

Research Article

Research on Rapid Detection Electrochemical Sensor-Assisted Textile Art Design

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Electrochemical sensor is a detection means that integrates electrochemical analysis technology with sensor technology. In this paper, we analyze the superiority of electrochemical sensors and the achievements made by electrochemical sensors in other related fields and argue the great impact of electrochemical sensors on modern industrial production and people's life; we present the unique application of electrochemical sensors in textile art and its supporting design with the development of electrochemical sensor-assisted textile art and its supporting design and analyze the current situation of textile art and development requiring technological innovation, rapid detection of electrochemical sensor-assisted design, and the corresponding improvement of the quality and quality of the design. Also, we focus on the combination of design and art, using the characteristics of electrochemical sensors, the artistic expression, and functional enhancement, focusing on the space supporting the artistic effect. In this paper, two fibers, PU and PU/PAN-SPA, were designed with the aid of electrochemical sensors for rapid detection and tested for their water absorption, moisture permeability, air permeability, and mechanical properties, all of which performed well and can be used as good materials for textile art design. The use of electrochemical sensors to assist in the design of suitable textile fiber materials according to artistic expression techniques can better stimulate the artist's creative inspiration and release more contemporary artistic energy.

1. Introduction

In the twenty-first century, textile art, as a traditional art discipline with a long history, began to face another transformation in the process of development of the times—the “technological turn.” The transformation of traditional textile art to technology has led textile artists to focus their vision on more cutting-edge science and technology, seeking a more open horizon for textile art. The development of technology, the extension of materials, the innovation of forms, and the transmission of emotions have become the main issues of concern for textile art in the new era. With the progress of science and technology in modern society, the sensor as a new type of detection technology has also been developed by leaps and bounds. Sensors can detect the information of the measured substance and transform it into an electrical signal or other forms of information output, which can meet the needs of information transmission, processing,

storage, display, recording, and control [1], which can be divided into physical sensors and chemical sensors because of the different external information and change effects. Physical sensors are devices that convert detected physical quantities such as light, sound, and temperature into electrical signals, while chemical sensors are sensor devices that respond to the type and concentration of specific chemical substances and output them as electrical signals.

As an important branch of chemical sensor, an electrochemical sensor is a device that can respond to chemical or biological information of analyte and convert it into an electrical signal for qualitative and quantitative analysis, which is generally composed of an identification element system (sensitive element) and conversion element system (converter), after the target to be measured reacts with the contact of electrode system (sensitive element); the conversion element converts the material information into being detectable after the target to be measured reacts with the electrode system

(sensitive element); the converter element converts the substance information into an electrical signal that can be detected, then processes and amplifies the signal through the electrochemical detector, and finally displays the output as a detection signal such as potential, resistance or current [2]. To obtain the best detection sensitivity and selectivity, the sensitive element is usually fixed to the working electrode surface in the form of a membrane as a conversion element. In recent years, electrochemical sensors are necessary for aiding the artistic design of textiles due to their sensitivity, speed, accuracy, and ease of miniaturization. The vast majority of textile molecules have an electrochemical response at the electrode, and therefore, electrochemical sensors have a wide range of applications in textile quality control, qualitative or quantitative analysis of textiles, textile design studies, and textile analytical testing [3]. Textiles are variable, and different surface characteristics and physical properties trigger different visual and tactile sensations. The accuracy of grasping the texture of textile materials affects the hidden inspiration of creators, the formation of creative thinking, and the merits of artworks. Therefore, through the in-depth study of the aesthetic properties and application techniques of textile materials, the artistic expression of materials is enriched while providing a theoretical basis for artistic creation. The study of rapid testing of textile materials with electrochemical sensor technology and art theory makes our understanding of textile materials more thorough and rational, which is an improvement to the innovative use of materials in integrated material art, broadens the field of the art aesthetic research objects, enables new inspirations and expressions to emerge in art creation, and inspires people to think deeply about materials in the general environment of integrated material art. The concept of material and the concept of form are deeply thought. The development and innovation of textile material art cannot be separated from the in-depth research and summary of the methods and techniques of materials. Through in-depth research on the application methods and techniques of synthetic fiber materials in integrated material art, textile materials can be appropriately used in integrated material painting art, and the characteristics of the materials can be distinctly presented in the process of integrated material art creation based on a comprehensive and profound understanding of the physical and chemical properties and aesthetic properties of textile materials, to achieve the purpose of rapid detection of electrochemical sensors. The purpose of assisting textile art design is discussed.

2. Related Work

Conventional textile materials typically consist of inherently ductile and extensible materials that have limited plasticity or resistance to bending, tensile, and impact loads. A common approach to developing textile material systems is to blend inorganic fillers into soft organic polymers, resulting in a composite textile material that combines the mechanical properties of the polymer matrix with the electrical and thermal properties of the inorganic dispersed phase. However, a limitation of this approach is that the high concentration of filler required to enhance the electrical or thermal properties often leads to a deterioration of the mechanical properties of

the polymer and causes the said composite to become stiffer and less elastic. The rapid detection of changes in various parts of the textile material by electrochemical sensors allows for effective textile art design.

In the textile field, the main branches of nonlinear science, fractals, and chaos are studied in two main areas, one is the use of fractals and chaos as a research method, for example: studying the curl of yarn or the appearance of textiles with the help of fractal parameters, physical simulation of textiles with the help of fractals, and studying the unevenness of yarn strips with the help of chaos. Another one is the application of nonlinear patterns generated based on fractal and chaos theory to textile pattern design. The literature [4] presents a systematic study of electrochemical sensors applied to nonlinear patterns (including various types of fractal and chaotic patterns) and mentions the application of these nonlinear patterns to the textile industry. The literature [5] discussed the possibilities and prospects of electrochemical sensors applied to nonlinear patterns, mainly fractal patterns, from the perspective of textile pattern design, respectively. The possibility of applying electrochemical sensors to textile designs such as carpets is addressed in the literature [6] while discussing the principles of generating weakly chaotic images such as uniform random nets and quasiregular patches. The literature [7] explores the application of electrochemical sensors in the design of grain weaves and print patterns, focusing on fractal patterns and the inclusion of various types of fractal and chaotic patterns. The literature [8] investigated the application of electrochemical sensors in nonlinear patterns (including various types of fractal and chaotic patterns) and the artistic design of textile patterns. The literature [9] investigated the application of electrochemical sensors in fractal patterns and explored the possibility and prospects of applying fractal patterns in weaving and printing designs, respectively; the literature [10] applied electrochemical sensors in jacquard and knitted fabrics to form products. The literature [11] asserts that nature is the best source of design inspiration, listing how designers have explored natural forms from ancient times to the present. The literature [12] combines textile art and science, suggesting that biological forms invariably have a spiral structure, revealing the nature of aesthetics in life and nature by using the scientific theory of spiral curves. The literature [13] uses the method of knowledge in the field of mathematics to elaborate the reasons why textile art presents certain definite forms, and even the forms that exist are more perfect than the imaginary ones, and it combines art in nature with electrochemical science, giving a more scientific basis to the beauty of forms in nature. The literature [14] combines the design concept of electrochemical sensors with practicality to play a vital role in the grasp of the sense of order in pattern design and to maintain the unity of order and form in plant form and pattern design. The literature [15] describes the dyeing properties and dyeing principles of different synthetic fiber materials. The literature [16] comprehensively introduces the physical and chemical properties, dyeing and finishing methods, production processes, and production processes of different textile materials. The literature [17] introduces the characteristics of different fabrics and the techniques of fabric reconstruction and partly talks about the surface characteristics of synthetic

fiber materials, which provides more possibilities for synthetic fiber materials to be used in artistic creation. The literature [18] focused on the physical and chemical properties and dyeing and finishing auxiliaries of polyester-cotton fabrics with different compositions. The literature [19] provides an important scientific basis for being able to correctly identify different synthetic fiber materials.

3. Research on Rapid Detection Electrochemical Sensor-Assisted Textile Art Design

3.1. An Investigation of the Principles of Rapid Detection Electrochemical Sensors Applied to Assist Textile Art Design. The working principle of electrochemical sensors is to convert the potential difference signal into other signals by detecting the potential difference generated by the electrochemical reaction of the identifier. Electrochemical sensors are a very common type of chemical sensor. It uses electrodes as the sensor conversion element and biological or inorganic material modified on the electrode as the sensitive element. The sensitive element is in contact with the ion or molecule of the measured substance, and a chemical reaction or change occurs, and the conversion element converts this reaction or changes directly or indirectly into an electrical signal to establish the relationship between the concentration, composition, and other chemical quantities of the subject matter and the output electrical signal, thus realizing the quantitative detection of the subject matter.

Molecular imprinting technique (MIT), first reported in the 1970s, is a recognition system that mimics an antigen-antibody or enzyme. The target molecule (or its structural analog) is used as the template molecule, and functional monomers with specific interactions with the template molecule are selected and polymerized by covalent or noncovalent bonding to produce a molecularly imprinted polymer; the template molecule is then eluted with an appropriate solvent or removed under certain conditions, leaving stereospecific imprinted pores in the imprinted polymer that is precisely complementary to the template molecule in terms of conformation, size, and binding sites [20]. Thus, the specific recognition of the target molecule is achieved. As shown in Figure 1, the preparation of molecularly imprinted polymers typically consists of three steps: a preassembly process, a polymerization process, and a template elution process.

According to the different binding modes of functional monomers and template molecules, molecular imprinting techniques can be divided into three categories: the covalent bonding method, the noncovalent bonding method, and the quasicovalent bonding method which is between covalent and noncovalent bonding methods. In the covalent bonding method, the functional monomer and the template molecule are combined in a reversible covalent bond, and the obtained polymer has a highly complementary spatial structure with the template molecule, with strong affinity and selectivity. However, during the recognition of template molecules, the efficiency is low because the covalent bonds are slow to bend and break. In the noncovalent bonding method, the template

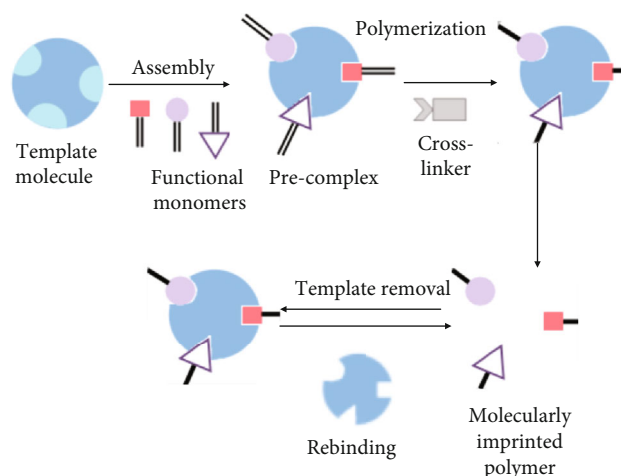


FIGURE 1: The preparation process of molecularly imprinted polymers.

molecule is combined with the functional monomer in the form of noncovalent bonds, such as hydrogen bonds, electrostatic interactions, π - π interactions, van der Waals forces, and hydrophobic forces, which can form multiple different sites of action. This method dissociates the adsorption equilibrium faster and is currently the main research hotspot for molecular imprinting techniques. The quasicovalent bonding method combines covalent and noncovalent bonding methods, but its synthesis and dissociation process is particularly tedious, which greatly limits the development of quasicovalent bonding method applications. The combination of molecular imprinting technology and electrochemical sensors can significantly improve the selectivity of electrochemical sensors, thus enabling the analytical detection of actual complex samples. Using molecularly imprinted membranes as recognition elements, molecularly imprinted sensitive membranes can be obtained by coating, electrochemical polymerization, or in situ polymerization on the surface of the working electrode [21]. When the target molecule in the solution selectively recognizes and binds to the matching hole in the molecularly imprinted membrane on the electrode surface, the electrochemical signal will change, thus realizing the specific detection of the target molecule. Molecularly imprinted electrochemical sensors are now used in textile art design, drug analysis, immunoassay, disease marker detection analysis, environmental analysis, and food safety.

The preparation of electrochemical sensors using screen-printing processes has become an important milestone in the development of electrochemical detection. Compared to conventional rod electrodes, screen-printed electrodes can be integrated with various portable test systems due to their small size and directly contact and sense the object to be detected in the environment while avoiding operations such as sampling and transportation. The preparation process of screen-printed electrodes consists of the following operational procedures.

3.1.1. Electrode Design. Electrodes can be designed in either a two-electrode or three-electrode form. Generally speaking, screen-printed electrodes are more often designed in a three-electrode form, consisting of a working electrode, a counter

electrode (auxiliary electrode), and a reference electrode. The number of working electrodes is increased to meet the needs of simultaneous detection of multiple substances, to modify different substances, or other electrochemical testing methods for selective testing. In addition, in commercial electrodes, auxiliary electrodes are added to the design of electrodes to calculate the current response of interfering substances to improve the accuracy of the sensor test results. In addition, screen printing techniques can be used to create microarrays of electrodes by wrapping the surface of a screen-printed electrode with a polymer material and then etching it using acoustic chemistry to create a random collection of microelectrodes. Another approach is to use an inert material to print on the surface of the carbon layer of the screen-printed electrode and then use laser etching to expose the surface of the carbon layer, thereby creating micrometer diameter cavities.

3.1.2. Substrate Material. From the electrode material point of view, the support material (substrate) is of great importance for the performance as well as the quality of the electrode. From the perspective of design requirements, support materials for screen-printed electrodes can be divided into rigid and flexible materials. Rigid materials are mechanically rigid to provide a solid and flat electrode surface, making the electrode itself more durable and less prone to wear. Common rigid materials include glass, alumina ceramics, aluminum sheets, and some rigid plastics such as polyvinyl chloride (PVC) and polyethylene terephthalate (PET). An example is a low-cost nanosilver screen-printed glass electrode to detect hydrogen peroxide. The glass substrate of the sensor does not need to be modified with an indium tin oxide coating, making the direct use of silver nanoparticles an economical and simple method. The sensor uses a glass electrode made of nanosilver ink as the working electrode and detects hydrogen peroxide in complex samples using cyclic voltammetry. It has the advantages of low detection limit ($0.3 \mu\text{mol/L}$), stable electrode performance, and high reproducibility. In contrast, a label-free molecular electrode for the detection of textiles was developed using a ceramic substrate. Low-temperature cofired ceramics were selected as the electrode substrate material due to their easy fabrication process, high biocompatibility, and high-temperature stability. Typically, low-temperature cofired ceramics come in the form of tapes, made using alumina, glass frit, and organic components, suitable for low-cost processing, and a wide variety of electrode thicknesses are available.

The flexible substrate has a wider range of applications. The most important feature of the flexible substrate is that the material itself is more ductile and flexible and can adapt to complex detection environments. Nonflexible materials can undergo fracture strain under large mechanical deformation, making irreversible damage to the sensor. Unlike rigid substrate electrodes, the pattern of flexible electrodes deforms under stress, so electrodes are typically designed with irregular geometries to meet mechanical requirements, such as origami structures and serrated or serpentine connections. This design ensures reliability and continuity of electrical signal transmission and allows the electrodes to have reversible changes under mechanical action. Flexible substrates are widely used in a variety of polymer materials,

such as flexible fabrics with rough surfaces, flexible screens, and flexible tattoo stickers.

3.1.3. Electrode Modification. The electrodes are pretreated with activation or chemical modification as required before use. Electrochemical activation operations can have stripping and renewing effects on the electrode surface of the working electrode. For example, the electrochemical activity of the electrode can be enhanced by preanodizing to enhance the functionality and roughness of the electrode surface to remove contaminants from the surface. The electrode is cyclically scanned in a sulfuric acid solution for 20 weeks before use to eliminate the effect of surface contaminants on the test results.

A flow chart for the detection of small fiber molecules in textiles by an electrochemical sensor is shown in Figure 2, and the principle can be expressed by the following equation:

$$KL(x, y) = \frac{\delta y}{\delta x} \cdot \sum_{i=1}^n X_i Y_i,$$

$$\text{Sigma}(\alpha, \beta) = \sigma_\alpha^2 \cdot \mu_\beta \sum_{i,j=1}^n \alpha_{ij} \beta_{ij}, \quad (1)$$

$$E(k) = R_k \cdot L_k^2 + \int Q_k x dx.$$

Here, we first transform the $KL(x, y)$ MLP (Multilayer Perceptron) to obtain its hidden layer representation μ_β and then compute the similarity (vector inner product) μ_β with the context vector σ_α^2 (model parameter, representing an abstract concept, obtained by gradient descent learning) and use the result as the weight of the first k sensor modality. However, the domain of the weights calculated in this way is from negative infinity to positive infinity, so finally, we need to normalize the weights by the softmax function to obtain μ_β , and the domain becomes $[0, 1]$.

3.2. Rapid Detection of the Electrochemical Sensor-Assisted Textile Art Design. Technical tools promote change in traditional industries and rapid detection of electrochemical sensors in the design process of the textile art design, as high-performance technical tools accelerate the development of the art and design industry, to improve the ceiling of the industry. A rapid detection electrochemical sensor for home textiles and their supporting pattern design, with its unique visual language, has changed the traditional design methods and processes and rapid detection electrochemical sensor technology for designers to provide a new form of artistic expression and space.

According to the principle of nonlinear science, through the rapid detection of electrochemical sensors, to generate some kind of graphics and animation with both aesthetic interest and scientific connotation, and in some way to demonstrate, play, and exhibit to the audience, such art is called nonlinear graphic art. The rise of nonlinear graphic art helps to combine modern science with modern art. Art and science are equally about innovation, and nonlinear art undoubtedly has more

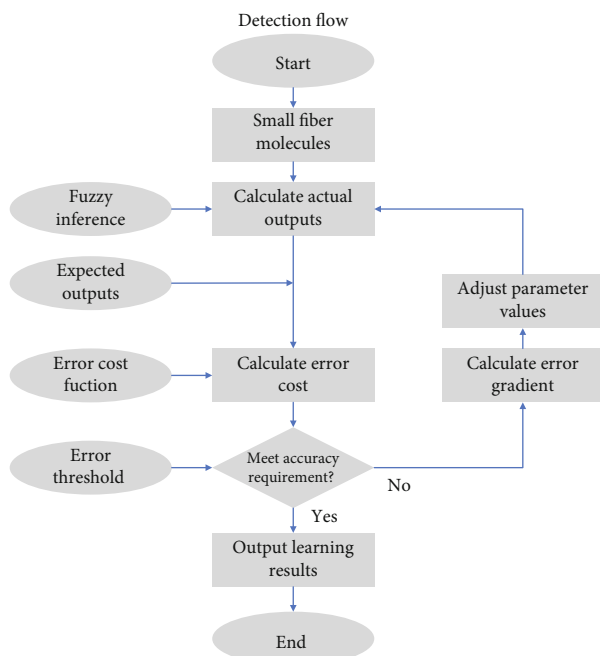


FIGURE 2: The flow of electrochemical sensor for detection of small fiber molecules in textiles.

room for innovation compared to traditional art, while nonlinear art itself is capable of constant innovation. Nonlinear art has an infinite variety of functions, an infinite variety of coloring schemes, and several methods of generation.

Synthetic fiber materials can be used in variable ways to create different art forms and artistic effects. The methods used in the creation of composite material art are mainly material, process methods, and artistic methods. The material method here mainly refers to a means by which the artist uses the physical or chemical properties of the material throughout the creation to achieve the creative intent. The physical properties of the material are the properties of the substance that manifest without chemical reaction, such as color, odor, form, boiling point, and hardness. The substance remains unchanged before and after the experiment. Only based on a full understanding of the physical properties of the material, it is possible to study the aesthetic properties of synthetic fiber materials and then use the aesthetics produced by the material to create art. Chemical properties, on the other hand, are properties that manifest themselves only when a change occurs, involving changes in the chemical composition of the substance's molecules, such as flammability, instability, acidity, alkalinity, thermal stability, and corrosion. The application of chemical properties of materials to the creation of integrated material art can lead to qualitative changes in materials, and electrochemical sensors for rapid detection technology, in this regard, have great prospects for application.

The methods of artistic creation formed under the auspices of synthetic fiber materials are as follows: (1) the synthetic fiber materials have their properties to achieve the satisfaction of the creative intent, and (2) the artist adds certain emotional properties to the synthetic fiber material

artificially. The obvious differences in texture, color, and expression of synthetic fiber materials determine that their emotional expression is rich and diverse. On the one hand, when the creator selects synthetic fiber materials, he or she needs to be clear about the aesthetic presentation of the work and the intention of expression, to be able to agree with the viewer and the artist in terms of emotion and to make the prior selection of the materials during creation to ensure that the physical or chemical properties of the materials can achieve the satisfaction of the artist's creative will. On the other hand, the creator introduces emotion into the material. If the synthetic fiber material takes on the artist's emotion and the author gives it some connotation or symbolic meaning, the synthetic fiber material gradually changes from a dull dead object to a rich and diverse living body, and its artistic status is clarified and enhanced. During the creation period, the author should have a comprehensive and precise grasp of the expressive power of the material to create the desired creative effect based on the status and existence of the texture and color.

In addition to the texture, color, and form of the material, the beauty of synthetic fiber materials in integrated material art is reflected in the application methods and production techniques of the material. For the most important issue, the works created with synthetic fiber materials as the main creation medium, using material methods, process methods, and art methods, have different dominant factors and effects: the material methods are based on the physical and chemical properties of synthetic fiber materials, which guide the growth state of the artist's creative thinking and make the works reveal rational beauty; the process methods are based on the traditional dyeing process, weaving process, and embroidery. The method of craftsmanship is dominated by a traditional dyeing process, weaving process, and embroidery, rendering the artistic atmosphere of the works; the method of art is dominated by the artist's subjective treatment of color and modeling expression, pursuing the final presentation of artistic effects. And then, the selection of creative techniques such as drawing, stitching, creasing, and overlapping not only produces rich texture and wonderful color changes on the surface of synthetic fiber materials but also brings visual and psychological experience to the viewers, which expands the artistic language of synthetic fiber materials in comprehensive material art.

Through electrostatic spinning technology with the fast detection of electrochemical sensors, hydrophobic PU nanofiber membranes with coarse fiber diameter, large pore size and low porosity, and hydrophilic PU/PAN-SPA nanofiber membranes with fine diameter, small pore size, and high porosity were prepared, and the bilayer nanofiber composites were constructed by laminating the two types of fiber membranes. The gradient difference in hydrophobicity and pore structure of the two membranes enables the bilayer composite to transport and directionally transfer liquids and can effectively prevent the reverse flow of liquids and finally successfully prepare the bilayer nanofiber composite with the function of unidirectional moisture conduction. In addition, the surface of the PU nanofiber membrane is smooth and flat, flexible, and elastic, as shown in Figure 3 for the preparation process.

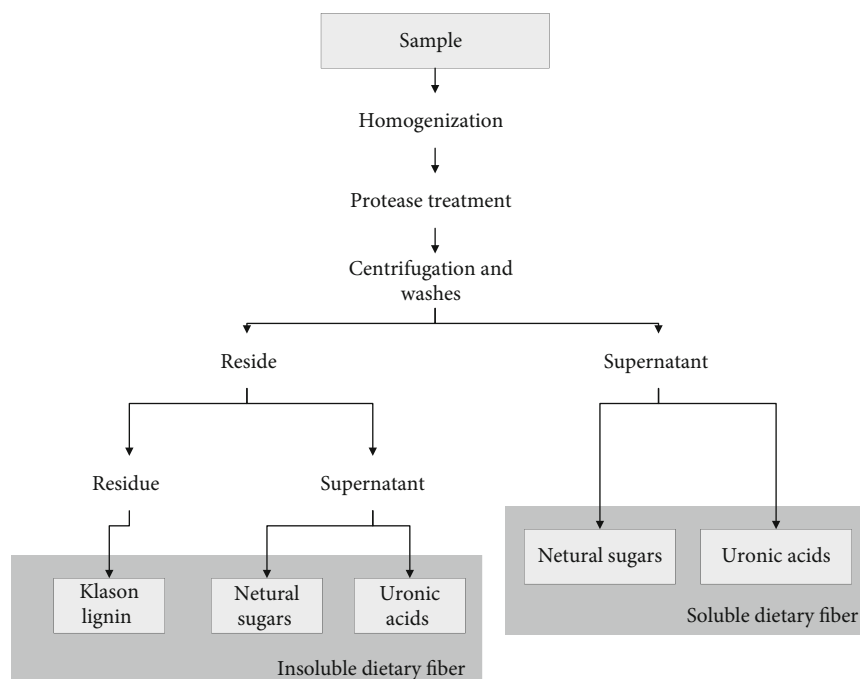


FIGURE 3: The flow of electrochemical sensor preparation fibers.

In this paper, two kinds of fibers, PU and PU/PAN-SPA, were prepared by the rapid detection technique of electrochemical sensor, both with a smooth and uniform surface, straight fibers without bonding and beads, and crossed and stacked between fibers with higher porosity. It can be used as an excellent raw material for textile art design.

4. Experimental Design and Conclusions

Wet environments can cause discomfort, but excessive water absorption in textiles can also lead to dry skin. Therefore, textiles need to absorb and transfer excess sweat from the skin and maintain a suitable moist environment at the skin to ensure a good wearing sensation, and the water absorption and equilibrium water content have a direct impact on the moisture absorption and moistening performance of the dressing. As shown in Figure 4, the water absorption and equilibrium water content of the nanofiber film showed a trend gradually increasing and then decreasing with the increase of SPA content, and the water absorption and equilibrium water content of the film reached the maximum when the SPA content increased to 10 wt%. This is because the water-soluble SPA is uniformly dispersed in the spinning solution made of organic solvents, and when the SPA content exceeds 10 wt%, the dispersion becomes poor, resulting in its easy deposition at the bottom of the supply cylinder during the spinning process, which eventually affects the SPA content in the fiber membrane. Therefore, the hydrophilicity of the PU/PAN-SPA nanofiber membrane was found to be the best when the concentration of SPA in the spinning solution was 10 wt% with the water absorption of 950% and the equilibrium water content of 94%.

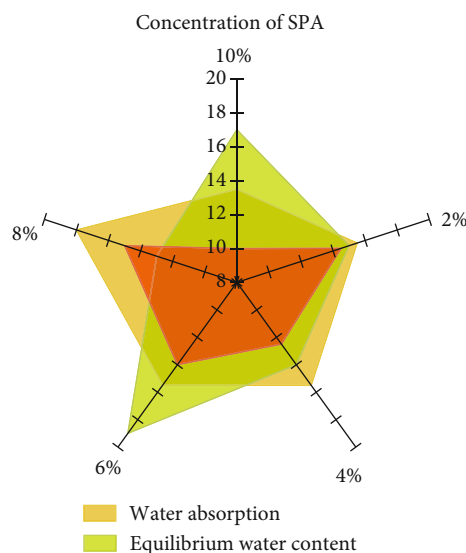


FIGURE 4: Water absorption and equilibrium water content of the nanofiber at different SPA.

As a textile material, it needs to have a certain degree of breathability and moisture permeability to maintain the exchange of gas at the wound. The YG461E-III fully automatic air permeability meter was used to measure the air permeability of the samples. The difference between the inside and outside was controlled to be 100 Pa, and the test area was 20 cm². At least 5 locations on the sample were randomly selected for measurement, and the permeability of the sample was counted and analyzed. The air permeability and moisture permeability of the PU/PAN-SPA nanofiber membrane are

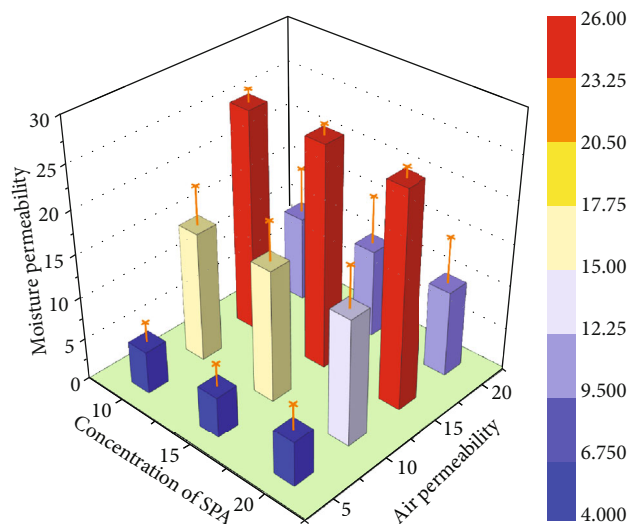


FIGURE 5: Moisture permeability and air permeability of nanofiber membranes at different SPA concentrations.

shown in Figure 5. As shown in Figure 5, the moisture permeability of the PU/PAN-SPA nanofiber membranes decreased gradually with the increase of SPA content when the concentration of SPA increased from 0% to 12 wt%, while the air permeability did not change much and was maintained at about 7 mm/s. This is because moisture permeability is mainly related to the hydrophobic property of the fiber membrane, while air permeability is mainly related to the morphological structure of the fiber membrane. When the concentration of SPA in the nanofiber membrane is high, the water vapor molecules escaping from the permeable cup will be adsorbed in the fiber membrane, resulting in the inability of water molecules to pass through the fiber membrane, thus reducing the permeability of the fiber membrane. The presence of SPA in the fiber membrane can significantly improve the hydrophilicity of the fiber membrane but hardly affect the morphological structure of the fiber membrane, so the permeability of the PU/PAN-SPA nanofiber membrane can be maintained at different SPA concentrations, while the moisture permeability will be significantly reduced.

The mechanical properties of the samples were tested by an XLW (EC) intelligent electronic tensile tester with a sample size of $50 \times 10 \text{ mm}^2$, 5 parallel specimens were selected for each sample, and the thickness of the specimens was measured by a thickness gauge, and the average value was taken from multiple measurements at a speed of 10 mm/min. The textile material needs to be mechanically strong and ductile to maintain a stable textile structure so that the prepared textile has good conformability and can fit well to the body parts and improve its comfort and applicability. The results of the mechanical properties of PU/PAN-SPA fiber films are shown in Figure 6. The tensile strengths of the PU/PAN-SPA membranes were in the range of 6-7.5 MPa, and the elongations at break were in the range of 40-50%, which were between the pure PAN and PU membranes. This indicates that the PU component added to the fiber membrane can improve

the mechanical properties of pure PAN fiber membrane, and the effect of SPA on the mechanical properties of the fiber membrane is not significant. Therefore, the PU/PAN-SPA nanofiber membranes prepared in this study have better toughness and mechanical strength and meet the requirements for textile applications.

As shown in Figure 7, we investigated the measured water pressure of PU/FPU/TPU waterproof and permeable fabrics with different TPU contents, which increased from 45.0 kPa to 78.9 kPa when the TPU content was increased from 0 to 75 wt%. In addition, we also investigated the relationship between the measured and theoretical water resistance pressure of PU/FPU/TPU waterproof and breathable fabric and the pore structure (maximum pore size) and surface wettability (water contact angle) of the fiber membrane and found that the experimental and theoretical values were in good agreement with the equation, and the measured and theoretical water resistance pressure of the waterproof and breathable fabric was linearly related to the pore size (maximum pore size D_{max}) and surface wettability (contact angle θ) of the fiber membrane. The graph also shows the important parameters of thermal comfort of PU/FPU/TPU waterproof and breathable fabrics: moisture permeability and air permeability, which decreased from $10.2 \text{ kg}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ and $28.7 \text{ mm}\cdot\text{s}^{-1}$ to $6.1 \text{ mm}\cdot\text{s}^{-1}$ and $5.6 \text{ kg}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$ when the TPU content increased from 0 to 75 wt%, respectively. The same pattern of moisture permeability and the changing pattern of moisture permeability and air permeability are consistent, which is due to the decrease of fiber membrane porosity. Therefore, the preparation of PU/FPU/TPU waterproof and moisture-permeable fabrics can provide theoretical guidance for the structural design of functional membranes with different protective and thermal comfort properties.

As can be seen from Figure 8, the surfaces of PU, PU/PAN-SPA, and PAN-SPA fibers are smooth and uniform, and the fibers are straight without bonding and beads, and the fibers are crossed and stacked with each other, forming a clear three-dimensional pore structure. Combined with the diameter distribution of each layer, it can be seen that the diameters of the middle and outer layers of the hydrophilic part are around 158.1 nm and 112.7 nm, and the fiber arrangement in the membrane is denser, with a smaller pore size and higher porosity, while the diameter of the fibers in the hydrophobic inner layer is relatively coarse, around 959.2 nm, and the fiber arrangement in the membrane is sparse, with larger pore size and lower porosity. Therefore, there is not only a hydrophobic gradient difference between the hydrophilic and hydrophobic layers but also a pore structure gradient difference, and these two gradients make the three-layer composite fiber membrane material and have a hydrophobic-hydrophilic gradient effect and differential capillary effect. The fibers between the membranes are overlapped and interspersed, and the bonding fastness between them is good. Therefore, the triple-layer fiber membrane has better toughness, stability, and plasticity and can be used as a more advanced textile material.

The artistic expression of synthetic fiber materials is mainly reflected in three aspects. Firstly, the inherent physical

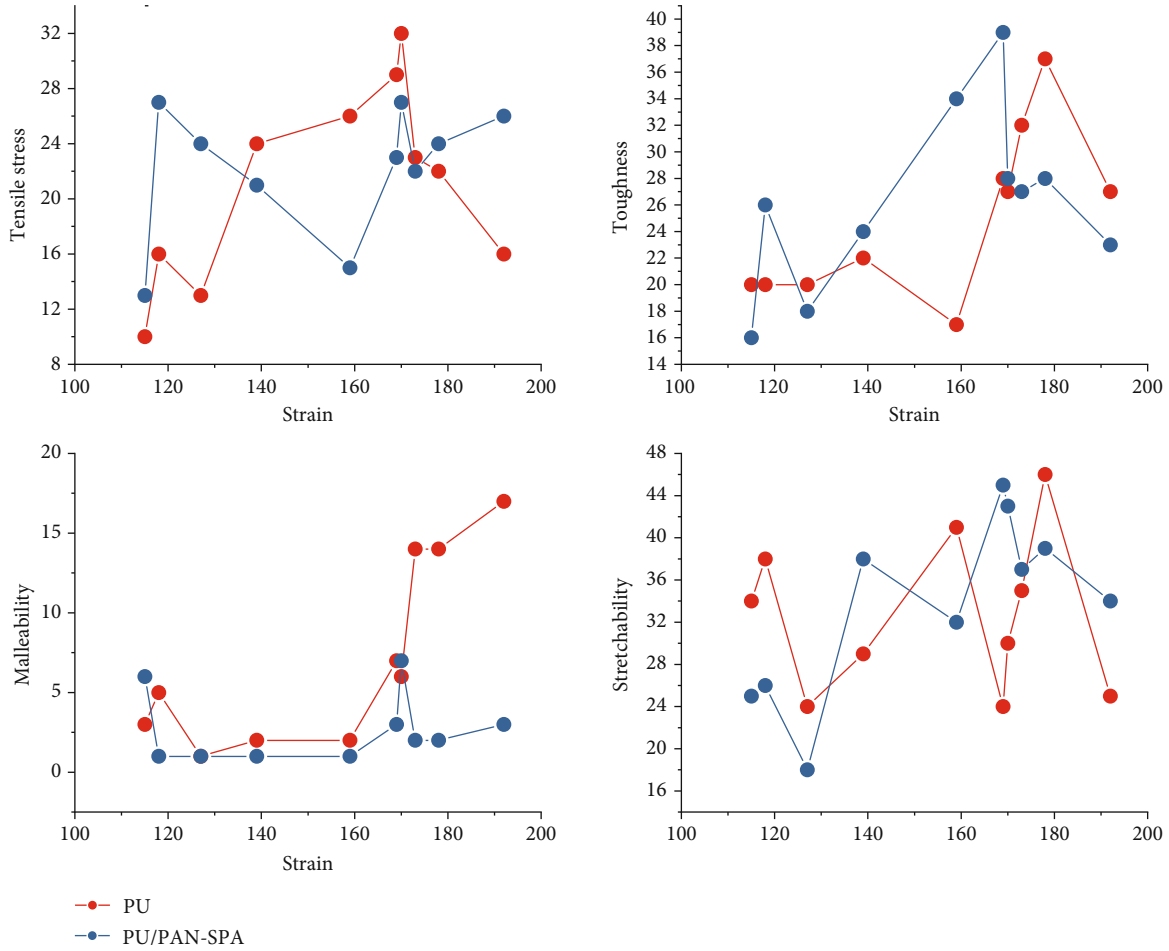


FIGURE 6: Mechanical properties of PU/PAN-SPA fiber.

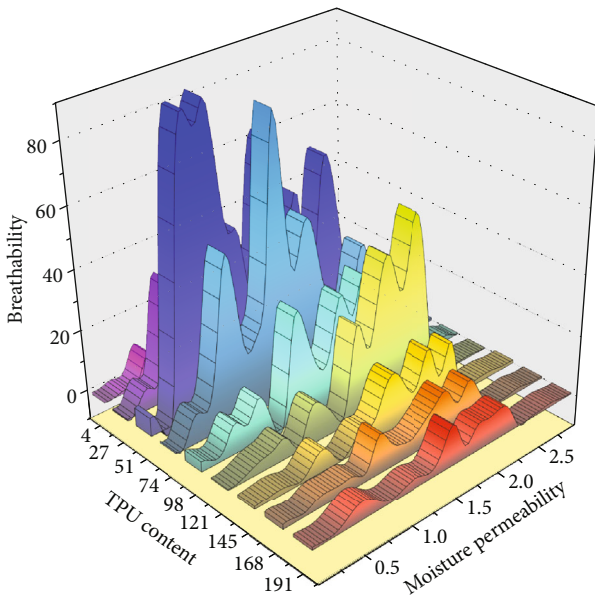


FIGURE 7: Study on the breathability and moisture permeability of fibers with different TPU content.

and chemical properties of synthetic fiber materials determine their suitability for artistic creation or not. Secondly, synthetic fiber materials have aesthetic properties in terms of texture, color, and form. On this basis, the artist gives it a richer emotional factor, making it a work of art with vitality. Thirdly, the production process of applying synthetic fiber materials for creation can also be used as the aesthetic object of art. This is mainly reflected in two aspects: (1) the chemical nature of synthetic fiber materials leads to “accidental phenomena” in the process of art creation, and (2) the integration of craft methods into the creation gives the work a “craft flavor.” The “accidental phenomenon” and the “craft flavor” can be directly used as aesthetic objects of art. Through the rapid detection of electrochemical sensors to assist in the design of synthetic textile fibers, it is possible to obtain suitable textile materials from the material layer, to obtain a better material carrier for emotion and presentation of ideas, and to realize the expansion and extension of the concept of contemporary art. Thinking about the use of synthetic fiber materials in the field of mixed material art creation will guide the creators of mixed material art to better grasp the characteristics of synthetic fiber materials, and at the same time, they can appropriately perform during the creation. In the case of gradual

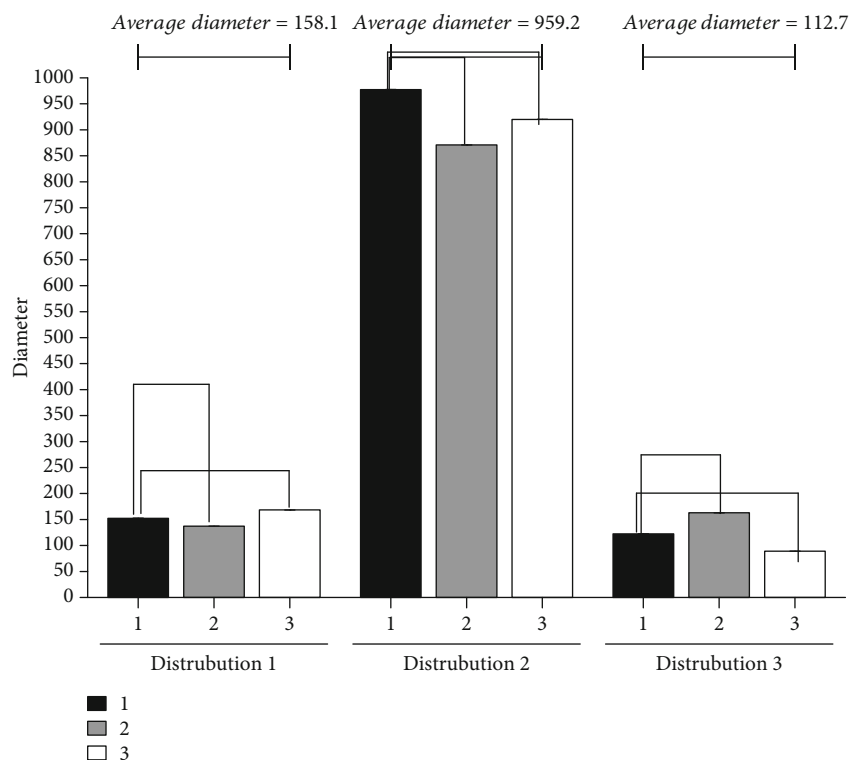


FIGURE 8: Distribution of diameters of the layers of fibrous membranes.

expansion of expression, synthetic fiber materials can better inspire the artist's creativity and release more contemporary art energy.

5. Conclusion

The most important characteristic of mixed media art is the diversity of materials and the combination of cross-disciplinary disciplines. Therefore, synthetic fiber materials are also liberated from the traditional textile and dyeing processes, and while serving as a medium for the creation of integrated material art, they also become one of the language elements of integrated material art and are resolved into many unitary elements, namely, the artistic expression of synthetic fiber materials and the unstable individual characteristics of synthetic fiber materials. This paper fully argues its superiority by analyzing the principle of the application of electrochemical sensors in the field of textile art; it presents the unique application of electrochemical sensors in textile art and its supporting design by assisting the development of textile art and supporting design with electrochemical sensors and analyzes the current situation of textile art and the need for technological innovation in its development. At the same time, focus on the combination of design and art, using the characteristics of electrochemical sensors, design synthetic fiber materials to meet the needs of art and the artistic expression and function to enhance, and focus on the space supporting the artistic effect. Through the analysis of the synthetic fiber materials used, the application methods of synthetic electrochemical sensor-assisted textile art design

in the creation of composite material art are summarized: material methods, process methods, and art methods.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

We declare that there is no conflict of interest.

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