The Research of Equipment Electricity Identification of UHV Power Transmission and Transformation Based on Electrochromic Material

Kang Chen, Linong Wang, Enwen Li & Bin Song

School of Electrical Engineering, Wuhan University, Wuhan 430072, China

ABSTRACT: Now, electroscope has disadvantage of large quality, inconvenient operation, and it has low quality of accuracy, adaptability, reliability and cost performance. In this paper, a new method for the identification of electricity test is presented. It uses electrochromic material for equipment electricity identification of UHV power transmission and transformation. When the device is charged, the material will change color as the charged signal; while the device is not charged, the material will return to the original color. The material has advantage of low energy consumption, no radiation, apparent identity, repeated use. This paper adopted three kinds of materials such as tungsten trioxide material, Ag-Polybutene (hereafter referred to as PB) composite material and graphene-Polyamide (hereafter referred to as PA) for production making and test. The results show that these three kinds of material have electricity identification performance, the properties of graphene-PA composites were the best, and it has the development prospect as eletrochromism material used for equipment electricity identification of UHV power transmission and transformation.

1 INTRODUCTION

The operation procedure of the electricity identification is a must to ensure the safety of the personnel when outage maintenance operation is done for power transmission and transformation equipment. Now, contact and non contact electroscopes are widely used for power transmission and transformation equipment. Contact electroscopes are used with insulation test pole, however, the UHV transmission line voltage grade is high, safety distance requirements strictly, and the length of the check pole and deflection is difficult to meet the requirements. Besides, it is not convenient for operation, and contact electroscope can’t effectively solve the inspection problem of DC electrical equipment. Non contact electroscopes achieve electricity identification by detecting the electric field near the charged device or partial discharge parameters. However, the accuracy of the test, adaptability, performance and other aspects has problems. Non contact electroscope has poor reliability in place of UHV substation, convector station and other complex electromagnetic environment.
In view of the present problems of the electroscope, this paper adopts electrochromic materials technology used in UHV power transmission and transformation equipment. The so-called electrochromism is refers to materials in under the action of alternating high and low positive and negative electric field, through injecting or extracting charge (ions or electrons). Thus, between the low transmittance of colored state or high transmittance achromatic state, it produced a reversible change in the special phenomena and reversible change of color and transparency in the appearance and performance. The electrochromic material has the characteristics of continuous optical performance, multi-color display, low working voltage, low energy consumption, no radiation, etc. It is used in active optical filter and so on.

This paper is based on the latest technology of electrochromism materials. Through the analysis, materials included $WO_3$ materials which is studied more at the present, Ag-PB, graphene-PA have been selected, made as electrochromism materials and used for the electrochromism test. After the distribution, mixing, and repeated adjustment of the appropriate paint, and then doing electrochromism performance test, it find that the above materials have characteristics of electricity identification. Among them, the test characteristic of graphene-PA material is more obvious, and the color change is reversible, the performance is the best.

2 PRODUCTION AND TESTING OF MATERIALS

2.1 Tungsten oxide materials

Most of inorganic electrochromism materials are transition metal oxide and their derivatives. Transition metal ions are generally easy to be colored and the ground state and the excited state energy difference is small. In this paper, a single step method is used to produce tungsten oxide pigment particles dispersion: Adding a certain amount of tungsten oxide precursors into the base fluid, by way of direct alcoholysis, hydrolysis, oxidation of tungsten based pigment particles is made. The water in the base fluid is removed by using the rotary evaporator and a certain amount of dispersant is added, after ultrasonic treatment. The oxidation of tungsten oxide particles uniformly dispersed in the base fluid to form stable oxidation tungsten based pigment particles dispersion. Single step method is relatively simple, easy to operate, and it can also meet the requirements of production, and can form a stable dispersion.

Materials including the polymer binders, fillers, solvents and so on are slowly added into the tungsten oxide pigment particle dispersion. At the same time, keep the constant speed of mixing, and then heat the material to 200 degrees. After, keeps high speed mixing lasting 12h. Cross configuration parameters is used for different binders, tungsten oxide pigment particles, packing etc, such as to determine the viscosity of the coating. For some tungsten oxide pigment
particle dispersant, it is necessary to add materials such as plasticizer, deforming agent and flowing agent and fully mix.

This experiment applies 500mA current to cable which is coating with inorganic materials for inspection while hollow steel tube is applied 200A current. Then we take pictures to record the data 30min after the current is cut off. Test field are shown in Figure 1, 2.

![Figure 1. The hollow steel pipe and cable before applying current.](image1)

![Figure 2. The hollow steel pipe and cable after applying current.](image2)

The cable is energized after half an hour and it does not change its color when it is applied with 500mA current. While the material has been changed obviously in half an hour when the hollow steel tube is applied with 200A current. The color of the most of the coatings change from the original yellow into blue purple, the color of the area of the coating is more obvious than the area of the coating thicker area, the thinner area of the coating is not to change color in the middle part. And when the power is cut off, the color of material still keeps blue and purple, and doesn’t return to the original yellow.

2.2 Ag-PB composite material

First, compound high dispersion solution of nano carbon nanotubes or silver nanowires, compound the chloroform solution of a certain concentration of PB monomer, with the above nano carbon nanotubes or silver nanowires of high dispersion solution to stir well, and adjust the viscosity and conductivity with the organic ion, high polymer PMMA, etc. The solution is coated
on a conductive glass or PET substrate, which is received by UV irradiation. and the PB organic molecule is synthesized by the photo polymerization. Under UV irradiation, the synthetic material is blue. And the longer the exposure time, the higher the degree of polymerization in situ, the color becomes blue.

The Ag-PB composite electrochromic coatings is modulated easily to facilitate, materials is coated on conductive glass or PET substrate by dip coating, spraying, spin coating or diffusion coating methods. Then dry film samples through the light polymerization and put it in the oven drying. Next apply dual stabilized power supply to the prepared samples, coating, and observe the color of materials.

From the experiment, we find that the color near the electrode changes from blue to red, but the visual effect is not obvious while power is on.

2.3 Graphene-PA composite material

The good dispersion of graphene is prepared first. The graphene purchased is dissolved in DMF solution to a certain concentration, with intense ultrasound lasting for 5 hours. And then fill them in the high pressure reaction kettle, and put them to the 200 degree of the reaction furnace heating reaction for 12 hours. After the reaction finishes, cool, filter and remove the reactants which are not reacted, and the graphene dispersion which remains are good.

First, composite PA organic molecule, the structure is confirmed by NMR, IR and UV. PA solution is prepared according to a certain concentration. And it is mixed with graphene dispersion liquid, stirred well. Then finish the graphene-PA organic inorganic composite dispersion. Next the polymer matrix, fillers, solvents, etc. is slowly added to graphene-PA organic inorganic composite dispersion while stirring. After all added, the material is heated to a certain temperature with high speed stirring for 12h, Cross configuration of different concentration of base ma-
terial, pigment particles, fillers, etc, is used to determine the viscosity of the coating. Then add materials such as plasticizer, deforming agent and flow ping agent and fully mix if necessary. Finally, fill the preparation of graphene-PA organic-inorganic composite coatings in plastic or glass containers.

The graphene-PA organic-inorganic composite electrochromic coatings is modulated easily to facilitate. materials is coated on conductive glass by dip coating, spraying, spin coating or diffusion coating methods. The samples is drying or baking in the oven, or with hair dryer. Through many experiments, the best formula and the way of the graphene-PA organic-inorganic composite electrochromic coatings are found. Then use dual stabilized power and supply coating sample with voltage. Observation of coating, discoloration are shown in figure 4. It is found that the color changes from colorless to dark blue immediately when the power is on. The color gradually becomes light blue, and finally becomes colorless when power is off. It is a reversible process, the whole process of change only a few seconds, and the visual effect is very obvious.

![Figure 4. Graphene-PA paint test chart.](image)

3 SUMMARY

In summary, this paper draws the following conclusions: Tungsten oxide based materials have the properties of eletrochromism, but the experimental results show that the color change is not reversible. Graphene–PA inorganic compound organic coating test electric effect is obvious, and the color change is reversible, it can be used as power transmission equipment electrical inspection marking materials. Subsequent work in this paper will study batch production plan of graphene-PA materials and coating technology.

REFERENCES


