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Study on the Preparation of ATF Oil Resistant Insulating Paint for Electric Vehicles

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Abstract

This paper develops a flame-retardant insulation paint for electric vehicle motors. The raw materials of the insulation paint include titanium dioxide nanotubes, polyester resin, curing agent, initiator, and diluent. The polyester resin is an unsaturated polyester resin containing halogens, which is made by reacting halogenated phthalic anhydride, polybasic acids, and polyols. The halogenated phthalic anhydride The feeding molar ratio of the polybasic acid and the polyol is 1:2.54.0:2.03.5, and the polybasic acid is at least two selected from the group consisting of adipic acid, phthalic acid, maleic anhydride, and glutaric anhydride. The polyol is at least two selected from the group consisting of propylene glycol, 1,4-butanediol, and ethylene glycol; The raw material also includes diisocyanate, and the feeding mass ratio of the diisocyanate to the unsaturated polyester resin containing halogen is 0.050.15:1. Among them, titanium dioxide nanotubes account for 3-9% of the total mass of the insulating paint material.

Keywords

Polyester; Titanium Dioxide; Nanotubes.

1. Introduction

Insulation material is one of the key materials in the manufacturing of automotive motors; Due to the involvement of vehicle and personal safety, there are high technical requirements for safety, durability, and reliability, such as flame retardancy, toughness, thermal stability, corrosion resistance, and wear resistance[1,2]. Ordinary insulation materials have poor flame retardancy, which can easily overheat in high-speed motors and even cause the insulation material on the motor rotor to catch fire. At the same time, ordinary insulation materials also have the problem of not being resistant to ATF oil (automatic transmission oil)[3]. Therefore, technicians in this field urgently need to seek an insulation paint that can be used in electric vehicles and has both resistance to ATF oil and flame retardancy. The vast majority of insulation coatings used in electric vehicle motors nowadays have poor flame retardancy, toughness, thermal stability, corrosion resistance, and wear resistance due to the use of polymer materials[4,5]. In order to further improve the performance of insulation coatings, it is necessary to doping inorganic materials. However, in order to achieve high performance, high doping is generally required, and high doping faces problems such as poor compatibility between doped particles and insulation coatings, 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.

Nano inorganic/organic polymer composite materials combine the excellent properties of inorganic, organic, and nanomaterials, and are a multifunctional new material with processable properties. They have broad application prospects in many fields [6-8]. Shirdar et al. [4] found that nanocomposites are known as new materials in the 21st century due to their unique design and properties that differ from traditional composite materials. Nano titanium dioxide (TiO2) is a multifunctional inorganic

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material, widely used in chemical sensors [8], UV resistance [9], photocatalysis [9-11], ink shading agents [12,13], corrosion resistant coatings, antibacterial agents [14], etc. due to its unique physical properties, good chemical stability, high refractive index, hydrophilicity, and strong oxidation [15]. Polymer materials, on the other hand, are widely used in resin lenses, optical coatings, optoelectronic devices, and anti reflection coatings due to their lightweight, impact resistance, easy processing and excellent optical properties. However, polymer materials also have the disadvantages of being brittle, not wear-resistant, and prone to yellowing and oxidative degradation when exposed to light for a long time, which greatly limits their application. By introducing nano TiO2, not only can the shortcomings of the aforementioned polymers be improved, but also new characteristics can be endowed to nanocomposites; At the same time, polymers can also enhance the adsorption and photocatalytic properties of nano TiO2, and are conducive to separation and recovery. In addition, the crystal form and purity of nano TiO2 are the main factors affecting its performance. The density and absorption capacity of rutile type nano TiO2 crystals are higher than those of anatase type, but anatase type has higher reflectivity for ultraviolet light. Anatase type nano TiO2 can accelerate the photooxidation rate of polyurethane, while rutile can stabilize polyurethane and delay its oxidation. Therefore, in the application field of nano TiO2/organic polymer composite materials, it is necessary to consider the stability and photodegradation of different crystal forms of nano TiO2 on the polymer matrix.

2. Sample Preparation and Analysis:

1) Prepare 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 1:5 mass ratio in a high-pressure reactor, 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) Add the titanium dioxide nanotubes 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.

3) Weigh each raw material according to the formula, mix the weighed halogenated phthalic anhydride, polybasic acid, titanium dioxide nanotube powder, and polyol, and undergo a condensation reaction at 190 200 ℃ until the acid value is ≤ 50mg KOH/g to obtain the unsaturated polyester resin containing halogen; Cool down to 100 120 ℃, add solvent, continue to cool down to 50 70 ℃, add diisocyanate dropwise, and react at a temperature less than 100 ℃. After the dropwise addition, continue the insulation reaction, separate the solvent, add the remaining raw materials, and mix to obtain the flame retardant insulating paint for electric vehicles that is resistant to ATF oil. Titanium dioxide nanotubes account for 3-9% of the total mass of the insulating paint material.

Table 1. Performance Comparison

	Example 1	Example 2	Example 3	Example 4	Pair ratio 1	Pair ratio 2
Gel time (min)	7	7	8	8	7	8
Neutral salt resistance (h)	87	89	85	94	75	66
Temperature resistance (℃)	211	222	231	213	210	221
Flame retardant grade	1	2	1	1	2	1

Compared to existing insulation coatings for electric vehicle motors, this article mainly relies on the flame retardancy, toughness, thermal stability, corrosion resistance, and wear resistance of polymer materials themselves. This article emphasizes the improvement of the flame retardancy, toughness, thermal stability, corrosion resistance, and wear resistance of insulation coatings for electric vehicle motors by using titanium dioxide nanotubes with hydrophobic coupling agent modification on the surface.

3. Summary

This article proposes a preparation method of insulating paint for electric vehicle motors doped with titanium dioxide nanotubes. Firstly, the surface of titanium dioxide nanotubes (chosen as a representative of titanium containing inorganic particles, considering that titanium dioxide nanotubes have better specific surface area and reaction activity in titanium containing inorganic particles) is hydrophobically modified with coupling agents. Finally, weigh each raw material according to the formula, mix the weighed halogenated phthalic anhydride, polybasic acid, titanium dioxide nanotube powder, and polyol, and undergo a condensation reaction at 190 200 ℃ until the acid value is ≤ 50mg KOH/g, to obtain the unsaturated polyester resin containing halogen; Cool down to 100 120 ℃, add solvent, continue to cool down to 50 70 ℃, add diisocyanate dropwise, react at a temperature less than 100 ℃, continue insulation reaction after dropwise addition, separate the solvent, add remaining raw materials, and mix to obtain the flame retardant insulation paint for electric vehicles, with titanium dioxide nanotubes accounting for 1-10% of the total mass of the insulation paint material. Due to the similarity in structure between other titanium containing inorganic particles and titanium dioxide nanotubes. Therefore, this patent can cover other titanium containing inorganic particle composite insulation coatings.

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