Application of Polypyrrole Cellulose Nanocrystalline Composite Conductive Material in Garment Design

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The Chinese nation has a long cultural history and has deep attainments in food, clothing, art, and other cultural fields. With the development of science, technology, economy, and culture, new materials continue to appear, providing new ideas for clothing design. Polypyrrole is a common conductive polymer. The pure pyrrole monomer presents a colorless oily liquid at room temperature, slightly soluble in water and nontoxic. Nanocrystals, also called nanoscale crystals, use high-energy polymer spheres to pack calcium, magnesium ions, and bicarbonate in water to produce a water-insoluble crystal structure. Conductive composite materials mainly refer to composite conductive polymer materials, which are composed of polymers and various conductive substances through a certain composite method. This article aims to study the application of polypyrrole cellulose nanocrystalline composite conductive material in clothing design. Starting from the structural characteristics of the polypyrrole cellulose nanocrystalline composite conductive material, this article uses case analysis to study deeply the suitable polypyrrole cellulose nanocrystalline composite conductive material. This article can effectively use the innovative application method of its appearance style, so as to realize its application in clothing design. Starting from the functional properties of the polypyrrole cellulose nanocrystalline composite conductive material, the specific application of the polypyrrole cellulose nanocrystalline composite conductive material in different clothing designs is analyzed. Combining the postmodernist clothing style characteristics, aesthetic habits, and the characteristics of polypyrrole cellulose nanocrystalline composite conductive materials, this paper studies the innovative style design of polypyrrole cellulose nanocrystalline composite conductive materials. The experimental results in this paper show that when the reaction time is 2 min, the reaction rate at this time is zero, indicating that this time is in the initial stage of the reaction. After 4 minutes, as the reaction time increases, the reaction rate shows an increasing trend; when the reaction time is longer than 10 minutes, the reaction rate increases slowly and has a downward trend, which indicates the end of the reaction. The highest average reaction rate is about 7.5 mg/min.

1. Introduction

With the progress of human civilization and science and technology, the expression of art has developed in diversified forms. With the continuous deepening of economic globalization, the world’s connections continue to diversify. The collision of the cultures of various countries in the world has made today’s clothing expressions more and more diversified. Materialism believes that material determines consciousness. Compared with the previous society, the current social life and technological means have undergone earth-shaking changes. People’s pursuit of clothing is no longer limited to keeping warm and hiding shame. The concept of “emphasising individuality” and “highlighting the self” has permeated all aspects of clothing design. Clothing aesthetics and distinctiveness have become the mainstream of the current pursuit, which requires designers to break the traditional shackles and find new breakthroughs in clothing design materials. This article aims to explore the application of polypyrrole cellulose nanocrystalline composite conductive materials in clothing design. Expanding the application field of polypyrrole cellulose nanocrystalline composite conductive materials will
create new possibilities for clothing design. The color, design, and fabric of clothing are the main parts of clothing. They are mutually independent and interrelated. Color and design can be embodied through production materials, and distinctive production materials can show the color and design of clothing. Through the use of different fabrics, more possibilities for clothing design can be provided. With the proposal of an environmentally and friendly society, saving resources and protecting the environment have become the current trend. As the most widely distributed and abundant renewable organic substance in nature, cellulose has naturally become a new choice for new clothing design. Therefore, the combination of polypyrrole cellulose material and clothing design is in line with the goals of compound environmental protection and sustainable economic development, and new innovations in clothing design are realized, which will have great significance for the entire clothing design industry. The starting point of the low carbon clothing design concept is to reduce the damage caused by harmful substances to the ecological environment and to reflect people's pursuit of high-quality life and their redefinition and interpretation of beauty.

The application of polypyrrole cellulose nanocrystalline composite conductive materials in clothing design can greatly enrich the types of clothing materials, derive new clothing ideas, and stimulate the market vitality of the clothing industry. Realizing the concept of environmental protection in clothing materials and achieving health and comfort in design are in line with the harmonious development needs of man and nature and create clothing with ecological aesthetics. This is in line with the current design requirements of seeking novelty and difference. The current clothing market is mostly converging, and homogeneity is becoming more and more serious. The use of new materials can promote the development of the clothing market, strengthen clothing styles, and meet individual needs. In the design and application of composite materials, while promoting its own excellent wearing performance, it avoids the disadvantage of excessively heavy clothing.

Cellulose is a widely existing material in nature, possessing many properties such as degradability, and it has become a hot new material nowadays. The current homogeneity of the clothing design industry is serious. How to activate its internal vitality and meet people's needs has become a serious problem to be solved. Peng et al. successfully prepared a bacterial cellulose (BC) film coated with polypyrrole (PPy) and copper oxide (CuO) as a flexible composite electrode for supercapacitor applications. Supercapacitors reach farad-level capacitance in a very small volume; no special charging circuit and control discharge circuit are required; compared with batteries, overcharging and overdischarging do not have a negative impact on their lifespan. The highest conductivity value of 7.4 S-cm\(^{-1}\) was obtained using a copper acetate aqueous solution with a concentration of 1wt%. Electrochemical measurements have proved that the supercapacitor using PPy/CuO/BC electrodes has a specific capacitance of 601 Fg\(^{-1}\), an energy density of 48.2 Wh\(\text{kg}^{-1}\), and a power density of 85.8 W\(\text{kg}^{-1}\) at a current density of 0.8 mA-cm\(^{-2}\). After 300 cycles, the specific capacitance remains at 385 Fg\(^{-1}\). The introduction of CuO nanoparticles increases the capacitance and at the same time proves that the development of flexible supercapacitors is of great significance to the growing demand for portable electronic products [1]. Al-Dulaimi et al. used in situ polymerization to prepare conductive polypyrrole (PPy) nanocomposites with cellulose nanocrystals (CNC). A new water-dispersible sample (PPy-CNC) was deposited as a thin film on a paper substrate as a conductive paper. The field emission scanning electron microscope (FESEM) image clearly showed the morphological modulation and uniformity of the PPy-CNC sample. The electrical properties of conductive paper were studied with different acid doping values. The results show that, as the pH value decreases, the electrical performance increases. Before the doping process, a cyclic voltammetry (CV) test is used to check the stability of the pure sample's redox performance. Cyclic voltammetry controls the electrode potential to scan one or more times with a triangular waveform at different rates over time. The potential range is to enable thorough reduction and oxidation reactions to occur alternately on the electrode, and the current-potential curve is recorded. The experiment found that, with the decrease of pH value, mechanical properties such as tensile index and elongation at break decreased slightly. The results of elongation at break of 0.65pH sample showed different responses to pH value [2]. Wang et al. proposed a flexible supercapacitor based on a polypyrrole-coated core-shell bacterial cellulose composite network. As the first step, by using 2,2,6,6-tetramethylpyridine-1-oxyl radical- (TEMPO)-mediated oxidation, the gel-type bacterial cellulose is converted into a single 3–5 nm diameter ultrathin bacteria. Cellulose nanofibers (TOBC) continuously and slightly disintegrate in water. In addition, the PPy-TOBC core-shell nanofiber network electrode is synthesized in situ by the oxidative polymerization of pyrrole and ferric chloride (III) on TOBC nanofibers in an aqueous medium. Due to the uniform coating of PPy nanoparticles on the TOBC nanofiber network, the PPy-TOBC core-shell nanofiber network electrode exhibits high porosity (101 m\(^2\)/g) and high conductivity (6.63 S/cm). The prepared PPy-TOBC supercapacitor battery is made of PVDF-EMIMBF4 (1-ethyl-3-methylimidazole tetrafluoroborate) polymer electrolyte. Under a current density of 0.2, it shows a specific capacitance of 153 F/g and an energy density of 21.22 Wh/kg-A/g [3]. Feng et al. synthesized a lightweight polypyrrole/cellulose aerogel (PPy/CA) composite with a three-dimensional (3D) conductive network through in situ polymerization and freeze-drying technology. Freeze-drying technology is a drying method that freezes water-containing materials below the freezing point, converts water into ice, and then converts the ice into vapor under higher vacuum to remove it. Due to the three-dimensional (3D) porous structure, PPy/CA composites show good elasticity and compressibility. The microwave absorption properties of PPy/CA composites are measured by the waveguide method. The results show that, by adjusting the compression ratio from 0% to 65%, the complex permittivity of the PPy/CA composite can be effectively adjusted. The PPy/CA composite exhibits the best microwave absorption performance at a compression ratio of 65%, with a minimum reflection
loss (RL) of 12.24 dB at 8.53 GHz and a thickness of 5 mm. In addition, the effective bandwidth (RL less than 10 dB) of the PPy/CA composite material can cover the entire X-band (8.2–12.4 GHz) by changing the thickness in the range of 4–5 mm. Controllable microwave absorption performance, green light weight, and good absorption performance are expected to become a promising microwave [4]. By developing the original design tool reDesign canvas, Kozłowski et al. solved this gap to support design entrepreneurs in developing sustainable fashion businesses. Many existing design tools in a sustainable fashion environment are too complex, too conceptual, require specialized applications, and are expensive. It was created for large companies, or it cannot fully support sustainable fashion design entrepreneurial practices. Microenterprises represent an important part of the fashion industry and can make meaningful contributions to the transition to a more sustainable apparel and textile industry. Under the guidance of design thinking and system thinking, the canvas is developed based on an in-depth review of academic literature and the collection of qualitative data. Qualitative data was collected through participatory action research (PAR) and interviews with 38 sustainable fashion design entrepreneurs and sustainable fashion experts. Both PAR and interviews are used to test and improve the redesigned canvas to ensure that requirements are met [5]. Widiaty et al. researched and developed Batik fashion design application, namely, Jatik Asyik. As a learning tool that integrates technological innovations into courses based on Industry 4.0, we have developed an e-commerce website for educational purposes based on Android and iOS and industrial purposes. The results of this research show that the developed applications promote easy-to-access usability, exciting and interesting experiences, and cultural experiences for users (students and industrial practitioners). In addition, the accuracy provided by the application can reduce preproduction failures of batik, including mass production. It can be concluded that the application is relevant in both educational and industry contexts [6]. Iliqueira et al. demonstrated the separation of nanofibers from carrot juice residue and their enhancement potential. Morphological properties, X-ray diffraction (XRD), and specific surface area (SSA) measurements show that carrot nanofibers (CNF) maintain the crystal structure of natural cellulose. At the same time, it exhibits an SSA as high as 246 m².g⁻¹ and a diameter of 3 to 36 nm. CNF can be redispersed in water after drying, so that the SSA and diameter of the nanofibers are comparable to those of the original undried CNF. Finally, we proposed the possibility of using CNF as a strong nanopaper with excellent mechanical properties (i.e., a modulus of 13.3 GPa and a strength of 175 MPa) or as a reinforcing phase in the polymer matrix (CAB). The interesting properties of carrot nanofibers in possible transportation and use in the dry state, as well as the remarkable mechanical properties that they impart to nanopaper and nanocomposites, may promote its application in environmentally benign components in industrial applications [7]. Cui et al. proposed the fact that the combination of a single metal active site connected to a nitrogen atom in the graphene basal plane will result in a composite material with excellent activity and stability as a counter electrode in a dye-sensitized solar cell (DSSC). A series of composite materials based on different metals (Mn, Fe, Co, Ni, and Cu) were synthesized and characterized. Electrochemical measurements show that CoN4/GN is a highly active and stable counter electrode for redox I/III mutual conversion. DFT calculations show that the excellent performance of CoN4/GN is due to the proper adsorption energy of iodine on the limited Co sites, resulting in a good balance between the adsorption and desorption processes. DSSCs with CoN4/GN electrodes further confirmed their superior electrochemical performance, which showed better power conversion efficiency than their Pt counterparts [8]. Although these theories have discussed polypyrrole cellulose and clothing design concepts to a certain extent and have produced certain research results, the combination of the two is not perfect and cannot be used in practice.

At present, the domestic research on cellulose nanofiber composite materials is less involved. In this paper, polypyrrole cellulose nanocrystalline composite conductive materials are used as raw materials, and cellulose nanofibers are extracted through various technical methods and combined with clothing design. This is in line with the harmonious development needs of man and nature and highlights the concept of environmental protection.

2. Application Method of Polypyrrole Cellulose Nanocrystalline Composite Conductive Material in Clothing Design

2.1. Overview of Cellulose. Cellulose is widely present in the natural range, especially in higher plants and seaweeds. The development of them will produce huge economic benefits. Cellulose is the material with the most natural organic content in existing materials. It is as high as 90% in cotton, and the proportion of cellulose in general plants is about 50% [9, 10]. At present, cellulose is used in a very wide range, and it is involved in plastics and scientific research equipment. Cellulose is a polyhydroxy polymer compound that neither dissolves nor melts; after etherification, cellulose can be dissolved in water, dilute alkali solution, and organic solvent and has thermoplastic properties. Figure 1 shows the structural model of cellulose.

Cellulose is mainly composed of macromolecular polysaccharides, which is the main component of green plants. There is also a small amount of cellulose in animals.
Cellulose is most named after the complete cellulose standard sample of the cell wall, and it is still in use today. The human body cannot decompose and utilize cellulose, but cellulose can absorb a large amount of water, increase the amount of feces, promote intestinal peristalsis, and shorten the residence time of carcinogens in the intestine, thereby preventing the occurrence of colon cancer. With the development of science and technology, science and technology can be used to realize artificial cellulose according to its laws [11, 12].

2.1.1. Hydrolysis Method. Acid water can remove the amorphous area of cellulose, reduce the size of cellulose, and produce artificial cellulose with high crystallinity. The cellulose produced by the hydrolysis method can achieve the purpose of surface modification of cellulose. During the preparation process, the properties of cellulose can be changed by changing the concentration and density of water. However, because this method involves strong acid, the equipment requirements are very high during the experiment [13]. The temperature is 90–100°C, and the hydrolysis time is 0.5–2 h. After the reaction is completed, it is cooled and sent to a neutralization tank and is adjusted to neutrality with liquid caustic soda. After filtration, the filter cake is dried at 80–100°C. Figure 2 is a schematic diagram of the production process of fiber materials.

2.1.2. Mechanical Method. The mechanical method is mainly to process the fibrous material under high pressure, so that the fibers in the material are broken or fibrillated, and the cellulose with a small size is separated after high pressure. The mechanical preparation of artificial cellulose does not require the use of chemical reagents, and the harm to the environment is very small. However, compared with the hydrolysis method, the diameter of the cellulose produced by this method is very large, and the power consumption is also very high [14].

2.1.3. Electrostatic Method. Electrostatic method is the abbreviation of electrostatic spinning method. This method is to compress high-concentration polymer through a syringe under the action of a strong electric field to form tiny cellulose. This method requires dissolving cellulose in a syringe, which can then be made into fiber membranes and fiber networks [15].

2.1.4. Biological Method. The cellulose prepared by microorganisms is called bacterial cellulose in habit, and the finished product prepared by this method is very close to natural cellulose. Compared with natural cellulose, bacterial cellulose has an ultrafine network structure. It has been found that a variety of bacteria can produce cellulose, such as *Acetobacter xylinum* and *Rhizobium* [16].

2.2. Composite Conductive Materials. The conductive material refers to the material formed by adding a few electric powders to the raw material. The most obvious advantage of this material is that the material has conductivity, which greatly expands its use range. The composite conductive material can prevent static electricity; at the same time, it can be used as a new shielding material; the conductive rubber has good air tightness and is often used as a sealing material. But how the circuits inside the materials are formed and what functions they have are what we need to introduce [17]. At the beginning, the whole model is regarded as a whole. The points of the material are considered as independent arrays. When the added material reaches a certain level, the diffusion phenomenon will occur. At this time, the function expression can be obtained:

$$\varphi = \varphi_a (z - z_b)^\beta,$$

where \( \varphi \) represents the conductivity of the composite material, \( \varphi_a \) represents the conductivity of the additive material,
\( \varepsilon - z_b \) represents the difference between the actual volume fraction of the additive material and the critical volume fraction, and \( \beta \) represents the dimensionality coefficient.

\[
\varepsilon_b = \left(1 + \frac{3S}{\Phi W}\right)^{-1}. \tag{2}
\]

Among them, \( \Phi \) represents the interface energy, \( W \) represents the conductive particles, and \( \Phi \) represents the critical value reached by the additive.

\[
\phi_1 \varepsilon_1 \varphi_1 + \phi_2 \varepsilon_2 \varphi_2 = 0, \tag{3}
\]

where \( \phi_1 \) represents the volume fraction, \( \phi_2 \) represents the conductive particles, \( \varphi_1 \) represents the volume fraction of the polymer, and \( \varphi \) represents the conductivity of the polymer.

\[
\phi_1 \varepsilon_1 - \phi_1 \varepsilon_2 + \phi_2 \varepsilon_1 - \phi_2 \varepsilon_2 = 0. \tag{4}
\]

The function expression can be simplified to

\[
\varepsilon_n^2 + \left[ (2 - 3 \phi_1) \varepsilon_1 + (2 - 3 \phi_2) \varepsilon_2 \right] \varepsilon_n - 2 \varepsilon_1 \varepsilon_2 = 0. \tag{5}
\]

When \( \varepsilon = \left[ (2 - 3 \phi_1) \varepsilon_1 + (2 - 3 \phi_2) \varepsilon_2 \right] \), the function expression can be simplified to

\[
\varepsilon_n^2 + \varepsilon_n - 2 \varepsilon_1 \varepsilon_2 = 0, \tag{6}
\]

\[
\varepsilon_n = \frac{-\varepsilon + \sqrt{\varepsilon^2 + 8 \varepsilon_1 \varepsilon_2}}{2}.
\]

When the volume of the additive is one-third, the composite conductive material will have a sudden drop in resistance. The effective medium model in this case can be expressed as

\[
(1 - \alpha) \frac{z_{3i} - z_{3f}}{z_{3i} + S z_{3f}} + \alpha \frac{z_{3f} - z_{3i}}{z_{3f} + S z_{3i}} = 0. \tag{7}
\]

Among them, \( S = (1 - \alpha_0) \alpha_1 \) and \( \alpha_0 \) represent the volume fraction of conductive particles, and \( \alpha_1 \) represents the critical volume fraction. Figure 3 shows common composite conductive materials.

When analyzing the current field of conductive materials, the function expression of Ohm’s law can be expressed as

\[
D = \beta^* A + \frac{\gamma v}{\gamma i} \ast (\nabla A) = 0. \tag{8}
\]

The obtained uniform medium space charge density can be expressed as

\[
\frac{\gamma v}{\gamma i} = \frac{\delta}{\mu} v_0 = 0. \tag{9}
\]

Differentiate it to get

\[
v(i) = v_0 e^{-ik \ast (\nabla A)}. \tag{10}
\]

Among them, \( k \) represents the charge relaxation time, which is determined by the properties of the material itself and can be changed by setting the dielectric constant and conductivity, and \( i \) represents the external time scale.

\[
D \ast \nabla = \nabla \ast (\beta S) + \frac{\delta}{\mu} = 0, \tag{11}
\]

where \( \beta \) represents the dielectric constant, \( \mu \) represents the electrical conductivity, \( S \) represents the electric field intensity, \( D \) represents the current intensity, and \( v \) represents the space charge density.

According to the existing research results, the nodal swimming force borne by particles in a fluid medium can be expressed as

\[
P = 3 \pi \eta_i h^2 \nabla G_{1L} T(S) \Re \left[ T(S) \right],
\]

\[
T(S) = \frac{\eta_x^* - \eta_z^*}{\eta_x^* + 2 \eta_z^*},
\]

\[
\eta^* = \eta - f \left( \frac{\lambda}{s} + \frac{2 \pi}{s} \right),
\]

where \( h \) represents the radius, \( \eta_x^* \) represents the dielectric constant of the fluid, \( \eta_z^* \) represents the dielectric constant of the composite material, \( \eta_x^* \) represents the dielectric constant of the fluid composite material, and \( G_{1L} \) represents the square gradient of the electric field.

In the simulation experiment, taking the experimental substance as an example, the electrophoresis size of the particles inside the chip can be expressed as

\[\text{Figure 3: Common composite conductive materials.}\]
2.3. Clothing Design. Design refers to the plan, conception, and establishment plan, including the meaning of imagery. The clothing design process is the process of conceiving the requirements of the design object, drawing out a plan, and then making it according to the drawing to meet customer requirements [18, 19]. Clothing design is closely related to fabrics. With the advent of the high-tech era, the shape and technology of clothing fabrics have become the mainstream of the moment. Compared with the design brought by traditional fabrics and cutting technology, technology has brought more possibilities to clothing design. Clothing design needs to follow the principles of unity, emphasis, balance, proportion, and rhythm. This article is a new possibility proposed in the current development process, using the characteristics of polypyrrole cellulose nanocrystalline composite conductive materials to realize the application in clothing design. This is a new material, which is different from traditional fabrics in terms of performance and texture [20]. Figure 4 is a schematic diagram of the clothing design results.

Figure 4: Schematic diagram of the garment design results.

\[
G_L^2 = \sqrt{(3 \cdot W_{dd} + 3 \cdot W_{jd})^2 + (3 \cdot W_{dd} + 3 \cdot W_{jd})^2}.
\]  

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Take fiber materials as an example. There are many kinds of fiber materials, and many scientific and technological methods are used. There are many reasons for this phenomenon. One is because of the continuous development of science and technology, and people's pursuit of life is becoming more and more diversified. The second is the continuous development of the economy. The demand is increasing, but this type of clothing is very destructive to nature. In order to reduce ecological pressure, researchers hope to develop materials that do not destroy the ecology and meet the needs. At present, many similar materials have appeared in the market. Take the tea fabric material as an example. This kind of material can be used to make daily clothing. The material uses molecular biology to extract fiber filaments. There are many similar products, and their similarities are the use of high-tech means to bring people a visual impact, which is in line with the current aesthetic trend and has attracted a lot of attention [21, 22].

3. Application Experiment of Polypyrrole Cellulose Nanocrystalline Composite Conductive Material in Clothing Design

3.1. Fabric Selection. In order to meet the current practical needs, we searched for materials that can shield electromagnetic waves during the experiment and found that different materials have different effects on electromagnetic waves when searching for information [23]. According to the data, it can be known that fabrics with strong conductivity have weaker emission capacity and materials with larger magnetic permeability have weaker absorption capacity. Table 1 reveals the parameters of the experimental fabrics.

According to the data in Table 1, the five experimental fabrics are divided into copper-nickel mixtures, copper-nickel-silver mixtures, silver fiber materials, and fiber and...
polyester mixtures. The organization of materials mainly includes twill, plain weave, and weft plain stitch. The thickness of the fourth material is the largest, reaching 0.534 mm. The thickness of the mixture of the third fiber and polyester is only 0.0136 mm. The density of the fourth material is also the largest, and the density of the first material is the smallest [24].

3.2. Optimization of Fiber Manufacturing Method. The fiber manufacturing method has been briefly summarized above. In this experiment, we take the hydrolysis method as an example for a brief analysis. Before the experiment, we prepare solutions of different solubility and then analyze the catalytic effect according to the fiber materials of different sizes obtained in different solutions. The specific experimental data are as follows.

According to the data in Table 2, we divided it into five groups during the experiment. The first group did not add any solution, the second group added ferric chloride solution, the third group added aluminum chloride solution, and the fourth group added copper chloride solution. The fifth group adds magnesium chloride solution. The concentration difference of the solution is not big; we regard them as equal. According to the last column of data in Table 2, it can be seen that the fiber material catalyzed by ferric chloride is the smallest. We theoretically regard it as the best catalytic solution. In order to verify its catalytic effect on fiber materials, we immediately treated ferric chloride alone. The solution was subjected to a catalytic experiment, and the specific conditions are shown in Table 3. In this experiment, we used ferric chloride for the experiment. Following the use of the controlled variable method to change the concentration of the ferric chloride solution, five experiments with concentrations of 0.01 m, 0.03 m, 0.06 m, 0.1 m, and 0.13 m were carried out. According to the experimental results, it is found that when the concentration of the ferric chloride solution is less than 0.1 m, the size of the cellulose obtained by its catalysis becomes smaller and smaller. However, when the concentration of the ferric chloride solution is greater than 0.1 m, the size of the catalyzed fiber material tends to increase. Therefore, the experiment shows that 0.1 m is the best hydrolyzed fiber material. When the solution is increasing to this extent, the hydrolysis effect of ferric chloride solution is continuously decreasing [25, 26].

3.3. Fiber Material Tensile Test. According to the data in Table 4, when the mass fraction of the additive is 1%, the tensile strength of the fiber material is 79.3 MPa. According to the comparison, the strength is the closest to the tensile strength of natural cellulose nanomaterials. According to the data of tensile strength, when the quality of additives increases, the tensile strength of fiber materials shows a downward trend. When the mass fraction of additives is 3%, the tensile strength of the fiber material is 70.69 MPa, and when the mass fraction of additives is 5%, the tensile strength of the fiber material is 68.3 MPa. When the mass fraction of the additive is 10%, the tensile strength of the fiber material is 63.5 MPa, and when the mass fraction of the additive is 15%, the tensile strength of the fiber material is 60.1 MPa. When the mass fraction of additives is 19%, the tensile strength of the fiber material is 55.3 MPa. Therefore, according to the experimental data, we can add different quality additives according to the material to be manufactured to change the tensile strength of the material [27].
4. Application Analysis of Polypyrrole Cellulose Nanocrystalline Composite Conductive Material in Clothing Design

4.1. Hydrophilicity Analysis of Fiber Materials. Clothing materials are always closely related to water. No matter what kind of clothing, they need to be in contact with water. However, once some materials come into contact with water, the original properties of the material will change, such as shrinkage. This requires us to overcome the shortcomings in the design of clothing fabrics in the early stage of clothing design. The cellulosic material exhibits good hydrophilic properties because of the large number of hydroxyl groups on the surface. In order to explore the performance changes of the combination of cellulose and conductive materials, we have carried out experimental research on this.

According to the data in Figure 5, it can be seen that when the contact angle of the fiber material is 125 degrees, it shows good hydrophilic characteristics. In the experiment, we used the controlled variable method to test. First of all, the fiber materials of the first group are unchanged, but the added composite materials are constantly changing. The first time was pure material, the second time was 1% composite material, the third time was 3% composite material, and the fourth time was 5% mass fraction. For the composite material, the composite material with a mass fraction of 10% is added for the fifth time. Depending on the material added, the hydrophilicity obtained is different. The second group of control experiments is generally similar to the first group. We changed the quality of the fiber material during the experiment. Then, the pure material was added for the first time, the composite material with a mass fraction of 1% was added for the second time, and the composite material with a mass fraction of 3% was added for the third time. The fourth addition is a composite material with a mass fraction of 5%, and the fifth addition is a composite material with a mass fraction of 10%. According to the two experiments, it is known that increasing the hydrophilicity is beneficial to the reproduction and growth of cells. However, there are many factors that affect the hydrophilicity of cellulose, such as the diameter and porosity of different fibers. Then, with the addition of composite materials, the hydrophilicity of composite cellulose is improved. The overall trend is to increase first and then decrease [28, 29].

4.2. Analysis of Conductive Materials. The most important thing for clothing materials is the uniform distribution of the materials. If the conductive material and the cellulose material are not uniform when they are combined, then it is a defective product for the clothing. In order to make the conductive material evenly distributed, it is an effective way to add a solvent. The following is the data obtained from the experiment.

According to the data in Figure 6, we grouped the experiment, one group was added with additives, and the other group was without additives. According to experiments, the resistance of the material is very high when no additives are added, especially when the proportion of raw materials is less than 26%. When additives are added, the electrical resistance of the material clearly shows a downward trend. When the proportion of raw materials is 22%, the electrical resistance without additives reaches 10,000, while the electrical resistance of the material drops below 6000 after the additives are added. However, when the proportion of raw materials is 26% and above, the resistance change with and without additives is not obvious. The use of additives for uniform resistance materials can be carried out according to the ratio of the composite material, and not all situations are applicable. In order to reduce the occurrence of accidental situations in the
experiment, we also conducted a set of similar experiments. According to the experimental results, the two sets of data are similar, so the conclusion is scientific [30].

4.3. Response Time Optimization Analysis. According to the data in Figure 7, when the reaction time is 2 min, the reaction rate at this time is zero, indicating that this time is in the initial stage of the reaction. After 4 minutes, as the reaction time increases, the reaction rate shows an increasing trend. When the reaction time is longer than 10 min, the reaction rate increases slowly and has a downward trend. P°_his indicates the end of the reaction, and the highest average reaction rate is around 7.5 mg/min. P°_he incubation time is 0 at 2 minutes, indicating that the actual reaction has not started. In the subsequent experiments, the incubation time has been maintained at 4.5 minutes. These data illustrate the stability of the reaction system.

5. Conclusions

The subject of this article is to study the application of polypyrrole cellulose nanocrystalline composite conductive materials in clothing design. With the continuous development of technology and economy, people’s pursuit has undergone tremendous changes, and there are more novel ideas for the pursuit of clothing design. This article aims to combine the advantages of cellulose materials and conductive materials to the field of clothing. In this article, the following tasks are mainly completed: (1) the article mainly analyzes the specific application of fiber materials in different clothing designs starting from the functional properties of fiber materials. At the same time, the development prospects of fiber materials were discussed from the perspective of design frontiers in combination with the market. (2) We should first choose materials that save energy and have low carbon emissions. More consideration is given to the renewable resources created by nature to lay the foundation for the production of high-quality clothing and to achieve low carbon, environmentally, and friendly clothing design. (3) The drug loading efficiency of all nanofiber membranes is above 90%. Compared with pure nanofibers, the hydrophilicity of composite nanofibers has been improved, and the drug loading has increased. However, there are many shortcomings in the research process of this article: (1) the wearing performance of electromagnetic shielding clothing directly affects the comfort of the wearer. How to optimize the shielding effectiveness and wearability of multilayer electromagnetic shielding clothing fabrics to better satisfy the use is also a problem that needs to be clarified in the next step. (2) When preparing the cellulose composite material, the carbon fiber thread has not been processed. (3) There are too few types of analysis on conductive materials, resulting in a lack of contrast.
Data Availability
No data were used to support this study.

Conflicts of Interest
The authors declare that they have no conflicts of interest to report regarding the present study.

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