

The application of epoxy resin coating in grounding grid

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Abstract. Epoxy resin anticorrosion coating is widely used in grounding grid corrosion protection because of its wide range of materials, good antiseptic effect and convenient processing. Based on the latest research progress, four kinds of epoxy anticorrosive coatings are introduced, which are structural modified epoxy coating, inorganic modified epoxy coating, organic modified epoxy coating and polyaniline / epoxy resin composite coating. In this paper, the current research progress of epoxy base coating is analyzed, and prospected the possible development direction of the anti-corrosion coating in the grounding grid, which provides a reference for coating corrosion prevention of grounding materials.

1. Introduction

Grounding grid is used as the grounding and lightning protection of substation ac and dc equipment, which plays an important part in the safe operation of power system transmission and distribution. The corrosion rate of grounding materials in soil is affected by soil pH, water content, salt content, organic matter content, microbial activity and other factors. The investigation results of many substations in China show that the effective lifetime of grounding materials in grounding grid is not more than 10 years, and in extreme cases, 3-4 years is seriously corroded and cannot be used continuously [1]. As an anticorrosive emerging technology, coating technology has been widely used in the field of anticorrosion. Epoxy resin - based anticorrosion coating is widely used because of its advantages such as good hydrolysis resistance, high strength, strong adhesion and good air tightness. Epoxy resin also has many shortcomings, such as brittleness, shock resistance, flexibility, low temperature resistance, UV resistance, linear difference. Therefore, it is necessary in order to modify the epoxy resin to improve its mechanical and corrosion resistance. At present, the modification of epoxy resin mainly focuses on the modification of epoxy resin structure, modification of inorganic filler and organic filler.

2. Structure modified epoxy resin

The introduction of specific functional groups in epoxy resin can improve the mechanical properties and anticorrosive properties of coatings. For example, the molecular structure of the naphthalene ring has low thermal expansion coefficient, excellent heat resistance and water resistance, but due to its rigid structure, the toughness of epoxy resin solidification is poor. Therefore, on the basis of the basic molecular skeleton of naphthalene, a good flexible fat chain is introduced, which makes the epoxy resin have a better flexibility [2]. Feng hao et al. create a modified epoxy resin that used polyetherketone-cadro(PEK-C) as a toughening agent and aromatic amine as curing agent, when



Wt.%(PEK-C) =45%~50%, the glass transition temperature (T_g) of modified epoxy resin is 179.8°C, and the roller peel strength is 123.60 N·mm/mm, which showed great thermal resistance [3]. According to Wang's study, side chain fluoridated epoxy resin was synthesized by laurylfluor-*o*-phenanthroline and bisphenol A epoxy resin. The results show that the fluorine content of the fluoridated epoxy resin is enriched on the surface, and the fracture elongation and impact strength are increased by 41% and 26.8% respectively compared with the bisphenol A epoxy resin, and the AC impedance is increased by more than 2 orders of magnitude. The toughness and electrical properties of fluoridated epoxy resin is improved remarkably [4].

3. Inorganic filler modified epoxy resin

Inorganic fillers can reduce the cost and fluidity of coatings, and improve the heat resistance, wear resistance, thermal conductivity and other mechanical properties of coatings.

Scale particle modified epoxy resin, such as glass flake, mica scale, aluminum powder graphite, etc, the most commonly used is glass scale packing. Glass flake is about 5 microns thickness for two-dimensional shards of glass. After joining resin are arranged parallel overlapping, the corrosive medium in speed is greatly delayed. Li bi-yuan et al. fill the curing epoxy resin with carbon black, anhydrous magnesium sulfate, aluminum oxide, found that the resistance to acid and alkali resistance of the epoxy resin modified have improved significantly. And compared with anhydrous Magnesium Sulfate and alumina, the carbon black showed the most noticeable improvement on the acid and alkali resistance of epoxy coatings. When the mass ratio of carbon black and epoxy resin was 2:20 and 1:20 respectively, the alkali resistance and acid resistance of the coatings increased by 10 times and 5 times respectively [5].

Fiber packing modified epoxy coatings conclude short glass fiber, carbon fiber, basalt fiber etc. Ye guo-rui et al. made a kind of modification graphene oxide by coupling agent and introduced it into the basalt fiber, and the modified basalt fiber epoxy resin was made. The results showed that the breaking strength of basalt fiber was enhanced by 30.8%, and the interlaminar shear strength of the composite fiber reinforced with graphene/basalt fiber/epoxy resin was increased by 10.6% [6]. Wang shu-juan et al. adding carbon fiber to epoxy resin, and was found that when composite modified carbon fiber content was 1.0%, the tensile strength of epoxy resin composites increased by 59.7%, the impact strength increased by 53.3% and the fracture elongation increased by 50.0%. In the meanwhile, the conductivity of epoxy resin was obviously improved [7].

Nanoparticles modified epoxy coatings conclude mica, silica, titanium dioxide, etc. Liu gang et al. added nano alumina to epoxy resin, and found that the anti-crack and expansion ability of the resin was improved obviously, while the other mechanical properties were basically unchanged [8]. Sun hong-mei et al. have added nano-silica to epoxy resin and experimented with electrical properties, and was found that the breakdown strength and dielectric loss of modified resin were improved, and the influence of resistivity and dielectric constant was not significant. Therefore, the addition of nano-silica can inhibit the electrical treeing of the resin and reduce the aging speed of the equipment [9].

4. Organic filler modified epoxy resin

Using rubber as modifier to modify epoxy resin can reduce the molecular internal stress, thus achieving the effect of enhancing the toughness and strength of paint. The nano-rubber modified epoxy resin prepared by Lin yan-yan et al., when the nano-rubber content was 6phr, the shear strength of the resin increased by 16.1%, the fracture elongation increased by 78.7% and the fracture energy increased by 3.65 times [10]. Xu li et al. modified the epoxy resin with the end hydroxyl butadiene rubber, and was found that the hydroxyl group reacted with the epoxide group in epoxy resin, were obtained good comprehensive mechanical properties and impact toughness, meanwhile the insulation resistance and dielectric strength increased, the dielectric constant and loss factor decreased, and the insulation capacity was improved [11].

5. Polyaniline /epoxy composited resin

Polyaniline is a kind of polymer material monomer with aniline, synthesized by chemical or electrochemical oxidation reaction. It has good environmental stability, simple synthesis method, low toxicity, easy material and high conductivity, also have protective properties to various materials such as carbon steel, Zn, Ti, Al and Cu. It has unique anti-pitting and anti-scratch performance, therefore, it is considered as a promising anticorrosion coating.

But there are many deficiencies in polyaniline, especially the insolubility, which greatly hinders the application of it. Polyaniline showed low solubility in a variety of organic solvents, such as carbon tetrachloride, trichloromethane and toluene. Although in N-methyl pyrrolidone (NMP), dimethyl sulfoxide (DMSO), dimethyl formamide (DMF) the solubility is higher, but the cost and environmental protection of the solvent limits on the application of polyaniline. It's low dispersion and adhesion in resin coatings also greatly reduce the anti-corrosion ability of polyaniline composite coatings. Therefore, the polyaniline material needs to be modified, composite or doped to synthesize composite materials with good anticorrosion properties.

Acid doped polyaniline coatings mainly have organic acid doping and inorganic acid doping, however, due to the large size of organic acids, the diffusion rate is slow and the doping effect is not good. Therefore, most of them are doped with inorganic acid. In 2007, Liu yi-jun et al. synthesized a conductive polyaniline by doped with hydrochloric acid, and then compounded it with epoxy resin to obtain a conductive coating, the electrical conductivity reached 10-8~10-5S/m [12]. In the same year, Fan hai-jun et al. found that the conductivity of polyaniline was strongly related to the strength of acid when it was made with inorganic acid as dopant. So they used perchloric acid as a dopant, as the result, the polyaniline films doped with perchloric acid have stronger electrical conductivity than the hydrochloric acid one [13].

Due to the sacrificial anode protection of metal, the dispersion and blocking action of metal oxides, the combination of metal or metal oxide with polyaniline can strengthen the anticorrosion of polyaniline. Wang hua et al. synthesized the polyaniline (PANI)/TiO₂ composites by chemical oxidation method, dissolve and paint it on the surface of 304 stainless steel, then observe the corrosion behavior of the sample in 3.5% NaCl solution. The result showed that PANI-TiO₂ composite coating has better protection to 304 stainless steel than polyaniline coating. When the content of TiO₂ is 5%, the corrosion resistance of the composite coating is the best, and the corrosion potential is 381mV higher than that of the bare stainless steel, and the protection efficiency is 95.44% [14].

Huang de-yong et al. made the composite materials of polyaniline and glass scales by chemical oxidation. When the quality ratio of polyaniline and glass fiber was 2:1, the crystal performance of it was not much affected, but it's thermal stability was greatly improved. As the result, the epoxy resin polymerization coating prepared by this composite material greatly enhanced the anticorrosion effect and impact resistance [15].

6. Conclusion

In this paper, variety of modification methods for epoxy resin and polyaniline anticorrosive coating are enumerated. However, in the grounding grid, the corrosion resistance of the coating is not the only need to be considered, but also the coating has certain requirements for electrical conductivity. If the resistance of the coating is too large, the grounding performance of the grounding grid will be reduced. When the power grid system fails, the short circuit current cannot be discharge through the grounding network in time, which will cause serious accidents. In the future, the modification methods of epoxy resin can be studied in the following aspects.

Select more kinds of film-forming resins for comparison.

Intrinsic type conductive anticorrosive coating is a coating made of conductive polymer as matrix, such as polypyrrole, polyaniline and polythiophene. Owing to its inherent characteristics, the conductive ability is limited. Therefore, different kinds of film forming resins can be considered to improve their conductivity in the case of corrosion protection of grounding grids with superior electrical conductivity.

Using different dispersants to improve the dispersibility of nano materials.

At present, there are many researches on carbon nano materials in coatings, but few of them are put into use, because nanoparticles have small particle size, large specific surface area and high intermolecular force, so it is easy to agglomerate and disperse in coatings, which leads to the decrease of the overall performance of the coatings. It is necessary to change the surface structure of nano material by dispersing agent and show the affinity with organic material [16].

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