Research Article

Application of Functional Nanomaterials in Aesthetic Art and Industrial Design Concept

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Industrial design (ID) refers to industrial product design based on engineering, aesthetics, and economy. Traditional industrial design refers to the creative activities of designing and designing products produced by industrial means to make the best match with the environment and the people who use them. This paper aims to study how to analyze and study the application of aesthetic art, that is, the concept of industrial design, based on functional nanomaterials, and this paper describes the electrospinning technology. This paper puts forward the problem of the industrial design concept, which is based on design aesthetics. Therefore, this paper focuses on the development of industrial design and related elements. The application of functional nanomaterials in industrial design is designed and analyzed. The experimental results show that when the acid soaking time is 4–12 days, the mechanical strength of the nano/fiber membrane is 7–9 MPa. Compared with the untreated nano/fiber membrane, it increased by 25.4%–48.8%, and the ductility decreased from 81.5% to 44.1%.

1. Introduction

Electrospinning technology has unique advantages in the synthesis of one-dimensional nanomaterials and has incomparable advantages compared with the traditional synthesis methods of one-dimensional nanomaterials. Industrial design is a practical activity to create a more harmonious and civilized way of life. It focuses on mass production and research products and pays attention to practicability, aesthetics, and environment of products. With regard to the ultimate goal of industrial projects, no matter what means and methods are used and from what point of view, the main work of industrial designers begins with the creation of product appearance.

The purpose of industrial design product aesthetics research is to endow industrial products with aesthetic value on the basis of meeting their practical functions. From the perspective of industrial design, this paper explores the design and application methods of nanomaterials based on the aesthetic theory of industrial design products. This paper applies the planning method to design practice in order to guide design practice and test the research results.

The innovations of this paper are as follows: (1) this paper combines nanomaterials with industrial design and introduces the theory and related methods of electrospinning in detail, and (2) in the face of functional nanomaterials, their infrared spectra and mechanical properties were tested in this paper. Through the evaluation of the experimental results, this paper comes to the conclusion that the electrospun nanofiber membrane has the advantages of high sensitivity, high repeatability, high stability, and convenient carrying and storage.

2. Related Work

Industrial design is an interdisciplinary activity aimed at developing new products that can be successfully put on the market. Generally speaking, the term industrial design is understood as a design process that leads to the determination of various characteristics of industrial forms. Katz
and Talmi have introduced a new course in the design and engineering laboratory. They got very positive feedback from a survey of students who completed their laboratory study. Most students say they like to learn and implement the concept of industrial design and combine engineering practice with creative design. However, his subjective factors account for the majority [1]. Armstrong explored the relationship between industrial design, fashion, consumption, and gender during the formation of American design specialization at the outbreak of World War II by carefully examining the visual and text content. He believed that fashion media has played a discourse role in improving the professional status of industrial designers. It provides a case for further thinking about the relationship between fashion and industrial design in the history of the design profession. However, his data are not sufficient [2]. Vargas Schüler et al. introduced the research on the attitude of students in the Department of Industrial Design and Manufacturing Engineering of Santa Maria Technical University in Federico, Chile, towards a circular economy (CE). The study developed qualitative and quantitative tools to capture how students respond to CE requirements. However, his research is not deep enough [3]. Milosavljevi examined the definition and nature of industrial design using comparative and historical scientific methods. Then he compared industrial design with trademarks by examining the similarities, differences, and overlaps of the legal protection of these intellectual property rights. However, his content is relatively simple [4]. Huang et al. have set up a model to illustrate the characteristics of undergraduate education in Chinese and American Industrial Design (ID) and investigated eight schools. They discussed the similarities and differences between ID undergraduate education in the two countries. The results show that there are differences in the two track models between China and the United States. Finally, they discussed the enlightenment of localization, openness, and globalization to ID education, as well as several directions of future development. However, their practical significance is not high [5]. Adamczyk and Graba took engineering research in the field of industrial design as an example to demonstrate the application of 3D printing in the design process. For many years, their design has been using standard technology. The development of additive manufacturing technology means that 3D printing is an indispensable element in industrial design. It can quickly create prototypes, that is, models of design details. However, their content is not novel enough [6]. Attias et al. introduced the ongoing research findings on mycelia providing cleaner life for building and designing products with a sustainable life cycle. The results showed that the characteristics of fungi, substrates, molds, and incubation conditions had a clear correlation with the characteristics of final materials. It depicts the significant effects on the material density, water absorption, and compressive strength of the final biocomposite. However, their steps are cumbersome [7]. The purpose of Zhou is to study the design and implementation of product industrial design management systems under the framework of green LCA theory. On the basis of previous studies and from the perspective of industrial design, they proposed an integrated evaluation system of green product industrial design knowledge based on life cycle evaluation. The experimental results show that the proposed method can meet the engineering requirements. However, its application scope is limited [8].

3. Functional Nanomaterial Method Based on Aesthetic Industrial Design

3.1. Industrial Design. The development of human design activities is divided into three stages: embryonic stage, process stage, and industrial design stage [9]. The first stage can be traced back to the Paleolithic age, when primitive people made practical and beautiful stone tools, resulting in the concept of human design. The development of handicrafts in architecture, furniture, and many other fields gave birth to the handicraft design stage.

The development history of industrial design is only two centuries. It is a design activity in recent society. However, industrial design involves many fields and has become an indispensable part of people’s life. There are many schools of industrial design, and the design styles also have their own characteristics, as shown in Figure 1.

Origin period (from the second half of the eighteenth century to the early twentieth century): this stage is a period of decline in the handicraft industry and transformation to industrialization.

3.1.1. Development Period (1920s∼1960s). Mechanization and industrialization have just sprung up. Product design starts from purposeful needs, and products mainly meet functional requirements. The style of simplicity and pragmatism is the main direction of this period.

3.1.2. Prosperous Period (1860s∼Now). It is also known as the postindustrial period. With the development of information technology, design not only pays attention to functionality but also pays attention to the mutual collocation of materials from the perspective of the design concept, culture, and style. It emphasizes the designer’s unique style.

3.2. Product Aesthetics. Product aesthetics is based on people’s needs and feelings and on meeting the use function. It achieves the purpose of meeting people’s aesthetic requirements by shaping the form, color, and cultural connotation of products [10]. It includes the following four categories: functional aesthetics, formal aesthetics, cultural aesthetics, and technical aesthetics (as shown in Figure 2).

3.2.1. Functional Aesthetics

(1) Practical Function. Practical means that it has advanced and complete functions and is suitable for people's use. Practical function refers to the function with practical use.

Practicality, as a basic feature of industrial design, can save manpower, time, and materials. Therefore, practicability
is equivalent to the functionality of industrial design products to a certain extent. Without practicability, industrial products will lose their significance. When performing actual functions, attention should be paid to the safety, reliability, and convenience of the product.

Safety is the starting point of the practical function of the product. The safety design of the product is to solve or avoid the safety problems caused by industrial products through the means of industrial design. Generally, the safety design of industrial products is embodied in physiology, psychology, and ecology.

Generally, humanized treatment is given to the product in terms of shape, structure, size, and material, so as to adapt various parameters of the product to human physiological characteristics and make the use process of the product more comfortable and pleasant [11]. For example, as shown in Figure 3, the safety of the kettle is increased by reasonably selecting the position of the handle and increasing the...
material thickness at the handle, so as to improve its practicability.

Good industrial product safety is reflected not only in ensuring the physiological safety of users but also in meeting higher-level psychological safety requirements. Through security design, users can experience good psychological feelings such as simplicity and ease of use, warmth, and intimacy. As shown in Figure 4(a), cylindrical glass can give people more sense of security and stability than conical glass in Figure 4(b).

Reliability refers to the ability of industrial products to perform specific functions without failure within a certain time and under certain conditions. The reliability of products can be evaluated by reliability failure rate, and so on. The higher the reliability of industrial design products, the longer the time it can work without failure, that is to say, the longer its service life. Reliability includes three elements: durability, maintainability, and design reliability [12].

Convenience refers to the ability or nature of industrial design products to facilitate use. The convenience design of products is actually a design that pursues convenience, practicality, and diversification.

(2) Aesthetic Function. The aesthetic function of industrial design refers to the visual impression of industrial design products to meet the aesthetic needs of users. The aesthetic function of products is to bring people original aesthetic information such as appearance and appearance and bring users a sense of pleasure. In industrial design, in addition to meeting the basic practical functions, it should also have aesthetic functions to bring beautiful feelings to customers. The aesthetic function of products is realized through two levels: aesthetic intuition and aesthetic imagination.

3.2.2. Formal Aesthetics. The “3F” law in industrial design (form, follow, and function), that is, form obeys function. The shape, color, and texture of products together constitute the formal beauty of industrial design products. Among them, the basic element of modeling is point, line, and surface. Through the movement and change of point, line, and surface, products with formal beauty are created. In industrial design, the point element is equivalent to a node, and the line and surface are equivalent to the path and area. When planning, the same as industrial design should follow the rules of formal aesthetics from the organization of point, line, and surface modeling elements to color matching [13, 14]. The different characteristics expressed by different line types are shown in Table 1.

Color is very intuitive in product design and is one of the important elements to form product style. Color can express feelings, and different colors and color combinations can bring people different feelings [15], as shown in Table 2.

3.2.3. Cultural Aesthetics. Culture is the general name of the material and spiritual wealth formed by the population in social life, such as history, geography, local customs, traditional customs, lifestyle, religious belief, literature and art, normative law, social system, mode of thinking, values, aesthetic taste, spiritual totem, and so on. Cultural aesthetics is to integrate the designer’s understanding of culture into the design process of industrial products so that industrial products have cultural connotations and aesthetic feelings. A good design must have characteristics and cultural connotations. When designing, it should also integrate the local regional culture so that citizens can obtain a sense of cultural identity and belong in the process of use [16, 17].

(1) Cultural Characteristics. Universality: culture is a common phenomenon in society. Culture in a certain region has strong commonality and universality. It is based on this characteristic that it is possible for designers to understand and grasp users’ needs for culture.

Differences: the differences in social backgrounds such as different nationalities and countries lead to great differences in culture, which is also the root of different design cultures and design localization.

Evolution: culture is relatively stable but not fixed. It will change with the development of society, and industrial product design will continue to innovate with the development of politics, economy, culture, and science and technology.

(2) Cultural Structure of Industrial Design. The structure of industrial design culture is generally divided into utensil culture, behavior culture, and concept culture.

Utensil culture (material culture): This culture refers to the culture at the material level, which refers to the sum of human material life and production mode.

Behavioral culture (institutional culture): It is a culture at the institutional level, which is reflected in various social relations between people, habits in people’s life and etiquette, folk customs, customs, and other forms of behavior patterns.

Conceptual culture (spiritual culture): This culture refers to the culture at the spiritual level. It is the value orientation, aesthetic taste, and mode of thinking summarized and accumulated by human beings in social practice and consciousness activities, including theoretical concepts, aesthetic orientation, literature and art, religion, ethics and morality, and so on.

(3) The Relationship between Industrial Design and Culture. Industrial design and culture cooperate with each other and develop synchronously. Culture is the basis of design, and the design that can be inherited must be products with high cultural value. Design is the material carrier of culture, and modern design is the unity of material civilization and spiritual civilization. It reflects the spirit of the times and regional characteristics of the product. The integration of culture in design lies in reflecting the connotation of culture.

3.2.4. Technical Aesthetics. Technology refers to the knowledge and operating skills in production. Technical aesthetics include the beauty of material and technology. Material is the material and texture of the product. It refers
to the aesthetic value of materials processed by their special texture or texture. Craft beauty is the process of beauty obtained by processing the materials through the process and technical methods of modern industrial design. Technological beauty is the prerequisite for their implementation. Only on the premise of material and technical feasibility can the design have significance [18, 19].

Different materials will give people different feelings. The use of materials can enrich the means of emotional information dissemination of products. The use of different materials can convey the different feelings of industrial design products, as shown in Table 3.

### 3.3. Theoretical Basis Electrospinning

Electrospinning is usually abbreviated as “electrospinning” and “electrospinning” in China. In recent years, electrospinning technology, as a new processing technology that can be used to manufacture ultrathin fibers, has attracted the research interest and extensive attention of scientists all over the world. Theoretically, any polymer material that can be dissolved or melted can be electrified [20]. So far, more than 40 polymers in the world have been successfully treated by electroplating technology. It includes natural polymers such as silk protein, DNA, and collagen. Synthetic polymers include polyurethane, polyactic acid,
polyvinyl alcohol, polyacrylonitrile, polycaprolactone, polyimide, and nylon.

3.3.1. Generation of Polymer Jet. Electrospinning is a special case of electrostatic atomization. In order to understand the process and theoretical basis of electrospinning technology in detail, we need to deeply master the basic theoretical knowledge of many first-class disciplines such as physics, chemistry, and chemical engineering. This basic knowledge includes many knowledge structures, such as mass conservation and heat transfer, including aerodynamics.

Only by observing the surface phenomenon can the droplet at the edge of the capillary become a curved hemisphere. When power is applied to the droplet surface, the curvature value on the droplet surface will gradually change with the change of potential. When the dynamic value gradually reaches the critical value \( V_c \), the hemispherical droplets will gradually become conical. The cone angle of this cone is 49.3 degrees, and the Taylor cone is this cone with potential.

The critical potential value \( V_c \) is expressed by the following formula:

\[
V_c = \sqrt{\frac{0.117\pi\alpha}{2\lambda L}} \left[ \ln \left( \frac{2\lambda}{R} \right) - 1.5 \right],
\]

where \( F \) represents the distance between the ground electrode and the capillary, \( L \) represents the length of the capillary, \( R \) represents the radius of the capillary, and \( L \) represents the surface tension of the liquid.

The physical state of the hemispherical droplet hanging at the mouth of the capillary nozzle is carefully studied. The solution spinning voltage \( V \) is similar to the formula above. It can be expressed as follows:

\[
V = 300\sqrt{20\pi\lambda r},
\]

\( r \) indicates the radius of the hanging drop.

In the derivation of formulas (1) and (2), it is assumed that air is around the droplets in the environment during the spinning process, and the fluid is a simple molecular structure. Through further analysis and study of electrostatic atomization theory, the strength characteristics of liquid play a great role in the whole process of electrostatic atomization, and the conductivity of the liquid is also related to the whole process of electrostatic atomization. Although the two simple formulas in the previous equilibrium theory do not include these characteristic parameters, these data are still special and key parameters in the dynamic process of electrospinning.

The shape of the Taylor cone during charging depends on the voltage applied to the fluid. For example, in the energization experiment with glycerol as raw material, the shape and size of the Taylor cone depend on the applied voltage. In a Newtonian fluid, the change of jet radius \( f(d) \) in electrospinning can be expressed as follows:

\[
f(d) = \left[ \frac{\rho W^3}{2\pi^2 IE_{\infty}} \right]^{1/4} d^{-1/4},
\]

where \( d \) represents the axial distance from the tip to the rotating head, \( r \) represents the fluid density, \( W \) represents the flow velocity, \( I \) represents the current, and \( V_{\infty} \) represents the electric field intensity. This formula further confirms the experimental results of Newtonian fluid electrospinning.

3.3.2. Stretching of Polymer Jet. In the 1960s, scientists laid a basic theoretical foundation for the fusion and rotation of electrically neutral fluids, and then scientists had a very deep understanding of this theoretical knowledge. The theoretical basis summarized by scientists is based on the balance of various mechanical scales \([21, 22]\), such as winding tension, rheological force, gravity, inertial force, surface tension, aerodynamics, and air resistance.

Under normal conditions, when the fluid is ejected from the capillary port, with the change of boundary conditions, the diameter of the ejected jet is slightly larger than that of the capillary, as shown in Figure 5.

By carefully observing the steady-state jet with distance \( x \), it is calculated from the outlet of the spinneret end, as shown in Figure 5. Its cross-section is \( C_x \). The average tensile stress is \( S_{xx} \), and the complete jet motion formula can be obtained through calculation. Its form is

\[
\pi R^2 (x) S_{xx} (x) = \pi R^2 S_{xx} (0) + \rho W (xV - \chi_0 V_0) + \pi a (R_0 - R) \]

\[
- \pi \int_0^x \rho g \, R^3 \, dx' + 2\pi \int_0^x S_{xxz} \, R \, dx.
\]

Formula (4) is the same as the formula of motion. After the whole interface of the jet is completed, the calculation formula of the continuity formula is as follows:

\[
\rho n R^2 (x) V (x) = \rho W = \text{constant}.
\]
The boundary conditions of the formula are constant extrusion rate $V_0$ and winding rate $V_L$:

$$V(x = 0) = V_0,$$  \hspace{1cm} (6)

$$V(x = L) = V_L.$$  \hspace{1cm} (7)

At this time, the $G_{\text{ext}}$ tension obtained at the winding point ($x = L$) is

$$G_{\text{ext}} = s_{xx}(L) + \pi R^2(L) = \pi R^2 s_{xx}(0) + \rho W (V_L - \chi_0 V_0) + \pi \alpha (R_0 - R_L) - \pi \int_0^L \rho g s_{xx} R b x' + 2 \pi \int_0^L s_{xx,c} R b x'. \hspace{1cm} (8)$$

In formulas (4)–(8), $V(x') = \overrightarrow{V}_s(x, r)$ represents the average axial velocity component of the jet in the whole section, $s_{xx}(x') = s_{xx}(x', r)$ represents the average tensile stress of the jet in the whole section, $R_0$ represents the initial radius of the jet in the hole, $R_L$ represents the final radius, and $s_{xx,c}$ represents the magnitude of the shear stress applied to the jet surface.

The first element $G_{\text{rev}} = \pi R^2 s_{xx}(0)$ is the viscoelastic response of the fluid to the shear flow of the original jet entering the threaded hole in the experiment, which is related to the voltage applied to the jet tip, and its value depends on the change of the rheological behavior of the liquid.

The second case is $G_{\text{in}}$, and the velocity $V_0$ coefficient $\chi_0$ is obtained from the acceleration from the initial velocity to the characteristic surface of the conventional velocity $V(x)$. The distribution of $V(x)$ is different, and their coefficients are expressed by $\chi$.

$$G_{\text{in}} = \rho W (\chi V - \chi_0 V_0) \approx \rho W (V - \chi_0 V_0). \hspace{1cm} (9)$$

The third condition $G_{\text{surf}}$ is that the surface tension is generated by changing the surface energy of the jet and the surface curvature of the jet. Its value is proportional to the surface tension $\alpha$, which is the interface between the jet and the surrounding medium.

The formula is as follows:

$$V_o = \sqrt{0.117 \pi \alpha R^2 \left(\frac{2H}{L}\right)^2 \ln \left(\frac{2L}{R}\right)} - 1.5. \hspace{1cm} (10)$$

In the above formula, the two elements are combined. The first element is related to gravity $g$. The gravity hypothesis generated by the jet itself can be expressed by the following formula:

$$\pi R^2(x) s_{xx}(x) = \pi R^2 s_{xx}(0) + \rho W (\chi V - \chi_0 V_0) + \pi \alpha (R_0 - R_L) - \pi \int_0^L \rho g s_{xx} R b x' + 2 \pi \int_0^L s_{xx,c} R b x'. \hspace{1cm} (11)$$

The integral in the above formula expresses the contribution of gravity $G_{\text{grav}}$, among them

$$g_x = f \left(1 - \frac{\rho_0}{\rho}\right) \cos \beta, \hspace{1cm} (12)$$

where $\rho_0$ represents the density of the medium environment, $\rho$ represents the density of the jet itself, and $f$ represents the value of gravitational acceleration. This is the angle between the vertical and axial directions of jet motion. $\beta$ is the force generated by the surface friction between the free surface of the moving jet and the surrounding medium.

The force balance formula (formula (4)) of the constant state jet can be best written as follows:

$$G_{\text{ext}} + G_{\text{grav}} = G_{\text{rev}} + G_{\text{in}} + G_{\text{surf}} + G_{\text{rev}}. \hspace{1cm} (13)$$

where all items in the above formula are positive, and only $G_{\text{grav}}$ value is negative. Various material properties and flow conditions determine the relative importance of each item.

If the steady-state jet decreases with its weight, this is a special case of the situation. The boundary conditions at this time are as follows:

$$G_{\text{ext}} = s_{xx}(x = L) = 0. \hspace{1cm} (14)$$

Or

$$V_L = 0 \ and \ G_{\text{ext}} < 0. \hspace{1cm} (15)$$

According to these theories, with the change of electric energy and surface force caused by the emergence and decomposition of fluid surface charge, considering the motion phenomenon of current volume dynamics, the whole charging process can be explained.

A doctor conducted a mathematical discussion on the phenomenon of the charged jet in the charging process. From the outlet of the capillary hole, at a certain distance down the jet, it can be considered that the jet motion is symmetrical, and a physical model can be created, as shown in the experimental setup in Figure 6.
The device is characterized by two parallel metal plates to form a flat plate capacitor. This form of parallel plate capacitor is installed to provide a set of parallel force lines to simplify various conditions of theoretical analysis, which is not needed in practical electrified machines. During the experiment, through adjustable parameters, the voltage value between the upper and lower plates can be adjusted to $V$, and the distance $d$ between the upper and lower plates can be adjusted. When the jet leaves the rotating capillary hole and enters the medium air, it is considered that the air resistance does not affect the jet surface. At the same time, it is necessary to assume that the jet fluid is an ideal Newtonian fluid, which is an uncompressed fluid.

The parameters of Newtonian fluid are as follows: the value of dielectric constant $a$, the value of conductivity $C$, the value of viscosity $P$, the value of interface voltage $\beta$. In the whole process of studying the charged jet with applied voltage, the free load relaxation of the system should be considered, and its relaxation time is expressed as follows:

$$\tau_a = \frac{a}{4\pi c}$$  \hspace{1cm} (16)

Formula (16) represents the local relaxation time of the total charge density of the medium.

The jet is considered thin, and the aspect ratio expansion is applied. Expanding $r$ with the Taylor series, among them, the axial velocity is $v_f$, the radial velocity is $v_r$, the radial electric field is $E_r$, and the axial electric field $E_f$ is a three-dimensional field.

$$v_f(f,r) = v_0(f) + v_1(f) r + v_2(f) r^2 + \cdots$$  \hspace{1cm} (17)

By transforming the above equations into space coordinate equations, we can get a set of equations.

The deduced mass conservation formula is

$$\phi_1(\pi h_2) + \phi_2(\pi h^2 v) = 0,$$  \hspace{1cm} (18)

where $H(f)$ is the value of jet radius with coordinate $F$ as the axis, and the value of axial velocity is $v_f$.

According to the theory, the charge conservation formula is

$$\phi_1(2\pi h\mu) + \phi_1(2\pi h\nu + \pi h^2 CE) = 0,$$  \hspace{1cm} (19)
where $\phi(f)$ is the value of charge surface density and $E(f)$ is the value of axial electric field intensity.

The momentum formula can be deduced as follows:

$$\phi_1 v + \phi_2 \left( \frac{v^2}{2} \right) = -\frac{1}{\rho} \phi_1 \rho + f + \frac{2\phi E}{h} + \frac{3v}{h^2} \phi_2 \left( h^2 \phi_2 v \right), \quad (20)$$

where $p(f)$ is the internal pressure value of the fluid. Also, there is an electrostatic value and tangential force $2\phi E/\rho h$ in the pressure.

4. Performance Experiment and Nanomaterials Based on Industrial Design Concept

4.1. Synthesis of PVA-GA Nano Spinning Fiber. Figure 7 shows the pva-ga nano spinning fiber membrane obtained by electrospinning technology and the SEM photos after crosslinking. It can be seen that the electrospinning fiber itself is very long, with continuity and a smooth surface. The fiber diameter obtained directly is about 150 nm, and the fiber diameter after soaking in water increases slightly, to about 180 nm. It is proved that the cross-linked pva-ga fiber not only has water resistance but also has a little swelling in water. At the same time, there is a close connection between fibers, rather than simply putting them together. This can be seen intuitively through the scanning photos. The cross-linked pva-ga fiber not only has a tighter structure but also has a much smaller macroscopic area than the pva-ga spinning fiber membrane without soaking [23].

4.2. Cross-Linking of PVA-GA Nano Spinning Fibers. Figure 8 shows the surface infrared spectra of pva-ga electrospun fiber films with different cross-linking degrees. The soaking time was 0, 4, 8, 12, 16, and 26 days. It can be seen from the spectrum that the absorption peak at 1,720 cm$^{-1}$ should belong to the stretching vibration of carbon-oxygen double bond of glutaraldehyde, which has disappeared after soaking for 3 days. At the same time, at the absorption peak of 1,240 cm$^{-1}$, the stretching vibration of the carbon-oxygen single bond belonging to the hydroxyl group of PVA also disappeared. It shows that the introduction of acid effectively promotes the combination of the aldehyde group of glutaraldehyde and the hydroxyl group of polyvinyl alcohol to form epoxy bond 3. What However, the subsequent mechanical property test data can be found (Table 4). With the increase in cross-linking time, the mechanical properties of the pva-ga electrospun fiber membrane are also enhanced. This shows that with the increase in acid soaking time, the cross-linking between PVA and GA occurs not only on the outer surface of the fiber but also inside [24, 25]. It promotes the enhancement of the mechanical properties of a single fiber and the improvement of the mechanical properties of the overall porous nanofiber membrane.

Directly obtained PVA-GA electrospinning fiber membrane without acid treatment showed typical polymer mechanics with good ductility (80%) and a rather low mechanical strength (5.9 MPa). Like most electrospun fiber membranes, this point is basically in the range of 4–6 MPa. The fundamental reason is that the principle of electrospinning is the rapid volatilization of solvent in the spinning process. In this process, the polymer or inorganic precursor cannot undergo a mild crystallization process, so the crystallization effect is not perfect. The inner surface of the fiber is relatively loose, and there is no good bonding force between molecules and particles, resulting in consistent poor mechanical strength properties [26, 27].

However, with the acid soaking treatment, PVA and GA that make up the fiber can have sufficient time for cross-linking, and the C=O double bond and C–O between each other can form a large epoxy bond under the action of acid, so they have the property of insoluble in water. The nanofiber membrane without acid treatment has the structure of a nonwoven fabric. There is only a simple
structure between fibers, and there is no good combination between them. After acid immersion, cross-linking first occurs on the fiber surface, and PVA and GA on the fiber and fiber surface react with each other first. Molecular binding can also occur at the intersection between different fibers, resulting in the close arrangement of fibers and fibers on the scanning image, forming a complete three-dimensional structure.
At the same time, the increase in acid soaking time gives PVA and GA more time to form more large epoxy bonds. This cross-linking does not only occur on the fiber surface. Because PVA-GA fiber still has certain swelling in methanol, a large amount of H can enter into the fiber, so the fiber also has a corresponding degree of cross-linking. The longer the soaking time, the more H entering the fiber, and the better the corresponding cross-linking degree. As a result, the mechanical properties of fiber membranes have been greatly enhanced. At the same time, the data also show that with the increase in cross-linking degree, the increase of mechanical properties presents an obvious ladder trend. When the acid soaking time is 4~12 days, the mechanical strength of nanofiber membrane is 7~9 MPa, which is 25.4%~48.8% higher than that of untreated nanofiber membrane, and the ductility decreases from 81.5% to 44.1%. When the acid soaking time increased to 16 or even 26 days, the data showed that the mechanical strength of the cross-linked nanofiber membrane increased significantly to 16.1~17.1 MPa, and the ductility decreased to 33.6~35.2%. The vast majority of H+ and GA should form a complete PVA. The crystallinity inside the fiber is well promoted by acid soaking, which leads to the significant improvement of the overall mechanical properties. It also explains why it is difficult to see the change of absorption peak in 6~26 days from the infrared spectrum.

Although science and technology have brought people a bilateral impression, it is undeniable that it has played a role in promoting social progress and design. Design aesthetics is embodied in all aspects of the product design process.

Compared with other preparation methods, the electrospun nanofiber membrane obtained in this chapter combines the advantages of high sensitivity, high repeatability, high stability, and convenient carrying and storage. It can better serve others in various designs and achieve the coordination and unity of people, products, and environment.

5. Discussion

Firstly, through the study of relevant knowledge points of literature works, this paper preliminarily mastered the relevant basic knowledge and analyzed how to study the industrial design concept based on aesthetic art. This paper expounds on the concept of nanomaterials and electrospinning-related algorithms and analyzes the applicability of functional nanomaterials in industrial design through experiments.

By improving people’s material living standards, consumers no longer only take their functions as the purchase standard when purchasing industrial products, but further, they should pay attention to the shape, aesthetic value, decorative effect, and other designs of products. Therefore, the design of industrial products not only as functional integration has become obsolete. Many industrial products combine function and decoration. It is not only excellent in function but also beautiful in appearance, which is becoming more and more popular. Especially with people’s pursuit of green nature and the deepening of the concept of environmental protection, industrial products become more and more important.

The experimental analysis shows that the electrospun nanofiber membrane has the advantages of high sensitivity, high repeatability, high stability, and convenient carrying and storage, which is in line with the purpose of industrial design. That is, it serves others, which is fundamentally different from artistic expression. Design often reflects the wishes of society and the needs of users, which depends on large-scale industrial production mode.

6. Conclusion

With the improvement of living standards, people’s consumption concept has undergone great changes. After meeting material needs, people begin to pay less attention to

| Electrospinning PVA/GA film with different immersed time (days) | Strain to failure (%) | Tensile strength (MPa) |
|---------------------------------------------------------------|-----------------------|-----------------------|
| Fresh PVA/GA film                                             | 81.5                  | 5.9                   |
| 4                                                            | 45.2                  | 8.6                   |
| 8                                                            | 44.1                  | 7.4                   |
| 12                                                           | 46.3                  | 7.7                   |
| 16                                                           | 33.6                  | 16.1                  |
| 26                                                           | 35.2                  | 17.1                  |
individual spiritual needs. The change in consumption concept makes industrial aesthetics an important part of product design. In recent years, China’s research on industrial aesthetic design is also very active. A large number of articles pay attention to design principles, form evaluation methods, style description, and other theoretical discussions on product form in industrial design, as well as the lack of application and practice research under the guidance of theory, so the applicability is not strong. The combination of industrial design and aesthetics promotes the unity of art, science, and culture. Its designs and creation stimulate people’s psychological state, which is people’s highest enjoyment. It profoundly reflects the essence of creation and nature and points out that industrial design aesthetics is the dialectical unity of typical aesthetics, technical aesthetics, and social aesthetics. This paper emphasizes the dialectical unity between typical aesthetics and modern aesthetics. Technical aesthetics and social aesthetics are the basic systems of industrial aesthetics and the design of modern architectural aesthetics, but the specific treatment methods still need to be further studied.

Data Availability

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Conflicts of Interest

The authors declare that there are no conflicts of interest.

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