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An Insulating Paint Doped with Titanium Containing Inorganic Particles and Its Preparation Method

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Abstract

This paper innovatively adopts a specific method to produce titanium dioxide nanotube materials with smaller sizes and microstructures, and due to the surface hydrophobicity treatment of the titanium dioxide nanotube materials, the titanium dioxide nanotube materials in this paper can stably exist and be applied to insulation paint with a large doping amount, and can participate in the cross-linking network of insulation paint resin, This enables the insulation paint in this paper to not only have excellent insulation and chemical stability, but also achieve excellent mechanical properties, overcoming the drawbacks of high doping in existing technologies that are not conducive to ordinary impregnation processes and VPI impregnation processes.

Keywords

Polyester; Titanium dioxide; Nanotubes.

1. INTRODUCTION

With the continuous development of motor technology, the power of the motor continues to increase, and the power consumption of the motor also increases, which may lead to problems such as insulation aging, coil breakdown, and motor burning[1-5]. Therefore, insulation paint needs to have excellent electrical, mechanical, and chemical stability at the same time, in order to increase the output force of the motor[6-9]. However, in existing technologies, insulation paint still has the problem of difficult to achieve excellent electrical, mechanical, and chemical stability, which greatly limits the quality and lifespan of the motor[10-12].

In order to further improve the performance of insulation paint, the method of doping inorganic particle materials is generally used. 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[13-16]. However, in order to achieve high performance, insulating paint generally requires high doping, and high doping will face problems such as poor compatibility between doped particles and insulating paint. On the one hand, due to the large size and uneven dispersion of doped particles, it is difficult to achieve a good composite effect; On the other hand, the incompatibility between thermal conductive materials and organic surface interfaces further limits the effectiveness of the material. Therefore, introducing titanium dioxide nanotube materials with smaller dimensions, better dispersibility, and surface hydrophobicity treatment into the insulation paint can improve the compounding effect and further enhance the electrical, mechanical, and chemical stability performance of the insulation paint.

2. SAMPLE PREPARATION AND ANALYSIS:

Preparation of titanium dioxide nanotubes:

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(1) Preparation of titanium dioxide nanotubes: Anatase phase titanium dioxide powder (with a particle size of about 50 nanometers) and a 10M concentration NaOH solution were added in a high-pressure reactor at a mass ratio of 1:5, sealed, and subjected to hydrothermal reaction 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 ℃.

Titanium dioxide nanotubes with surface hydrophobic treatment:

(1) Preparation of titanium dioxide nanotubes: Anatase phase titanium dioxide powder (with a particle size of about 50 nanometers) and a 10M concentration NaOH solution were added in a high-pressure reactor at a mass ratio of 1:5, sealed, and subjected to hydrothermal reaction 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) Hydrophobic treatment of titanium dioxide nanotube surface: add the titanium dioxide nanotube or other titanium containing particles obtained from the previous reaction to a mixture of silane coupling agent and anhydrous ethanol (volume ratio 1:10) in a mass fraction of 10% -20%, and sonicate for 10 minutes for dispersion treatment; 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.

Example 1

This example provides an insulating paint, calculated by mass fraction. The raw materials for the thermal conductive insulating paint in the paper include: 10 parts of isophthalic anhydride, 22 parts of maleic anhydride, 23.6 parts of 1,2-propanediol, 4 parts of surface hydrophobic treated titanium dioxide nanotubes prepared in Example 2, 1 part of benzoyl peroxide, 0.05 parts of cobalt naphthenate, 23 parts of styrene, and 0.02 parts of hydroquinone.

The preparation method is as follows: weigh each raw material according to the formula, and then add m-phthalic anhydride, maleic anhydride, 1,2-propanediol, and surface hydrophobic treated titanium dioxide nanotubes to the reaction vessel. Under the protection of protective gas, heat up and stir, raise the temperature to 160 ℃, and heat up the reaction to an acid value of 45 ± 1mg KOH/g, raise the temperature to 175 ℃. Heat up the reaction to an acid value of 35 ± 1mg KOH/g, and raise the temperature to 200 ℃, Hold the reaction until the acid value is 12 ± 1mg KOH/g and end the reaction; Then cool to room temperature, add remaining raw materials, mix and react to prepare the paper insulation paint.

Example 2

Basically the same as Example 1, the difference is only that the addition amount of surface hydrophobic treated titanium dioxide nanotubes prepared in Example 2 is 2 parts.

Example 3

Basically the same as Example 1, the difference is only that the addition amount of surface hydrophobic treated titanium dioxide nanotubes prepared in Example 2 is 8 parts.

Example 4

Basically the same as Example 1, the difference is only that the titanium dioxide nanotubes were prepared using Example 1 and did not undergo surface hydrophobicity treatment.

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Proportion Ratio 1

Basically the same as Application Example 1, the difference is only that the titanium dioxide powder particles are used to replace the surface hydrophobic treated titanium dioxide nanotubes, and the content of titanium dioxide is consistent with Application Example 1 (4 parts).

Proportion Ratio 2

Basically the same as Application Example 1, the difference is only that: basically the same as Application Example 1, the difference is that no titanium dioxide material is added. The specific preparation method is as follows: weigh each raw material according to the formula, and then add isophthalic anhydride, maleic anhydride, and 1,2-propanediol to the reaction vessel. Under the protection of protective gas, heat up and stir, heat up to 160 ℃, hold the reaction until the acid value is 45 ± 1mg KOH/g, and heat up to 175 °C, Hold the reaction until the acid value is 35 ± 1mg KOH/g, raise the temperature to 200 °C, and hold the reaction until the acid value is 12 ± 1mg KOH/g to end the reaction; Then cool to room temperature, add remaining raw materials, mix and react to prepare the paper insulation paint.

Test conditions:

The viscosity is directly tested using insulating paint according to standards. Prepare 1mm thick paint film according to the standard for electrical strength, volume resistivity, and dielectric loss tangent value. Curing process: 140 ℃, 2 hours; 160 ℃, 6 hours. Thermal conductivity prepared according to standard length and width 10mm × 10mm, 1mm thick thermal conductive film, curing process: 140 ℃, 2 hours; 160 ℃, 6 hours. Prepare the spiral coil according to the standard bonding strength and the preparation process. Place the spiral coil in the paint in the forward direction for 10 minutes, remove it, and place it in a 140 ℃ oven for 2 hours; Then reverse the spiral coil into the paint and place it in an oven at 140 ℃ for 2 hours; 160 ℃, 6 hours. Prepare a sample with a thickness of 5mm according to the standard for heat resistance index. Curing process: 140 ℃, 2 hours; 160 ℃, 6 hours.

Table 1. Performance Comparison

	Example 1	Example 2	Example 3	Example 4	Pair ratio 1	Pair ratio 2
Breakdown strength (KV/mm)	32	32	31	34	31	32
Dielectric loss tan δ (%)	0.2	0.3	0.1	0.3	0.2	0.1

3. SUMMARY

After inorganic or organic surface modification, nano TiO_2 has greatly expanded its application scope. But there are still some questions. The problem needs to be urgently solved: develop a low-cost, easy to operate, and modification methods that can be used for large-scale production; Continue to optimize and modify process conditions, study the reaction mechanisms of various modifiers, and evaluate their effectiveness in reverse engineering. The modification should be influenced by parameters such as temperature, acidity, alkalinity, and reaction time during the process. The impact of the effect; In addition, inorganic organic synergistic modification of nano TiO_2 is also a future research hotspot.

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