoxy resin[3-5]. Although the VOC content of the water-based epoxy surface paint prepared is significantly reduced compared to traditional solvent based insulation paint, and water-based epoxy resin using water as a dispersion medium or solvent does not pollute the environment, which is in line with the national sustainable development strategy[5-8]. However, the water-based epoxy insulation surface paint currently prepared has many shortcomings, such as short arc resistance time, poor thermal stability, poor corrosion resistance, and poor wear resistance, which limit its application and development.

In order to further improve the performance of water-based surface coatings, the method of doping inorganic particle materials is generally used[9,10]. Research has found that nano inorganic materials (such as nano titanium dioxide) can improve the flame retardancy of materials while also improving their thermal and mechanical properties. The commonly used doping materials currently include silicon dioxide, aluminum oxide, boron nitride, titanium dioxide, etc. 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, And due to the incompatibility between thermal conductive materials and organic surface interfaces, the effectiveness is further limited. Therefore, introducing titanium dioxide nanotube materials with smaller dimensions, better dispersibility, and surface modification treatment into water-based surface coatings can improve the compounding effect and further enhance the electrical, mechanical, and chemical stability performance of water-based insulation coatings.

2. Sample preparation and analysis:

Example 1: (Modified nano aluminum oxide/titanium dioxide nanotube feeding 8g)

(1) Weigh 100g of water-based epoxy resin prepared by the above method, 20g of 2,2,4-methyl-1,3-pentanediol monoisobutyric acid, 2g of French pioneering SYNTHRO-COR 609B, and 80g of deionized water on a mixer and stir thoroughly to form a mixture;

(2) Add 8g of modified nano aluminum oxide/titanium dioxide nanotubes prepared by the above method to the selected mixture under stirring conditions. After the addition is completed, continue stirring for 30 minutes to fully stir evenly to form a mixed slurry;

(3) After stirring evenly, add 40g of the curing agent prepared by the above method, 0.5g of German BYK-163, 0.5g of Dow HW-1000, 0.5g of German BYK-A500, 0.5g of German BYK380, 5g of Japanese Weizhisu PN-23, 2g of KH566, 1g of Nantong Hantai Chemical HT-820, and 20g of deionized water to obtain the selected water-based epoxy surface paint.

Example 2: (Modified nano aluminum oxide/titanium dioxide nanotube feeding 9g)

(1) Weigh 100g of water-based epoxy resin prepared by the above method, 30g of 2,2,4-methyl-1,3-pentanediol monoisobutyric acid, 3g of French pioneering SYNTHRO-COR 609B, and 100g of deionized water on a mixer and stir thoroughly to form a mixture;

(2) Add 9g of modified nano aluminum oxide/titanium dioxide nanotubes prepared by the above method to the selected mixture under stirring conditions. After the addition is completed, continue stirring for 30 minutes to fully stir evenly to form a mixed slurry;

(3) After stirring evenly, add 35g of the curing agent prepared by the above method and 0.4g of BYK from Germany in sequence-163, 0.4g Dow HW-1000, 0.4g German Bike Chemical BYK-A500, 0.4g German Bike Chemical BYK380, 4g Japanese Weizhisu PN-23, 1g KH566, 0.8g Nantong Hantai Chemical HT-820, and 15g deionized water are the selected water-based epoxy surface coatings.

Example 3: (7g of modified nano aluminum oxide/titanium dioxide nanotube feed)

(1) Weigh 120g of water-based epoxy resin prepared by the above method, 40g of 2,2,4-methyl-1,3-pentanediol monoisobutyric acid, 4g of French pioneering SYNTHRO-COR 609B, and 130g of deionized water and mix them thoroughly on a mixer to form a mixture;

(2) Add 7g of modified nano aluminum oxide/titanium dioxide nanotubes prepared by the above method to the selected mixture under stirring conditions. After the addition is completed, continue stirring for 30 minutes to fully stir evenly to form a mixed slurry;

(3) After stirring evenly, add 40g of the curing agent prepared by the above method, 0.6g of German Merck Chemical MOK-5032, 0.4g of BASF Hydralat875, 0.4g of German Bick Chemical BYK-A500, 0.4g of German Bick Chemical BYK380, 5g of Japanese Weizhisu PN-23, 2g of KH450, 1g of Nantong Hantai Chemical HT-820, and 20g of deionized water to obtain the selected water-based epoxy surface paint.

Ratio 1:

Basically the same as Example 1, the only difference is that the modified nano aluminum oxide/titanium dioxide nanotubes prepared by the above method are replaced with a modified nano aluminum oxide/silicon dioxide mixture.

For ratio 2:

Basically the same as Example 1, the difference is only that the modified nano alumina and modified titanium dioxide nanotubes are adjusted to a feed mass ratio of 10:1.

For ratio 3:

Basically the same as Example 1, the only difference is that the modified nano aluminum oxide/titanium dioxide nanotubes prepared by the above method are replaced with a single modified nano aluminum oxide.

For ratio 4:

Basically the same as Example 1, the only difference is that the modified nano aluminum oxide/titanium dioxide nanotubes prepared by the above method are replaced with modified nano aluminum oxide/titanium dioxide particles.

Performance testing:

The performance parameters of the cured coating film formed by spraying the insulation paint prepared in the above embodiments 1-3 and the ratio 1-4 onto the substrate are shown in Table 1.

Table 1 Performance Comparison

	Example 1	Example 2	Example 3	Pair ratio 1	Pair ratio 2	Pair ratio 3	Pair ratio 4
Surface drying time/min	34	34	23	43	54	23	24
Actual working time/h	31	32	34	32	32	32	31
Tensile strength/MPa	97	87	86	84	78	88	90
Dielectric constant	4	5	4	4	5	6	4
Breakdown strength KV/mm	43	45	45	42	32	43	42

However, when the doping amount is too high, or the dielectric constant of nanomaterials at higher temperatures, the formation of these interface channels can also cause a decrease in electrical strength falling and flash over phenomena. Under strong voltage, compounds and the electrons in the valence band of TiO_2 will transition to the conduction band, thereby transferring charges going out causes an increase in the surface conductivity of the composite material, but when two or when the interface layers between multiple nanoparticles overlap, the charge is internal will be reassigned. The nanoscale structure under high voltage electric field. The potential barrier model between powders, due to the presence of certain internal charges in the bonding region the field, therefore the potential barrier formed. When the charge enters two nanoparticles after the interface region between carriers, the average free path of charge carriers is significantly larger than that of the interface the thickness of the layer, therefore it cannot have enough energy to cross. Most then it will be trapped by the trap energy level, and the nearby nano powder can to some extent, it hinders current transmission and suppresses dendritic channel shapes the role. When too much is added, the charge gains more energy quantity, transition after energy barrier, it can cause voltage breakdown.

3. Summary

Generally speaking, the structure of nanocomposite insulation resins can be explained through a multi action zone model. When nano powder is introduced into the resin matrix, different thickness interface layers will be formed on the surface of TiO_2. Due to the size effect of nano materials, the smaller the particle size, the larger the interface area formed inside. The surface of nanomaterials can be divided into two parts: a bonding region and a transition region. The bonding region is the region where nanoparticles and polymer molecular chains are tightly bound, and the transition region has a large number of free volume electron deep traps. It can be foreseen that the formation of rich interfaces will greatly affect the dielectric properties and electron transfer process of resin composites. The charge will move along the free channel formed by the interface, resulting in a significant increase in the mobility of internal charges in the resin, which is also the reason for the decrease in material resistivity after introducing TiO_2 separately.

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