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Innovative Applications of Photochromic Textiles in China Chic Fashion Design

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----------ABSTRACT----------
With the comprehensive revival of Chinese culture, China Chic has been widely recognized as a unique cultural phenomenon in the field of fashion design. However, existing research has mainly focused on aspects such as cultural communication, marketing, and fashion trends, with limited studies on the application of textile technology in China Chic fashion, particularly regarding photochromic materials. Photochromic textiles, due to their ability to respond to changes in light conditions, have shown great potential in the field of smart textiles. This study reviews relevant domestic and international literature, analyzes the characteristics of photochromic materials and their application value in China Chic fashion design, and explores their impact on design concepts, aesthetic expression, and consumer experience. The findings indicate that photochromic textiles not only enhance the visual appeal of China Chic fashion but also contribute to the development of smart fashion. This research aims to provide theoretical support and practical references for the integration of textile technology into China Chic fashion design.
Keywords: *Photochromic textiles; China Chic; Fashion design; Smart textiles*

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I. Introduction

Photochromic textiles were defined as materials with special functionalities that were capable of having their colors changed under ultraviolet irradiation, and after the light had been withdrawn, their original hues were restored. Photochromic materials were mainly divided into organic photochromic materials and inorganic photochromic materials [1]. At that time, most research was concentrated on organic photochromic materials, primarily because their performance was considered to be relatively stable and their application prospects were deemed promising.

In recent years, “China Chic” was reported to have swept through China’s fashion industry. “China Chic” was characterized as a unique style that was formed by combining tradition with modern trends and possessing an Eastern aesthetic. At the same time that “China Chic” was said to have swept the apparel industry, photochromic textiles, as novel functional fabrics, were employed to provide significant support for the design and production of “China Chic” garments. This study was conducted to provide a brief summary of the principles, characteristics, and applications of photochromic textiles in “China Chic” apparel, so that a reference might be provided for the further development of photochromic textiles in “China Chic” fashion.

II. Overview of Photochromic Textiles

Photochromic materials were defined based on the intrinsic molecular structural characteristics of these special materials; under the excitation of ultraviolet light or other specific wavelengths, their molecular structures were induced to change, causing the materials to change color. When the light was withdrawn or the stimulus ceased, the molecular structures were restored to their original configurations, and the materials were caused to revert to their original colors in a reversible manner. Furthermore, the degree and speed of the color change could be adjusted by controlling the intensity of the light and the duration of irradiation, as illustrated in Figure 1.

Photochromic materials were mainly divided into organic photochromic materials and inorganic photochromic materials. Organic photochromic materials, due to their performance advantages, had received greater attention; as shown in Table 1 [3], the characteristics and differences between organic and inorganic photochromic materials were compared.

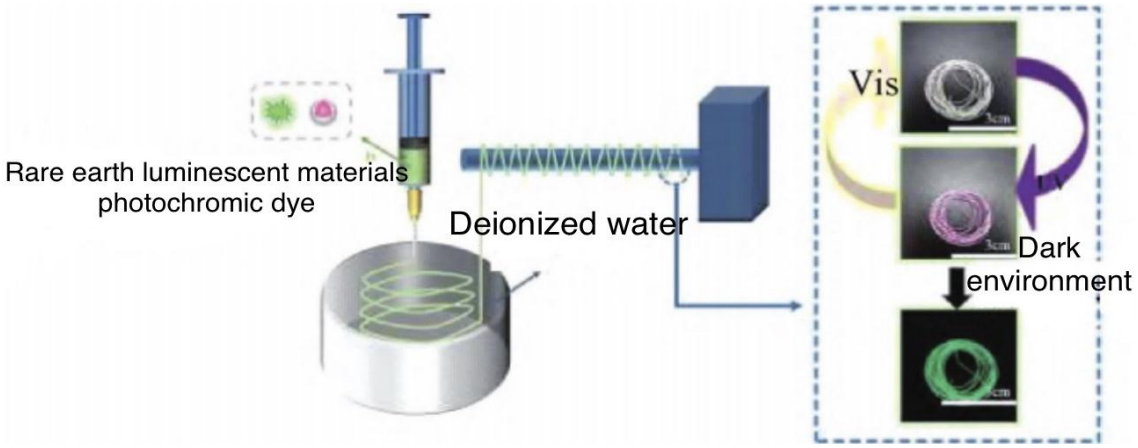

Fig.1. Schematic diagram of the preparation and reversible photochromic phenomenon of photochromic fibers [2]

Table 1. Types of Photochromic Fibers [3]

Material Type	Organic Photochromic Materials	Inorganic Photochromic Materials
Chromic Principle	Formation of molecular structural isomers; group migration; redox reactions; chemical bond cleavage; valence state changes	Electron transfer between lattices caused by impurities or crystal defects; redox reactions
Representative Materials	Spiropyrans, spirooxazines, fulgides, diarylethenes, azobenzenes, naphthopyrans, and related heterocyclic complexes	Transition metal oxides, metal halides, rare-earth complexes
Advantages	Easy synthesis, numerous derivatives, wide photo-response range, high sensitivity	Long service life, good thermal stability, high-temperature resistance, fatigue resistance, insensitive to the environment
Disadvantages	Poor stability, high environmental sensitivity, easily oxidized, poor fatigue resistance, difficult to clean	Larger particle size, slower coloration, lower photosensitivity, unclear absorption of light

At that time, new research achievements in photochromic materials were continuously produced. Shen et al. [2] successfully developed an innovative photochromic luminescent fiber. This fiber was fabricated by employing rare earth luminescent phosphors as the light source, while a photochromic yellow microcapsule (PYM) was utilized as the reversible photochromic material. Under the excitation of ultraviolet light, this fiber was found to exhibit significant persistent luminescence and photochromic properties. Furthermore, after more than 20 cycles of reversible color change tests, cotton fabrics made from this fiber were observed to maintain excellent repeatable photochromic performance. Li Pan et al. [4] achieved new progress in the field of wearable, multicolored interactive photochromic fibers. A research team employed a mass-producible, multi-material fiber preform thermal drawing method to realize a highly flexible, uniformly luminescent photochromic fiber that could be modulated across a wide color gamut. With the advancement of technology, more photochromic materials with increasingly superior performance were expected to emerge. The application of photochromic textiles in China Chic apparel was found to enhance the interest and innovation of China Chic garments through the influence of light, temperature, and other external factors.

2Performance Testing of Photochromic Textiles

Superior overall performance is an essential criterion for evaluating textile materials. Conducting color-changing performance tests and color fastness tests on newer photochromic textiles helps practically assess their application value and development potential in China Chic fashion.

2.1UV Sunlight Color-Changing Performance Test

Most materials with photochromic capabilities exhibit different color responses when exposed to ultraviolet (UV) light. For instance, Wu et al. [5] utilized screen printing technology to develop intelligent photochromic fabrics with rapid color-changing capabilities and high fatigue resistance, using their self-prepared photochromic microcapsules. These fabrics demonstrated excellent photo-responsive properties, reaching maximum color intensity after 12 seconds of UV exposure and retaining clear pattern color changes even after 20 cycles of color switching.

A series of experiments were conducted to test responses to UV stimulation. As illustrated in Fig. 2(a), after irradiation, the photochromic polyester fabric exhibited a clear absorption peak within the visible region, with absorbance stabilizing between 10 and 14 seconds and reaching saturation at 12 seconds. Fig. 2(b and c) depict the color changes of the fabrics from perspectives of absorbance and visual color variations, respectively.

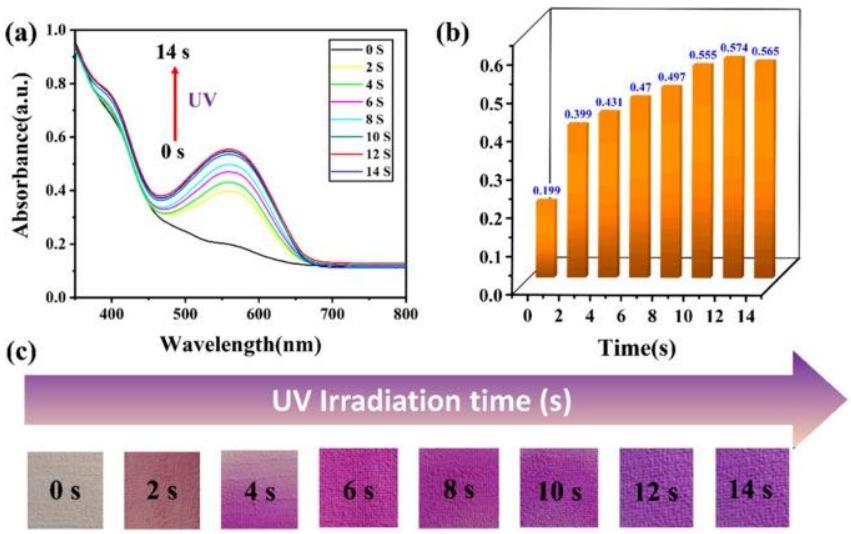

Fig. 2. (a and b) Effect of UV irradiation time on the absorbance of photochromic polyester fabric; (c) Color change of fabrics at different UV radiation times [5]

Additionally, Jing Li et al. [6] employed a screen printing method to prepare intelligent fabrics with dual responses to temperature and light. They mixed temperature-responsive polymers, rare-earth photosensitive materials, adhesives, and thickeners in specific proportions to formulate the printing paste. To evaluate the color-changing performance, three samples composed of different proportions of rare-earth photo-sensitive microcapsules and temperature-sensitive materials were tested. A heater was placed under a standard D65 light source, and the photochromic fabric was heated from 31°C to 40°C. The color changes during heating were photographed using an iPhone 11 Pro, and RGB color values were measured using Photoshop's eyedropper tool. The results are presented in Table 2 andTable 3.

Table 2. Display of temperature-sensitive/light-sensitive dual-response smart fabric with temperature changes [6]

process parameters of sample	temperature-sensitive discoloration performance of sample			
	below 23℃	Between 23-30℃	Between 31-40℃	Above 40℃
	Orange	Orange	Yellow	Yellow
1#Orange temperature-responsive polymers:rare earth photosensitive paste:adhesive:thickening agent: water=10%;12%:25%:43%:10%)				
	Blue	Blue	Green	Green
2#(Blue temperature-responsive polymers: rare earth photosensitive paste:adhesive:thickening agent:water=10%:12%:25%:43%:10%)				

3#(Orange temperature-responsive polymers:blue temperature-Responsive polymers:rare earth paste:adhesive:thickening agent: water =5%:5%:12%:25%: 43%:10%)	Brown	Brown	Pale yellow	Brown
				
	White	White	White	White
4#(Rare earth photosensitive paste: adhesive:thickening agent:water= 22%:25%:43%:10%)				

Table 3. Color parameter changes during the heating process of temperature-sensitive/light-sensitive dual-response smart fabric [6]

Temperature℃-¹	1#			2#			3#			4#		
	R	G	B	R	G	B	R	G	B	R	G	B
Below23℃	187	100	72	62	90	126	118	108	106	169	166	157
Between23-30℃	187	100	72	62	90	126	118	108	106	169	166	157
Between31-40℃	184	182	99	96	131	98	181	200	181	169	166	157
Above40℃	218	221	90	98	187	126	160	190	190	169	166	157

2.2 Color Fastness Test Evaluation of Photochromic Textiles

Currently developed photochromic textiles exhibit generally good color fastness, benefiting from mature color fixation technologies. For example, Deng Xiaozhen [7] used pigment printing to create color-changing printed fabrics, which were fixed through baking. These fabrics were then cut into small samples (4×10 cm) and tested for rubbing color fastness and washing color fastness according to Chinese national standards GB/T 3920-2008 and GB/T 3921-2008. Results indicated a dry rubbing fastness rating of level 4, wet rubbing fastness of level 3-4, washing fade fastness of level 4-5, and washing stain fastness of level 4-5. Different fabric materials exhibited consistent color-changing performance and fastness.

Experiments demonstrated that photochromic printed textiles possess excellent color fastness, making them suitable for fashion accessories. The results, based on national standards GB/T 3920-2008 and GB/T 3921-2008, showed dry rubbing fastness at level 4, wet rubbing fastness at level 3-4, washing fade fastness at level 4-5, and washing stain fastness at level 4-5, as illustrated inTable 4.

These results indicate that various new photochromic textiles developed currently show excellent sensitivity to UV light, superior color-changing performance, and color fastness, highlighting significant potential and application value within the fashion accessories and apparel industry.

Table 4. Color Fastness Test Results [7]

Test Sample	Color Before Change (Flesh Pink) 	Color After Change (Apricot Yellow) 

	Color Before Change (Light Yellow)	Color After Change (Algae Green)
	PANTONE 11-0622TPG	PANTONE 14-5707TPG
Color Change Level	Grade 4–5	Grade 4–5
Staining Level	Grade 4–5	Grade 4–5
Dry Rubbing Staining Level	Grade 4	Grade 4
Wet Rubbing Staining Level	Grade 3–4	Grade 3–4

III. Application of Photochromic Textiles in "China Chic" Fashion

With the rise of "China Chic," the fusion of traditional culture and contemporary trends has become a notable highlight in the fashion industry. Under this trend, the use of photochromic textiles has revitalized "China Chic" clothing, perfectly merging innovation with fashion.

3.1Interaction Between Photochromic Textile Colors and "China Chic" Patterns

Photochromic textiles change color upon exposure to ultraviolet (UV) radiation, causing localized color changes within fabric patterns that alter the overall visual appearance subtly yet dynamically. The key characteristic of photochromic textiles is their capability for static-to-dynamic color transitions, thereby creating novel patterns and visual effects. When designing color-changing prints, this property should be fully exploited, with comprehensive consideration of the interplay between pattern design and color combinations. Color design plays a particularly crucial role in the creation process, as photochromic textiles respond dynamically to light environments, enhancing visual appeal.

In the ANREALAGE Fall/Winter 2023 fashion show, Kunihiko Morinaga utilized photochromic materials to present an extraordinary fusion of technology and fashion. By combining photochromic materials with faux fur, velvet, and lace, garments displayed vibrant patterns and colors under UV illumination (Fig. 3). Once UV exposure ceased, garments reverted to their original colors, enhancing their playful and visually engaging attributes.

Fig. 3. ANREALAGE Fall/Winter 2023 fashion show garments

Multiple design methodologies leverage the unique characteristics of photochromic materials, including overall color transitions, partial pattern color changes, and appearances of previously invisible patterns. For example, partial color changes within patterns significantly influence overall visual perception. The combination of yellow and green normally conveys warmth and harmony; however, when yellow transitions to purple under UV exposure, the green-purple pairing evokes cooler, adjacent color effects. Conversely, when yellow changes to red, the red-green combination creates an energetic contrast effect, as illustrated in Fig. 4. [8]

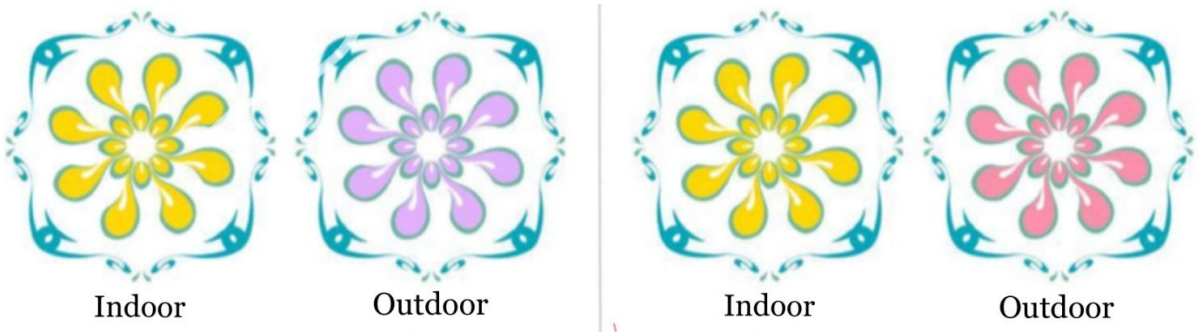

Fig. 4. Photochromic pattern design [8]

3.2Personalized Customization

Photochromic textiles provide abundant creative inspiration for designers of "China Chic" fashion. By integrating the unique properties of photochromic fibers with traditional cultural elements and contemporary design techniques, personalized designs in "China Chic" clothing can be developed. Techniques such as embroidery, printing, and weaving with photochromic fibers enable garments to display varying patterns and colors under sunlight.

Example:

Additionally, photochromic jacquard fabrics can incorporate traditional Chinese auspicious symbols, such as clouds and the "福" character, symbolizing prosperity and good fortune. Using a double-weft weaving technique, the "Huan Yun Fu Jin" fabric features a central artistic "福" character encircled by cloud motifs. The fabric specifications include a warp density of 540 threads per 10 cm, a weft density of 720 threads per 10 cm, and a thickness of 1.618 mm (sample E). Detailed specifications and weaving parameters are shown in Table 5, and the final visual results are depicted in Fig. 5. [9]

Table 5. Specifications and Weaving Parameters of "Huan Yun Fu Jin" Fabric Samples [9]

Item	Parameter
Warp Yarn (15.6 tex)	Polyester composite filament (white)
Weft Yarn A (16.7 tex × 2)	Polyester (red)
Weft Yarn B (27.8 tex)	PMMA side-emitting optical fiber
Warp Density (ends/10 cm)	540
Weft Density (picks/10 cm)	720
Pattern Repeat Size (cm)	11.00 × 9.21
Thickness (mm)	1.618 ± 0.209
Weaving Machine	SGA598 electronic jacquard loom
Loom Setup	Single set, single harness
Reed Drawing	Reed number: 136# (metric); Ends per dent: 4
Number of Jacquard Needles	2688
Finished Fabric Width (cm)	Inner width: 46 Outer width: 50

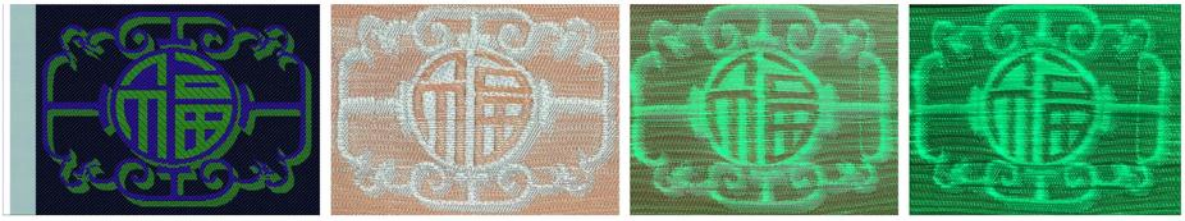

Fig. 5. "Huan Yun Fu Jin" fabric: (a) partial pattern design, (b) before illumination, (c) natural lighting effect, and (d) darkroom lighting effect [9]

3.3 Market Potential of Photochromic Textiles

The application of photochromic textiles in "China Chic" fashion meets consumer demands for style, individuality, and functionality. As market awareness increases, consumer recognition and acceptance of photochromic textiles are expected to rise, expanding their market share within the "China Chic" fashion sector.

Moreover, applying photochromic textiles in "China Chic" apparel encourages more cross-industry collaborations, including partnerships with technology firms and artistic institutions to create uniquely designed, culturally resonant photochromic clothing, further enhancing the value of "China Chic" brands.

Considering comprehensive experimental data and market feedback, intelligent fibers have significant potential in "China Chic" clothing. Rational and strategic use of intelligent fibers can substantially elevate both the functionality and fashionability of "China Chic" apparel. As production costs decrease and relevant technologies mature, intelligent fibers will see broader application.

IV. Impact of Photochromic Textiles on "China Chic" Fashion

With the continuous advancement of China's scientific research capabilities, the production processes and performance of photochromic textiles are expected to improve significantly. In the future, photochromic textiles will become lighter, softer, and exhibit faster and more stable color-changing capabilities, thus providing designers of "China Chic" fashion with expanded creative possibilities.

Furthermore, photochromic textiles enhance emotional interaction with consumers. When wearing photochromic clothing, consumers experience visual resonance as they witness clothing colors dynamically change in response to lighting conditions, consequently increasing their interest in purchasing "China Chic" apparel.

Moreover, incorporating photochromic textiles into "China Chic" fashion not only amplifies the visual impact of garments but also significantly enhances their functional characteristics. Advances in textile technology are notably promoting the evolution of "China Chic" apparel, where the widespread adoption of new materials, innovative processes, and intelligent manufacturing techniques contribute to blending traditional culture with technology. This integration has led to substantial progress in design aesthetics, functional performance, environmental sustainability, and market competitiveness. For instance, applying photochromic textiles to outdoor sportswear enables garments to darken automatically under intense sunlight, providing sun protection, and lighten under cloudy or indoor conditions, enhancing comfort and breathability. This intelligent color-changing capability greatly fulfills consumer preferences and needs.

Thus, the utilization of photochromic textiles in "China Chic" fashion provides new developmental directions for China's apparel industry. Under the guidance of innovation and style, photochromic textiles will help promote "China Chic" fashion internationally, thereby disseminating Chinese culture globally.。

V. Conclusion

Photochromic textiles exhibit numerous advantageous properties, including:

(1) Environmental friendliness: They eliminate the need for dyes, thereby reducing environmental pollution.

(2) Intelligence: Colors automatically adjust based on external lighting conditions, achieving intelligent color adaptation.

(3) Diversity: Varied and rich color effects can be realized by adjusting the types and concentrations of photosensitive substances.

(4) Durability: They possess excellent washing, light, and heat resistance, leading to prolonged service life.

The application of photochromic textiles in "China Chic" fashion has substantially driven innovation within China's apparel industry. With the gradual maturation of technology and continuous market expansion, the use of photochromic textiles in "China Chic" apparel will unlock immense potential. Apparel enterprises should seize this opportunity, intensify their research efforts, and promote extensive application of photochromic textiles, thus contributing to the flourishing development of the apparel industry.

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