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Retraction

Retracted: Heating Properties of Graphene Oxide Nanosheets and Their Application in Clothing Design

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] X. Luan, "Heating Properties of Graphene Oxide Nanosheets and Their Application in Clothing Design," *Advances in Materials Science and Engineering*, vol. 2022, Article ID 6400827, 11 pages, 2022.

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Research Article

Heating Properties of Graphene Oxide Nanosheets and Their Application in Clothing Design

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Graphene oxide nanosheets are nanomaterials with a layered structure, which have good thermal conductivity and heat dissipation. This article aims to integrate it into clothing design to alleviate the existing contradictions in the development of the clothing market. In this article, an overview of clothing design is firstly suggested, and then the structure and properties of graphene oxide nanosheets are expounded. A comparative test was carried out in terms of style and mechanical properties. The results showed that the thermal conductivity of graphene oxide clothing materials was maintained at a maximum of about 37.8°C, and the heat dissipation performance could be maintained at a minimum of about 27.1°C, which fully verified its operability. Popularizing it in the current stage of clothing design can effectively improve the performance and comfort of clothing.

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1. Introduction

With the progress of the times and the rapid development of the economy, people continue to put forward higher requirements for material and spiritual life in the relatively mature technology of modern science and technology. As an indispensable consumable in the daily life of the masses, clothing is also following the development of the market and constantly transforming and upgrading to meet the individual needs of consumers. The development of clothing is inseparable from the long history and culture of a society, which not only arises in culture but also coexists with culture. In all countries in the world, clothing is not only a practical tool for keeping warm and covering the body but also an important medium for conveying human spiritual civilization. It is closely related to everyone's life and plays a pivotal role in the development of a country. The change in the selection of clothing materials has gone through a long and tortuous process. From ancient animal fur to more comfortable cotton and linen fabrics, this change also reflects the progress and change of human society to a certain extent. However, in this fast-paced information age, science and technology are constantly innovating at speed visible to the naked eye, and clothing materials are gradually becoming technologically advanced, and the clothing market has ushered in a new turning point in development.

At this stage, the clothing market has begun to make some preliminary attempts, and nanomaterials have a variety of excellent properties, such as antiaging, anti-ultraviolet, and high toughness. Thus, it is undoubtedly the best choice in clothing material innovation. Some companies have tried to apply nanomaterials to fabrics and achieved some good results, but at this stage, the seasonality of nanoclothing products in the clothing market is not obvious, and many clothing design products are only suitable for warmer spring and summer. These products are not very practical in cold weather areas or when the temperature is low. Graphene oxide is a new type of heat-conducting and heat-dissipating material. Compared with other nanomaterials, graphene oxide has a unique structure, and its composition is in the shape of a sheet, so we usually call it graphene oxide nanosheets. In addition to its excellent electrical, optical, and mechanical properties, it also has good thermal conductivity and heat dissipation. It can be

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used in clothing design to solve the problem of keeping clothing warm.

Based on the design of clothing materials, this article explores the application value and role of the heating properties of graphene oxide nanosheets. It can make clothing material selection meet the development of the times, has practical guiding significance and practical significance for the transformation and upgrading of the clothing market, and can also provide new ideas for the application research of nanomaterials.

2. Related Work

In recent years, many scholars have studied graphene oxide nanosheets. Allahresani used chloropropyltrimethoxysilane as a reactive surface modifier and supported it on modified graphene oxide nanosheets. He characterized heterogeneous nanocatalysts by Fourier transform infrared spectroscopy isotherms and atomic absorption spectroscopy [1]. An et al. synthesized graphene oxide (GO) nanosheets using a modified Hummers method using graphite powder as raw material, and then he designed a method to study the assembly of GO/montmorillonite (MMT) composites [2]. Zia et al. synthesized acrylic acid and used it to construct modified graphene oxide nanosheet paste electrodes. They used cyclic voltammetry, chronoamperometry, and square wave voltammetry to study the electrooxidative reaction of isoproterenol on the modified electrode surface [3]. Al-Najjari et al. designed a hybrid bionanoassembled sensor for in situ detection of the organophosphorus insecticide diazinon. The sensing activity of this biosensor was achieved using in situ *Escherichia coli* hydrolase self-assembly on gold nanoparticle-modified graphene oxide [4]. Fernandez-Sotillo and Ferreira-Aparicio analyzed the phenomenon of nanographene oxide film growth induced by open-area copper substrates. This phenomenon is initiated by the self-assembly and reduction of graphene oxide flakes on the copper surface and then gradually expands to the open area [5]. Chen et al. investigated a nanocatalyst based on copper sulfide nanodots. It was grown on graphene oxide nanocomposites and applied in the electrocatalytic sensing of caffeic acid [6]. In summary, after several years of exploration, graphene oxide nanosheets have been deeply studied by many scholars. However, there are not many studies that integrate its heat-generating properties with clothing design. Therefore, in order to promote the in-depth development of the application of nanomaterials, the practical research on the integration of the two is urgent.

3. Clothing Design and Graphene Oxide Research

3.1. Overview of Traditional Clothing Design. Traditional clothing has undergone earth-shaking changes in the continuous maturation and improvement of science and technology. Traditional clothing materials have gradually lost their competitiveness, and their market share has gradually been replaced with new materials based on emerging technologies [7]. In the field of clothing design, the composition of an excellent product must be made of excellent clothing materials, so traditional clothing must be constantly innovated on this basis, understand the laws of market development, cater to the development characteristics of the times, strictly classify clothing materials, and carry out transformation and upgrading.

3.1.1. Classification of Traditional Clothing. The traditional clothing classification proposed in this article is divided according to the selection of clothing materials. In the past clothing market, the selection of clothing materials is divided into three fields: fabrics, leather, and innovative development materials.

(1) Clothing Fabrics. Fabric can be understood as a fabric produced from antifiber [8, 9]. It has a variety of styles and is loved by people of different ages, so it is also a commonly used fabric in the clothing market in recent decades [10]. Fabrics can be subdivided into different types according to different properties (such as material use, composition, processing method, and organizational structure).

(2) Leather for Clothing. Speaking of leather materials, first of all, it needs to think about the origin and development of clothing. Since ancient times, people's clothing materials have had a huge relationship with livestock skins. At that time, social productivity was extremely low, and the manufacture of tools had not yet started. In order to resist the cold, people use local materials and choose the fur of animals as a shelter tool. However, under the influence of history, even in modern times with advanced technology, there are still many animal fur sweater products in the clothing market, and leather is derived from fur materials [11]. Fur was defined as animal hair in previous studies, while leather can be divided into fur and leather in modern times, as shown in Figure 1.

There are many types of fur and leather. For example, fur can be divided into natural fur and artificial fur, and leather can also be divided into natural leather and artificial leather. The specific classification is shown in Table 1.

3.1.2. Composition of Traditional Clothing. The important foundations of modeling design are plane structure, three-dimensional structure, and color structure. Its main purpose is to scientifically and systematically study the cultural connotation, essential characteristics, and constituent elements in the design process [12]. The concept of material orientation and structure includes the basic structural elements of modern design in clothing design, and it is truly reflected in the professional design of clothing using the important methods of composing clothing materials. Designers apply clothing materials through various intuitive methods, connect basic structural elements, and adopt a variety of thinking modes to actively expand the breadth and depth of research design thinking. Finally, they are actively touched by design inspiration, improve their imagination, fully understand the characteristics and laws of material composition, and further develop from cognitive materials to designing clothing. In the design process, the mechanism

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Figure 1: Legend of fur and leather.

Table 1: Classification of fur and leather.

Clothing materials	Types	Sequence	Subdivision types
Fur	Natural fur	1	Small fur and fine skin
		2	Large fur and fine skin
		3	Coarse fur
		4	Miscellaneous fur
	Artificial fur	1	Woven artificial fur
		2	Knitted artificial fur
		3	Artificial roll fur
Leather	Natural leather	1	Cow leather
		2	Pig leather
		3	Sheep leather
	Artificial leather	1	Artificial leather
		2	Synthetic leather
		3	Deer leather

of processing materials actively enriches the material composition mode, which promotes the design of the material mechanism to be recreated [13]. From the perspective of scientific rationality, it analyzes the various characteristics of materials, then recognizes and studies the artistry, and then creates clothing materials, which include the following forms when applied to clothing:

(1) The Same Material. The composition of the same material is reflected in the design of clothing with the same material [14]. If the surface mechanism of the material has the same effect, it is easy to produce a dull and single feeling. The thinking of fashion designers should be diffused. They can combine modern scientific and technological means according to the slight differences (material color, tactility, and advantages) of materials so that the same materials can also show different aesthetics and functions. This is not only an innovation in materials but also an improvement in design. This can not only diversify the appearance and function of clothing but also help to deepen the design concept. The specific means are shown in Table 2.

In addition to the above-mentioned means of processing materials, the mechanism of the material itself cannot be ignored. Each material has different characteristics depending on its construction. The size and thickness of the yarn also affect the comfort and stimulation of the material to a certain extent. Thicker yarns are widely distributed in clothing, which will reduce the comfort of clothing. On the contrary, if the yarns are thinner and denser, the warmth and comfort of clothing will be enhanced. The choice of the method of coloring the fabric material and the selection of wrinkles caused by the method of finishing the material are all the design methods of the material, and they are also the factors that cannot be ignored in the process of clothing design.

(2) Different Materials. In clothing design, common clothing materials include cotton-type materials, hemp-type materials, silk-type materials, wool-type materials, and purified fiber fabrics. Each material has its own unique texture due to its own unique structure, just like the touch, color, and performance we just mentioned. Various types of textile materials have different texture effects due to different raw fibers, weaving methods, and finishing [15]. The composition of different materials is to connect with each other in the difference of the characteristics of different materials so as to give people a strong contrast in the sense of the material. However, this strong contrast is not negative but a contrast of harmony and communion. This forms an innovative form and beauty effect, which is also an important feature of modern design and an important means of applying texture in clothing design. There are two specific forms:

The first is the composition of the material. It is composed of materials that have little difference in appearance and are very close in terms of material quality, hardness, and thickness. This combination of forms will inevitably form a sense of harmony in the vision. For example, there are many spliced clothing products in the clothing market that are made of cotton, linen, and corduroy. These two fabrics are similar in quality and thickness, and they combine to form a sense of texture coordination.

The second is the composition of the contrasting materials. Contrary to similar materials, the comparative materials are composed of materials with large differences in appearance and in terms of material quality, hardness, and thickness. Although this splicing will give people a strong visual impact, this impact will not destroy the overall proportion of clothing. And in practical applications, the ratio of this splicing is often only offset to one material, and the two materials are not spliced in equal proportions. It also

Table 2: Fashion design expression means of the same material.

Sequence	Methods	Meaning
1	Pleat	Method for producing various textures of materials
2	Hollowed out	Make the surface texture of the material form a contrast between virtual and real changes
3	Floating embroidery	Make the material surface have four convex texture similar to relief
4	Tie knot	Make a convex circle appear on the flat surface of the material
5	Patchwork	Make the front and back of the material have various textures and different luster
6	Dilapidated	Make the material show a sense of obsolescence
7	Weave	Splicing untreated materials

often uses the same color system in color printing and dyeing; for example, simply use bright colors or uniformly use dark colors. So the appearance of the clothing is still roughly coordinated.

The composition of different materials, specifically the combination of delicate and coarse materials, transparency, and opacity, highlights the characteristics of the work [16]. Using the texture changes of various materials is also an important way to enrich the overall texture of clothing.

3.1.3. Innovation of Clothing Materials. Clothing materials have a history of development, as shown in Figure 2. It has developed from the ancient times when civilization had just become civilized and from a diversified clothing market that is mainly made of animal fur materials. Even though it has produced a huge change, people's basic requirements for clothing have not changed. Keeping warm from the cold is still the most important issue people consider when choosing clothing. Therefore, we must focus on the second, on the basis of ensuring that the clothing conforms to the trend of the market, constantly integrate high-tech, and develop products that are more convenient and can maximize cold resistance and warmth.

Today is an era of highly developed science and technology, an era of extremely developed information, an era of economic integration, and an era of rapid knowledge update. These factors will inevitably prompt people to produce new clothing requirements. The rapid development of clothing not only highlights the characteristics of the masses but also shows individuality, creating clothing works that conform to the characteristics of the times, which is also the goal that designers have been pursuing [17].

Continuous transformation at the level of style has obviously failed to meet the market's demand for clothing development, so another way needs to be found. The development of new products in clothing materials and the mutual cooperation and integration of technology, culture, and art are the primary tasks for the transformation and upgrading of the clothing market. Through the innovation of clothing materials, personalized clothing design has been demonstrated, and clothing materials have also undergone artistic changes. Whoever gets the innovative materials for clothing will occupy the market.

In the overall structure of clothing design, in addition to elements such as style and color, materials are also one of the most important elements. The material of a piece of clothing can define the temperament and style of the whole clothing. The performance and texture of the material also have a certain impact on the appearance of the clothing. Based on this, clothing designers should start from the perspective of clothing material performance. To a certain extent, the realization of design ideals is determined by the ability to understand and manipulate materials, which is also an important skill for designers to master.

3.2. Theoretical Basis of Graphene Oxide Nanosheets. Before understanding the concept of graphene oxide, it is necessary to first understand the graphene material. Graphene has excellent optical, electrical, and mechanical properties, has important application prospects in materials science, micronano processing, energy, biomedicine, and drug delivery, and is considered to be a revolutionary material in the future. Graphene is a lattice material formed by the combination of multiple hybrid carbon atoms. It is one of the basic components of other dimensional materials, and it is also being studied. It is one of the materials with excellent heat generation and electrical conductivity discovered in the field, and its volume is also very small [18, 19].

Graphene oxide, as its name suggests, is a single layer of graphite oxide [20]. Graphite oxide is similar to graphite and still maintains a layered structure, but many oxygen-containing functional groups are introduced into its lamellae, and the monolayer structure obtained by different forms of exfoliation operations (solvent peel, thermal peel, or mechanical peel), as shown in Figure 3, is called graphene oxide. Graphite oxide is generally obtained by oxidation reaction of strongly oxidizing substances and graphite under the condition of a strong acid solvent.

3.2.1. Graphene Oxide Nanosheet Structure. The graphene oxide structure is basically the same as the graphene structure, both of which are two-dimensional planar structures. The difference is that the surface of the plane introduces abundant oxygen-containing groups such as -OH, -O-, C=O, and -COOH groups are introduced to the edge. As shown in Figure 4, through AFM characterization, the thickness of graphene oxide is about 1 nm, which is larger than the graphite interlayer spacing of 0.339 nm [21]. The increase in thickness is mainly due to the insertion of oxygen-containing functional groups (such as epoxy, hydroxyl, carbonyl, and carboxyl) and the adsorption of water molecules.

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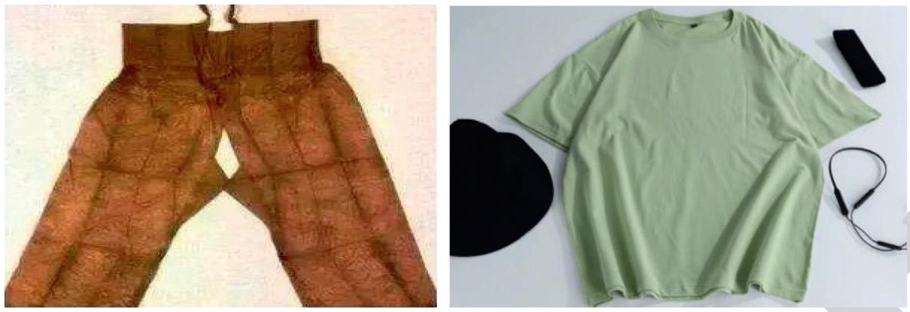

Figure 2: Development and change of clothing materials.

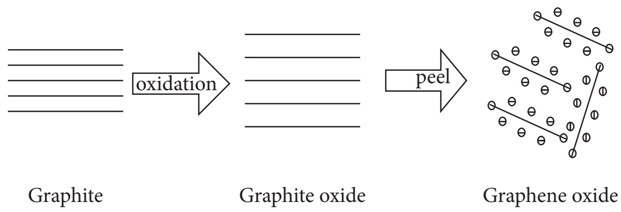

Figure 3: Legend of stripping operation.

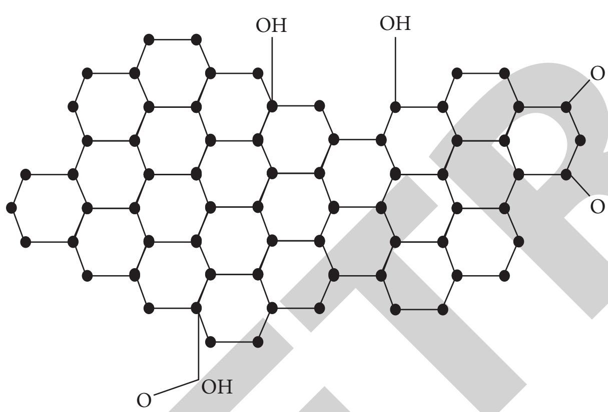

Figure 4: Graphene oxide structure.

3.2.2. Properties of Graphene Oxide Nanosheets

(1) Heat-Generating Properties. From a macroscopic point of view, if the temperature of the two solid materials is different, the heat will spontaneously transfer from the high-temperature direction to the low-temperature direction. This phenomenon is called heat conduction [22, 23]. Thermal conductivity (λ) is a physical index that characterizes the ease of heat conduction of a material, which is expressed by the following formula [24]:

$$\lambda = \frac{1}{3}CvL. \tag{1}$$

In equation (1), C is the heat capacity per unit volume, v is the propagation velocity of the phonon, and L is the mean free path of the phonon, that is, the distance the phonon travels from the initial scattering to when it receives the second scattering.

For graphite materials, the thermal conductivity at room temperature mainly depends on the size of the mean free path of phonons, which is related to the collision and scattering of phonons and the plane size of the graphite mesh L_α. The bigger L_α, the bigger L, and the bigger λ.

In the graphite polycrystalline structure, the smaller the grain size, the worse the performance of the material. Because the small size of the grain increases the number of grain boundaries in the structure, it produces more defects, which cause phonons to be scattered, resulting in a smaller mean free path. Then in the preparation of graphite materials, in order to prevent the decrease of thermal conductivity, the generation of defects should be appropriately reduced. This also means that the better the thermal conductivity of a graphite material, the closer the crystal structure of the material to an ideal state. The meaning of the thermal diffusivity α is the degree of heat diffusion in the material structure, that is, the ability to coordinate the internal temperature of the material, which is expressed by the following formula [25]:

$$\alpha = \frac{\lambda}{\rho C}. \tag{2}$$

The parameter definitions in equation (2) are shown in Table 3.

To sum up, the thermal diffusivity is related to the density of the object, the speed of phonon propagation, and the mean free path of phonons. The thermal diffusivity can be expressed by the following formula:

$$\alpha = \frac{vL}{3\rho}. \tag{3}$$

The parameter explanations in equation (3) are shown in Table 4.

In equation (3), we can know that when the density of graphene oxide nanosheets remains unchanged, the propagation speed of phonons and the mean free path can affect the thermal diffusivity value of the material to a certain extent. And for the graphene oxide nanosheets at room temperature, the thermal conductivity is obviously changed by the change of the phonon mean free path. Therefore, we can conclude that the thermal diffusivity is also affected by the change of the phonon-free path. Therefore, in the graphite polycrystalline structure, the small size of the grains will increase the number of grain boundaries in the

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Table 3: Parameter definition in the formula.

Sequence	Parameter	Interpretation	Unit
1	α	Thermal diffusion coefficient	m^2/s
2	λ	Thermal conductivity	$W/(m \cdot K)$
3	ρ	Density	kg/m^3
4	C	Specific heat capacity	$J/(kg \cdot K)$

Table 4: Parameter definition in the formula.

Sequence	Parameter	Interpretation	Unit
1	α	Thermal diffusion coefficient	m^2/s
2	ρ	Density	kg/m^3
3	v	Phonon propagation velocity	—
4	L	Mean free path of phonon	—

structure, and more defects will be generated. The thermal conductivity will also decrease.

(2) Adsorption Properties. Due to the large conjugated structure contained in graphene oxide, it also has a high adsorption capacity. After the introduction of different functional groups (such as $-OH$, $-SH$, $-NH_2$) through surface modification, on the one hand, the hydrophilic and hydrophobic properties of graphene surface can be improved, and on the other hand, the number of adsorption sites and adsorption affinity of graphene can also be changed.

According to the equilibrium adsorption formula [26],

$$Q_e = \frac{(C_0 - C_e) \times v}{m}. \quad (4)$$

Among them, C_0 and C_e are the initial concentration of the compound and the concentration after adsorption equilibrium, respectively, mg/L. v is the volume of the compound in the adsorption experiment mL. m is the addition amount of the adsorbent mg. The adsorption coefficient $(K_d, \mathrm{L/kg})$ of a compound is the ratio of the adsorption amount to the compound concentration in the solution when the adsorption is in equilibrium. The formula for calculating the adsorption coefficient is as follows [27, 28]:

$$K_d = \frac{Q_e}{C_e}. \quad (5)$$

A pseudo-first-order kinetic model and a pseudo-second-order kinetic model were introduced to analyze the adsorption kinetic curves of naphthalene molecules on graphene and graphene oxide. The formula of the pseudo-first-order kinetics is as follows [29]:

$$\ln(Q_e - Q_t) = \ln Q_e - k_1 t. \quad (6)$$

Among them, Q_e and Q_t are the adsorption amount of the sample mg/g at adsorption equilibrium and time t, respectively; t is the adsorption time h; k_1 is the adsorption rate constant $1/h$. The formula of the pseudo-second-order kinetics is as follows [30]:

$$\frac{t}{Q_t} = \frac{1}{k_2 Q_{e^2}} + \frac{t}{Q_e}, \quad (7)$$

where k_2 is the adsorption rate constant, and $g \cdot mg^{-1} \cdot h^{-1}$.

The adsorption isotherm and DA model were introduced to analyze the adsorption isotherm curves of objects on graphene and graphene oxide. The formula for the model is as follows:

$$Q_e = K_f C_{e^n}, \quad (8)$$

where Q_e is the adsorption amount on the solid surface at the adsorption equilibrium mg/g; C_e is the concentration of the compound in the solution at the adsorption equilibrium mg/L; K_f and n are the model parameters. The formula for another model is as follows [31, 32]:

$$Q_e = \frac{Q_m C_e}{(K_L + C_e)}, \quad (9)$$

where Q_m is the maximum adsorption capacity when the adsorption reaches saturation, and K_L is the model parameter. The formula of the DA model is as follows:

$$\log Q_e = \log Q_m + \left(\frac{\varepsilon_{sw}}{E}\right)^b. \quad (10)$$

In the following equation,

$$\varepsilon_{sw} = -\mathrm{RT} \ln\left(\frac{C_e}{C_s}\right), \quad (11)$$

where ε_{sw} is the adsorption potential kJ/mol and R is the ideal gas constant, which is $0.008314\,\mathrm{kJ/(mol \cdot K)}$. T is the temperature of the solute, and K, C_s is the solubility of the compound mg/L in water. E and b are DA model parameters.

(3) Optical Properties. It studies its optical properties from the reflection coefficient and transmission coefficient of graphene oxide. It assumes that a beam of light is incident on the nanosheet layer from the air, as shown in Figure 5. Light will be reflected and transmitted at the interface, the propagation of light in the material will be attenuated, and the phase will also change. Light may produce multiple reflections and transmission superpositions in the incident and transmitted directions, resulting in interference effects. Using this interference effect, the refractive index and thickness of graphene oxide can also be obtained.

The incident wave is first reflected at interface 1, and the rest of the wave will enter the film layer and then reflect at interfaces 1 and 2 successively. Each time a part of the wave passes through the corresponding interface, and the summation of each part is used to obtain the combined amplitude of the reflected wave and the transmitted wave. It can be obtained from Figure 5 that the combined amplitude reflection coefficient is as follows:

$$r = \frac{r_1 + r_2 e^{-2i\delta}}{1 + r_1 r_2 e^{-2i\delta}}. \quad (12)$$

In the following equation,

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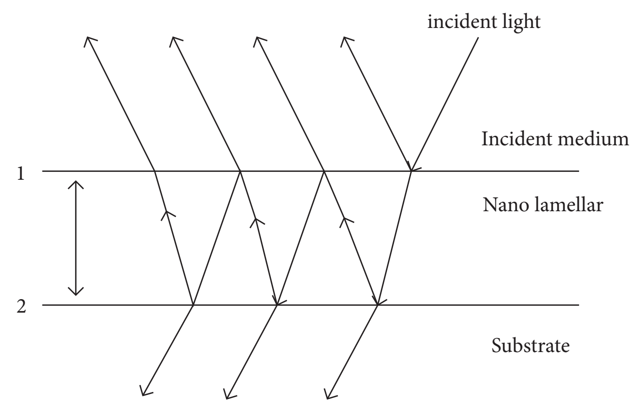

Figure 5: Transmission and reflection of graphene oxide.

$$r_1 = r_1^+,$$
$$r_2 = r_2^+, \tag{13}$$
$$\delta = \frac{2\pi \bar{n} d}{\lambda}.$$

Likewise, the reflection coefficient of the resultant amplitude is as follows:

$$t = \frac{t_1 t_2 e^{-i\delta}}{1 + r_1 r_2 e^{-2i\delta}}. \tag{14}$$

In the following equation,

$$t_1 = t_1^+,$$
$$t_2 = t_2^+. \tag{15}$$

In this way, the reflection coefficient and transmission coefficient of the nanosheet are obtained; that is to say, the nanosheet can be regarded as an interface, and the reflection coefficient and transmission coefficient of its amplitude are given above. The reflectivity of the nanosheets is as follows:

$$R = r \cdot r^*. \tag{16}$$

The transmittance of nanosheets is as follows:

$$T = \frac{n_s}{n_0} t \cdot t^*. \tag{17}$$

It assumes that the base medium has no absorption, substitutes the reflection coefficient and transmission coefficients t_1, t_2, r_1 and r_1 into the formula, and then arranges the reflectivity of the nanosheet layer using equation (16):

$$R = \frac{a_1 e^{\mu} + a_2 e^{-\mu} + a_3 \cos \nu + a_4 \sin \nu}{b_1 e^{\mu} + b_2 e^{-\mu} + b_3 \cos \nu + b_4 \sin \nu}. \tag{18}$$

In

$$\mu = \frac{4\pi k d}{\lambda},$$
$$\nu = \frac{4\pi n d}{\lambda}. \tag{19}$$

λ is the wavelength in vacuum. The transmission coefficient of the nanosheet layer can also be obtained as follows:

$$T = \frac{16 n_0 n_s \left(n^2 + k^2\right)}{b_1 e^{\mu} + b_2 e^{-\mu} + b_3 \cos \nu + b_4 \sin \nu}. \tag{20}$$

The relationship between the square of the absorption coefficient and the photon energy calculated from the transmission coefficient of the graphene oxide nanosheet is shown in Figure 6.

4. Fashion Design Practice

In this article, = the research on the heat generation characteristics of graphene oxide nanosheets is applied to modern clothing design to investigate its heat generation and heat dissipation. When a garment has a special function, it is also a very important issue whether the original style and mechanical properties of the fabric are maintained at the same time. Therefore, in accordance with modern clothing standards, this article also tested the style of the design samples (popular style and texture harmony) and mechanical properties (drape, burst strength). It was compared with the traditionally designed clothing to verify the feasibility of applying the heat-generating properties of graphene oxide nanosheets to clothing design.

(1) Heat Generation and Heat Dissipation. Under different temperature differences, people have different functional requirements for clothing. In the relatively cold autumn and winter, the clothing needs to have the function of keeping out the cold and keeping warm. In the relatively hot spring and summer, the clothing also needs good ventilation and heat dissipation. Based on this, this article takes the normal human body temperature of 36.5°C as the standard and tests the thermal conductivity and heat dissipation of graphene oxide nanosheet clothing and traditionally designed clothing at different temperatures (9°C and 38°C) under different action times (1 h to3.5 h). The test results are shown in Figures 7 and 8:

It can be seen from Figure 7 that the initial temperature of the garment designed with graphene oxide material is 25.1°C when the room temperature is 9°C, and the final temperature of the garment is maintained at about 37.8°C after 3.5 hours of action. The initial temperature of the clothing under the traditional design material at the same room temperature is 9.3°C, and after 3.5 hours of action, the final temperature of the clothing is maintained at about 13.9°C.

It can be seen from Figure 8 that the initial temperature of the garment designed with graphene oxide material is 34.8°C when the room temperature is 38°C, and the final temperature of the garment is about 27.1°C after 3.5 h of action time. The initial temperature of the clothing under the traditional design material at the same room temperature is 37.1°C, and after 3.5 hours of action time, the final temperature of the clothing is maintained at about 35.0°C, and the change is small.

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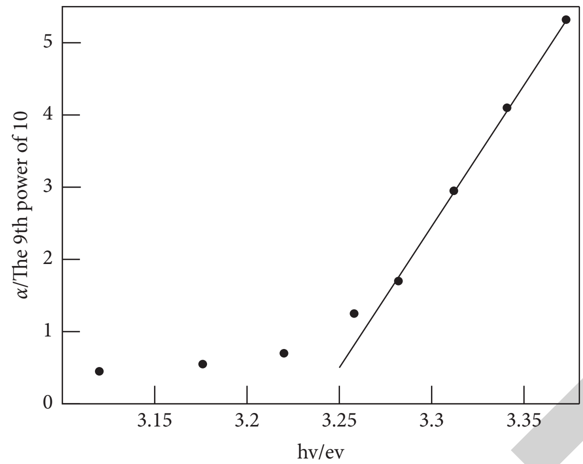

Figure 6: Optical band gap of graphene oxide.

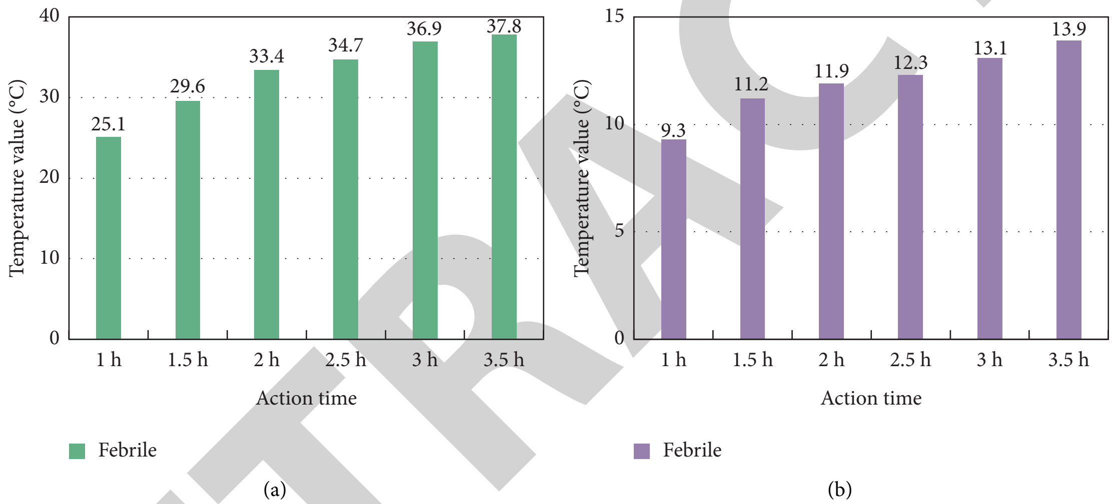

Figure 7: Study on clothing heating. (a) is the thermal conductivity temperature of clothing under graphene oxide material. (b) shows the thermal conductivity temperature of clothing under traditional design materials.

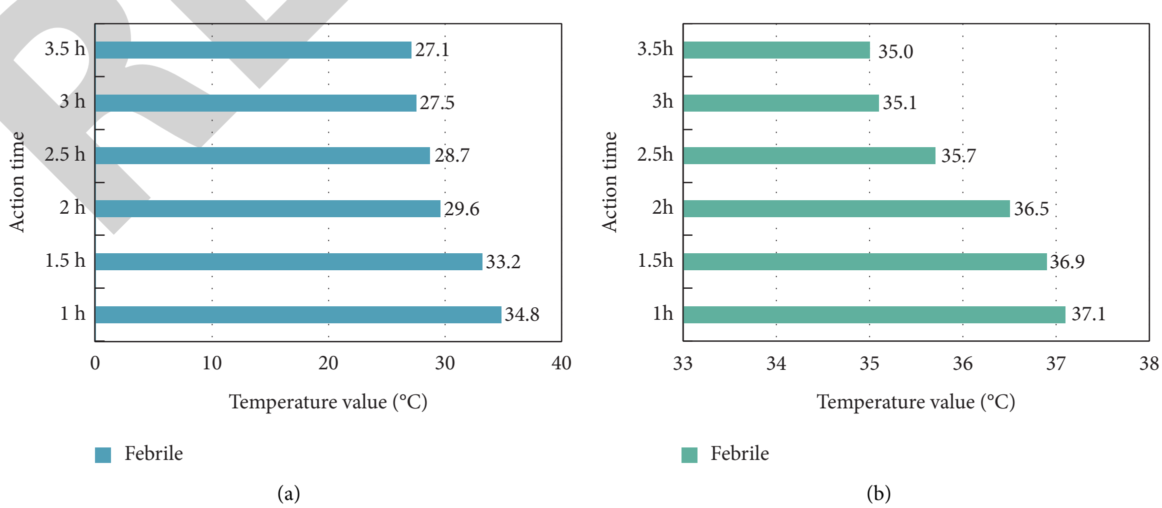

Figure 8: Clothing heat dissipation temperature under different materials. (a) shows the heat dissipation temperature of the garment under the graphene oxide material. (b) shows the heat dissipation temperature of clothing under traditional design materials.

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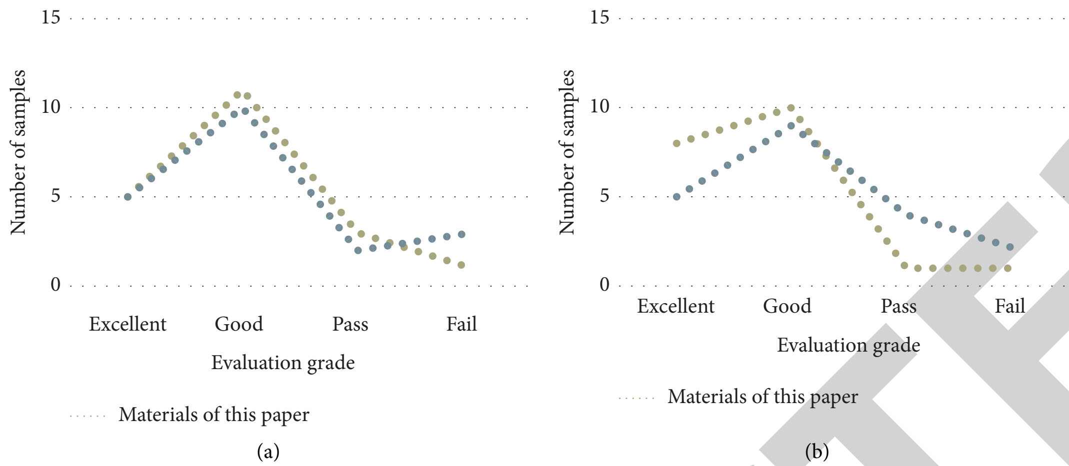

Figure 9: Fashion and texture harmony test. (a) shows the style popularity test of two design materials. (b) shows the texture harmony test of the two design materials.

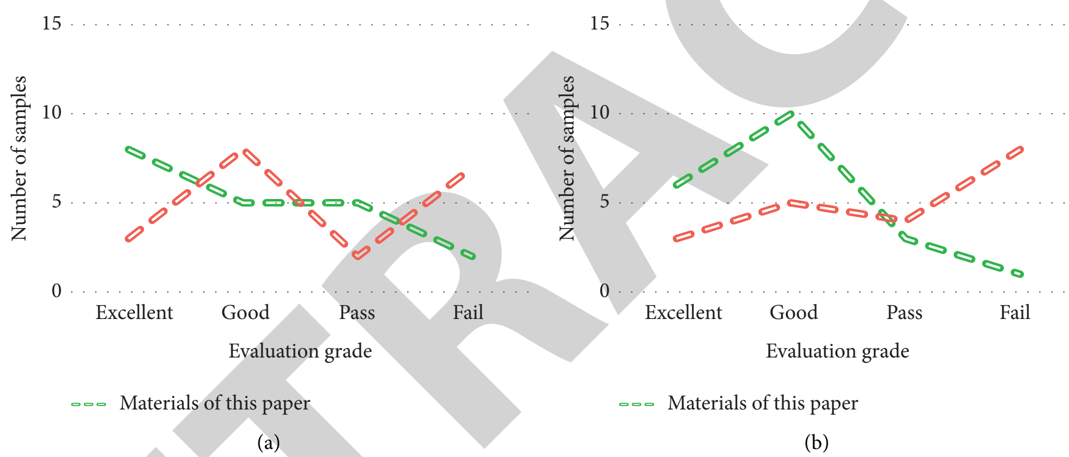

Figure 10: Suspension and bursting strength test. (a) shows the drape test of two design materials. (b) shows the burst strength test of the two design materials.

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(2) Test of Style and Mechanical Properties. In the style and mechanical performance tests, 20 samples of graphene oxide nanosheet clothing and traditionally designed clothing were randomly selected as the test objects to test whether they met modern clothing standards. The test results are shown in Figures 9 and 10.

It can be seen from Figure 9 that there are 5 pieces of clothing styles under the design of graphene oxide material with excellent grades of popularity, 11 pieces of good grades, 3 pieces of qualified grades, 1 piece of unqualified grades, and 8 pieces of an excellent level of texture harmony. There are 10 items in the grade, 1 item in the qualified grade, and 1 item in the unqualified grade. There are 5 items in the popular and excellent grades of the clothing styles under the traditional material design, 10 items in the good grade, 2 items in the qualified grade, and 3 items in the unqualified grade. There are 5 excellent grades of texture harmony, 9 good grades, 4 qualified grades, and 2 unqualified grades.

As can be seen from Figure 10, there are 8 pieces of excellent drape sense of clothing under the design of graphene oxide material, 5 pieces of good level, 5 pieces of qualified level, 2 pieces of unqualified level, and 6 pieces of excellent burst strength. There are 10 good grades, 3 qualified grades, and 1 unqualified grade; under the traditional material design, there are 3 excellent grades of clothing drape, 8 good grades, 2 qualified grades, 7 unqualified grades, 3 burst strength grades, 5 good grades, and qualified grades. There are 4 pieces in total, and there are 8 pieces of unqualified grades.

5. Discussion

Through the comparative experimental data of graphene oxide material clothing and traditional material clothing, the following conclusions can be drawn:

(1) In terms of thermal conductivity and heat dissipation of clothing, the difference between the final temperature and the initial temperature of graphene oxide clothing is 12.7°C at a room temperature of

9°C. The thermal conductivity effect is ideal, while the temperature difference of traditional material clothing is only 4.6°C, and the initial temperature and final temperature are not as high as that of graphene oxide material clothing, indicating that the thermal insulation effect of graphene oxide material clothing is also excellent.

(2) At the level of modern clothing standards, the overall proportion of graphene oxide material clothing with good and above grades is 85%, and the overall proportion of mechanical properties in good and above grades is 72.5%; the overall proportion of traditional material clothing styles in the good and above grades is only 72.5%, and the overall proportion of mechanical properties in the good and above grades is only 41.5%

The whole comparative experimental data show that under the condition of keeping other experimental conditions the same, the test results of graphene oxide material clothing are ideal in terms of thermal conductivity and heat dissipation of clothing, as well as in terms of style and mechanical properties of clothing. This shows that the clothing materials using the heating properties of graphene oxide nanosheets can be of a more full application value than that of modern clothing standards.

6. Conclusion

The rapid economic level not only gives the clothing market more space for development but also puts forward higher development requirements. Solving the problem of the weak seasonality of clothing is the primary task of the transformation and upgrading of today's clothing market. The graphene oxide nanosheets have good heating properties and can quickly adapt to temperature differences in different seasons. Moreover, it conducts heat conduction and heat dissipation according to the needs of the human body and has great application value. It is believed that with the progress of the times and the continuous improvement of technology, the application of the heating properties of graphene oxide nanosheets in clothing design will be more mature.

Although this article has carried out in-depth research on the design of clothing by using the heating properties of graphene oxide nanosheets, there are still many deficiencies. The performance test of clothing based on graphene oxide nanosheet design was carried out under ideal conditions and did not take into account the actual interference factors, which needs further improvement. The research is still in the preliminary stage. In the future work, we will study suitable research methods and means from more perspectives based on the existing technology and level and continuously improve the quality of the research work.

Data Availability

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

Conflicts of Interest

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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