The preparation of portable reversible temperature-indicating patch for electricity power supply system

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Abstract: A new designed timely temperature display patch has been proposed, which could effective improve overheating survey efficiency.This method is based on the idea of gain and loss type thermal paint, which can effectively realize the temperature warning in the power grid. When the indicated device line temperature reaches 70 degrees Celsius or above, the color of the patch changes from dark blue to colorless, which can easily indicate whether the power grid is There is overheating. At the same time, the patch is convenient and easy to carry, and can be attached to any electrical equipment and circuit that needs to sense temperature. It is also expected to be used in conjunction with a computer to automatically identify whether there is overheating in the system.

1. Introduction

In recent years, the demand for power supply has also increased with rapid development of Chinese society and economy.[1] In order to meet the daily demand for electricity in production and life, the power supply system needs to ensure electricity production with safety, continuous supply and timely maintenance of electricity.[2] In the maintenance process, one of the most important tasks is to check whether there is overheating in the power equipment or the power network. Generally speaking, overheating may come from the equipment itself, or it may come from human operation.[3] The overheating caused by the aging of its own quality and operation is generally a problem of the equipment itself. The main reasons for this usually comes from factors such as short circuit, overload, poor interface contact, internal metal heating in the power supply network, and poor heat dissipation in the power grid. The overheating caused by improper operation, measurement deviation, and untimely maintenance can generally be regarded as main man-made causes. Once the power equipment or power network is overheated, it will seriously affect the normal operation of the power system, and cause serious safety accidents, and even threaten the life and property safety of society.[4] Therefore, in order to ensure the safe operation of the power grid, it is necessary to prevent overheating of power equipment and lines during its work.

Generally speaking, the power system relies on manual inspections to ensure that all parts of the equipment and lines are in normal working conditions.[5] However, because many equipment or lines are located high in in air, it is not easy to directly observe whether overheating or signs of overheating have occurred. In order to eliminate the hidden safety hazards caused by overheating as much as possible, daily safety inspections involve a huge workload and seriously affect work efficiency.

In order to improve the efficiency of power inspections, the introduction of effective technical means into inspection work has become a research direction that is being vigorously explored in the power field. Current research directions include the use of infrared detection, insulation circuit detection, paint temperature sensing display and other research paths.[6] Among them, temperature-indicating paint can quickly indicate the temperature of the tested material through the color change in a sensitive, efficient, and timely manner.[7] After a local heating situation occurs, the color will change, thereby instructing power inspectors to pay attention to potential risks and take timely measures to avoid unnecessary safety risks and property losses.

There are many discoloration principles of reversible temperature-indicating coatings. Among them, one classification that has been studied more is to use the electronic gain and loss mechanism to realize the color change of reversible temperature-indicating coatings at different temperatures.[8] Triphenylmethane phthalide-based heat-sensitive coatings are currently more researched electronic gain-and-loss heat-sensitive coatings. Triphenylmethanephthalide organics exist as electron donors in the system, phenolic hydroxyl organics exist as electron acceptors, and organic solvents that can undergo phase change at corresponding temperatures are used as temperature regulators.[9] After the electron donor and the electron acceptor are combined, electron transfer occurs between the two organic substances, and the electron donor that loses electrons will undergo a change in electron conjugation, thereby appearing color. When their temperature rises to the phase transition temperature of the solvent, the electron donor and electron acceptor solvent will dissolve in the solvent, and the electron transfer phenomenon between the donor and the acceptor will disappear, and the color will fade. According to different actual needs, you can choose different solvents to determine the color temperature of the final selected material.

At present, there are still some shortcomings and problems in the application of temperature-indicating coatings. First of all, for the power transmission network, the parts that need temperature measurement are often located high in the sky, and';l the spatial locations are relatively scattered. At present, many maintenance and treatment tasks still require manual high-altitude operations. Therefore, carrying large volumes of liquid coatings is relatively dangerous and time-consuming. In view of the above situation, it is of great value and significance to develop a portable patch that is small in size and can effectively indicate the timely temperature of power equipment components. Herein, a new designed timely temperature display patch has been proposed, which could effective improve overheating survey efficiency.

2. Preparation Process

2.1. Color-changing powder preparation

Take 0.01 mol of crystal violet lactone, 0.01 mol of bisphenol A, and 1.0 mol of behenyl alcohol. Put them in 50 mL of acetone solvent, and stir under heating until all powders are completely dissolved in the solvent. After cooling down to room temperature, chemicals precipitate out. With the drying process, the color changed from transparent to blue. When completely dried up, the corresponding the core material of color-changing powder can be obtained.

2.2. Color-changing microencapsulation preparation

Weigh 6 grams, 4 grams of urea and 28 ml of 35% formaldehyde solution respectively first. Add the formaldehyde solution into a three-necked flask, adjust the PH value of the formaldehyde solvent with triethanolamine to the range of 8.5, add 6 grams of urea during stirring and then heat to 60 degrees Celsius, and keep the temperature at a constant temperature for 60 minutes. After that, raise the temperature of the system to 90°C, add another 4 g of urea and keep stirring for 30 minutes to give prepolymer. Add 10 g of color-changing together with 1 g Gum arabic in 50 mL water. Use a high-shear emulsifier to emulsify it for 10 minutes, and add the prepared prepolymer, and emulsify once more for another 10 minutes to obtain O/W emulsion. After that, slowly add dilute hydrochloric acid to adjust the pH of the solution to about 3 and keep it at 90 degrees Celsius for 1 hour; then continue to adjust the pH of the solution to 8.5 with triethanolamine, and then lower the reaction temperature to 75 degrees Celsius. And turn off the heater, after washing and drying, the blue thermochromic material wrapped by urea-formaldehyde resin as microcapsules is obtained.

2.3. Reversible color patch preparation

Take 10 grams of the temperature-indicating color-changing material wrapped in microcapsules and add it to 100 ml of epoxy varnish. At the same time, fully mix and stir it into blue paint. Use a brush to apply the paint to the aluminum foil tape. After it is dried, cut it out. The shape, that is, the production of a 70°C reversible color patch that is convenient to visually detect the temperature of power equipment. The finished product structure diagram is shown in the Figure 1.

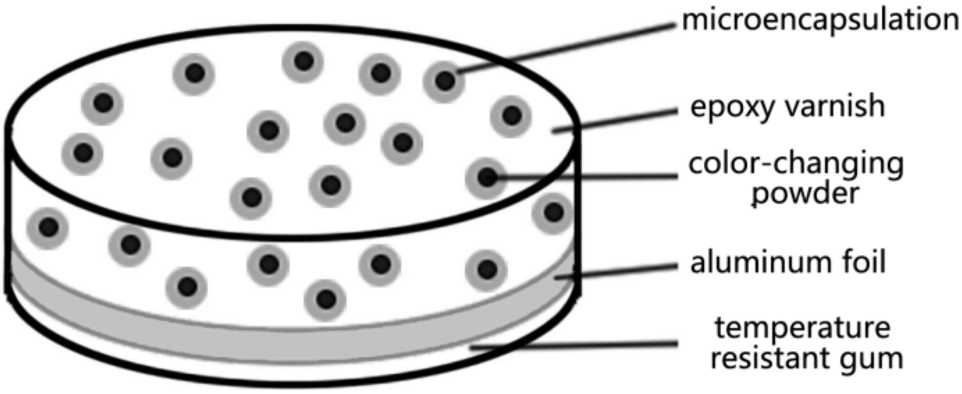

Figure 1 The structure of reversible color patch

3. Characterization and analysis

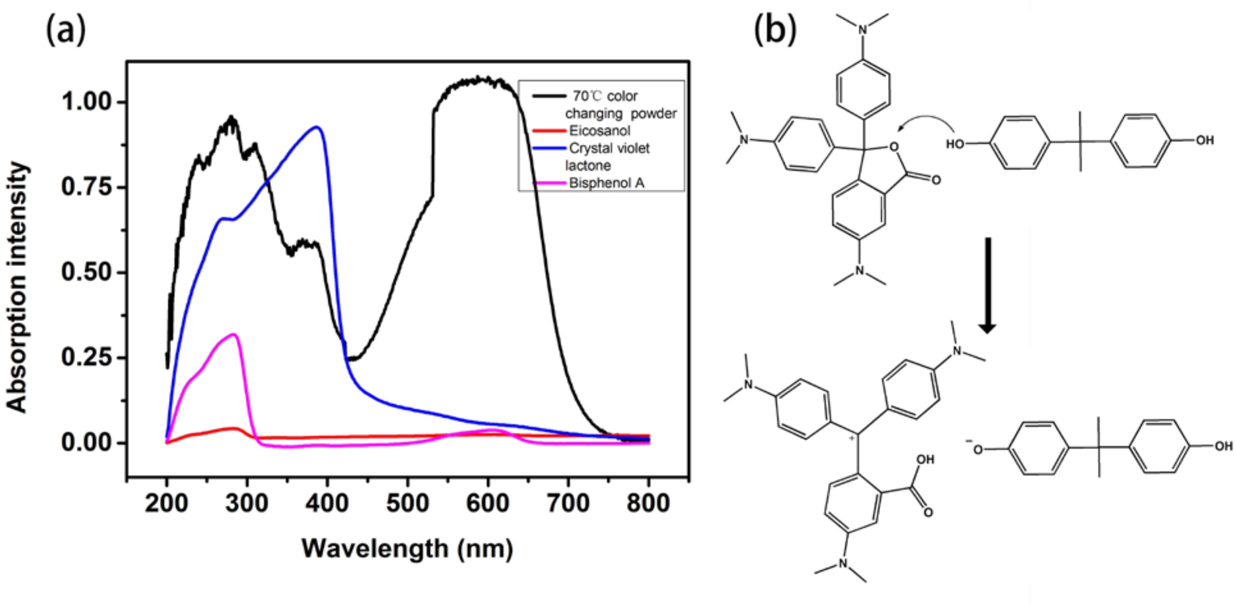

Figure 2 (a) The UV-vis absorption spectrum of color-change powder; (b) the structure variation

As the most eye-catching change, the color may change greatly from blue to white when it was heated above 70 oC. This variation mainly result from the preparation of color-changing powder. The obtained color-changing powder core material is blue, and the color of the initial raw material is white. The color change is obviously visible to the naked eye. This phenomena can not only be directly observed, but also can be shown through the ultraviolet-visible absorption spectrum. In the ultraviolet-visible absorption spectrum, the absorption intensity of crystal violet lactone, bisphenol A, and behenyldiol in the visible light region is very weak in the range of 780 to 400 nm, and when they are fully combined, there can be observed with a strong absorption in the range of 700- 550 nm . The main reason for the new absorption peak in the visible light region is shown in the figure. When bisphenol A is mixed with crystal violet lactone, electron transfer via two kinds of molecures occurs, that crystal violet lactone molecule gives an electron to bisphenol A. The loss of electron leads to structure variation of the crystal violet lactone, that its three benzene rings comes to the same plane. This change result in further enhanced π-electron conjugation performance in the plane, thus the ultraviolet-visible absorption spectrum data is red-shifted.

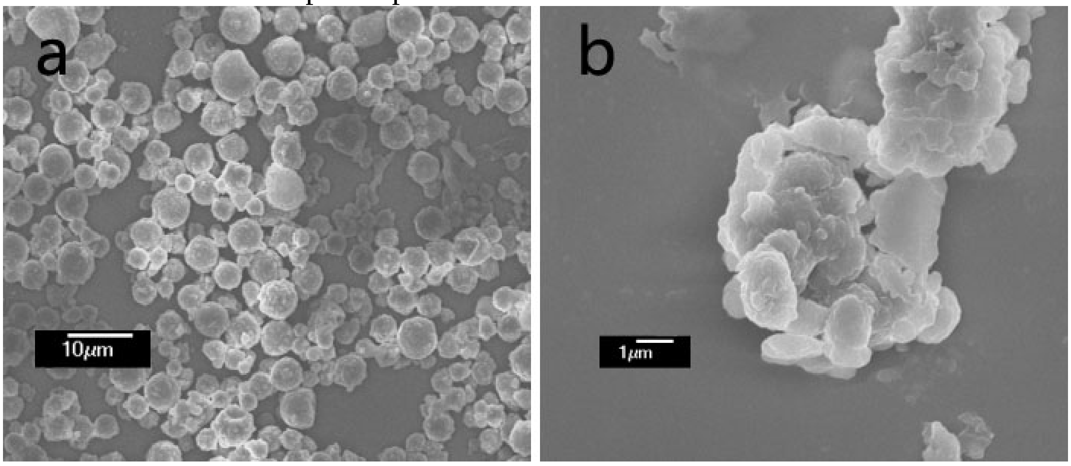

Figure 3 The SEM photos of well prepared micro-encapsulation (a) and micro-encapsulation without enough emulsion dispersion.

The effect of microcapsule coating and the influence of different factors on microcapsule coating can be observed with scanning electron microscope (SEM). As shown in Figure 3, when the implementation is carried out step by step according to the above sequence, it can be observed that the urea-formaldehyde resin is tightly wrapped around the color-changing powder, and the prepared microcapsules are spherical with a diameter of about 5-10 microns. Among them, when preparing the O/W emulsion, whether sufficient high-speed emulsification and dispersion is carried out is an important factor in obtaining a good package. When the sample is not emulsified at high speed without rotating and stirring, the obtained sample cannot show microcapsule package. On the contrary, it has a blocky or flaky appearance. This fully shows that high-speed emulsification and dispersion are at the core of the entire microcapsule coating process.

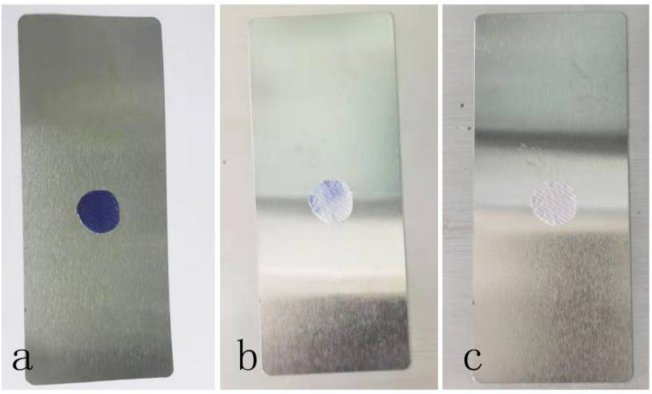

Figure 4 The photos of color-changing patch (a) below 68 oC, color changing process (b), and above 70 oC (c).

In order to verify the reversible thermochromic patch, place the patch in a water bath and observe the color change of the thermochromic patch. The heating rate of the water bath is 1 minute and 1 degree Celsius. It can be observed that when the temperature of the environment rises to 68 degrees Celsius, the color of the patch begins to fade gradually. When the temperature rises to 70 Celsius degree, the color completely fades and appears white. Continue heating the water bath Up to 80 degrees Celsius, no further color changes occurred. Then gradually reduce the temperature of the water bath. When the temperature of the water bath decreases to 69 degrees Celsius, the color-changing patch appears lighter blue, and the color returns to dark blue as the temperature further decreases. After more than 3 cycles of testing, the color display and fading did not change significantly, which proves that the prepared material is reversible and can be used to indicate the timely temperature of the equipment to be measured.

In order to test the corrosion resistance of the prepared patch, we tested the corrosion resistance of the prepared material under the condition of salt spray. As shown in the figure, it can be found that after 48 hours of salt spray with 5% sodium chloride solution at room temperature, no corrosion is found on the material body, indicating that this kind of patch has the ability to work continuously in complex and harsh natural environment.

In order to satisfy the construction of smart grid in the future, the temperature-indicating reversible patch can also be connected to the computer system through color recognition. As shown in Figure 4, when the specific temperature is not reached, the color of the prepared patch is expressed as R: 46 G: 49 B: 99 (#2e3163) according to the RGB color; and when the temperature rises, the color of the material fades, and the color on the patch is displayed as the base The color of the material metal changes to R: 203 G: 197 B: 199 (#cbc5c7), where the color values of R and G vary greatly. After many tests, the color variation could be revealed digitally with the change of values of R and G, that when the patch comes to higher than 70 oC both of the values of R and G exceed 180. If this part of information is input online through a computer terminal, the value of these two parameters can be changed In the case of unmanned operation, timely judge the timely temperature of the currently tested equipment or circuit.

4. Conclusion

To sum up, a new designed timely temperature display patch has been proposed, which could effective improve overheating survey efficiency.This method is based on the idea of gain and loss type thermal paint, which can effectively realize the temperature warning in the power grid. When the indicated device line temperature reaches 70 degrees Celsius or above, the color of the patch changes from dark blue to colorless, which can easily indicate whether the power grid is There is overheating. At the same time, the patch is convenient and easy to carry, and can be attached to any electrical equipment and circuit that needs to sense temperature. It is also expected to be used in conjunction with a computer to automatically identify whether there is overheating in the system..

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