

# Developing a Design Collection Using Photochromic Dyes

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**Abstract:** This project aims to revolutionize the fashion landscape by using photochromic dyes that represent an intriguing fusion of scientific innovation and creative design, offering a glimpse into the future of interactive and dynamic textiles. The journey of designing, developing, and exploring the commercial viability of these textiles is a multifaceted process that encompasses research, design, construction and market analysis. At the outset, extensive research is conducted into understanding of photochromic materials, compounds that undergo reversible color changes in response to light exposure. The goal is to create garments using photochromic dyes that retain their color-changing properties while maintaining the integrity and functionality of the fabric. In this project, a design collection along with the design boards such as inspiration board, mood board, colour board, etc. are made according to the theme. Finally, the garments are constructed, and a photoshoot is carried out. Further, a post-design survey is conducted to analyze the commercial viability of the photochromic garments. As technology continues to advance, the potential for further innovation and refinement in photochromic textiles remains boundless, promising a future where textiles are not just static objects but dynamic expressions of creativity and functionality.

**Keywords:** Photochromic dyes, Market research, Innovation, Creativity, Functionality, Viability.

## 1. Introduction

Step into a world where colors dance with the light, transforming ordinary lenses into magical portals of perception. In this the realm of photochromic dyes, where shades shift, and hues evolve in response to the sun's gentle touch, it is a journey through the science of change and the art of adaptation, where dyes become more than mere coloring agent – they become windows to a dynamic world of style and functionality. There is emergence of novel multidisciplinary collaborations at the intersection of science, technology, materials, and fashion, driving advancements in smart textiles research states [1], [2]. The utilization of chromic dyes holds promise for the development of numerous responsive and adaptive products. Chromic dyes, characterized by their ability to undergo color changes, emission, or erasure in response to external stimuli, offer significant potential. The term "chromic" denotes a reversible color change, with implications extending to the reversible alteration of other physical properties. These external stimuli include light (photochromic), heat (thermochromic),

electricity (electrochromic), pressure (piezochromic), liquid (solvatochromic), or electron beam (Carsolchromic). Chromic textiles, also referred to as chameleon textiles, are fabrics or fibers capable of changing color when influenced by external environmental stimuli [7].

Commercially accessible photochromic dyes exhibit a notable color shift, typically transitioning from colorless to colored, upon exposure to ultraviolet (UV) radiation [4]. Upon removal of the UV source, these dyes commonly revert to their original state through thermal means. Photochromism has garnered significant attention owing to its substantial commercial applications in ophthalmology, such as eyeglasses transforming into sunglasses upon sunlight exposure, as well as its potential utility in information recording materials, smart textiles, and various other domains. Positive photochromism refers to the phenomenon where a material undergoes a reversible change in color when exposed to light, typically ultraviolet (UV) radiation [10], [11]. In positive photochromic substances, exposure to light causes a molecular rearrangement that leads to the formation of colored species, resulting in a visible change in hue. Negative photochromism refers to the phenomenon where a material undergoes a reversible color change when exposed to light, typically ultraviolet (UV) radiation, resulting in a reduction or disappearance of color [6], [8]. In negative photochromic substances, exposure to light causes a molecular rearrangement that results in discoloration or bleaching of the material. This color change is temporary and can be reversed by removing or changing the light source.

Photochromic dyes are made from organic molecules that undergo reversible chemical reactions when exposed to light, causing them to change color. These molecules typically contain a conjugated system of double bonds or other light-sensitive functional groups. Common examples include spiropyrans, spirooxazines, fulgides, and diarylethenes. When exposed to ultraviolet (UV) or visible light, these molecules undergo a structural change that alters their absorption properties, resulting in a change in color. Photochromic materials find widespread application in textiles [3]. Common organic photochromic compounds include azobenzenes, spiropyrans, spirooxazines, viologens, fulgides, 1,4-dihydroxyanthraquinone, and diarylethenes. These compounds operate based on various photochromic mechanisms, such as

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molecular isomerization, ionization, and redox reactions. Among these, azobenzenes, spiropyrans, and viologens are particularly prevalent in textile applications.

The stability of photochromic prints is assessed concerning mechanical and chemical factors, such as rubbing and washing. Mechanical abrasion has a lesser impact on the color performance of photochromic prints compared to mechanical-chemical action, particularly during washing at elevated temperatures [9]. While washing affects the textile material, the photochromic activity of inkjet printing remains largely intact and minimally affects the textile's characteristics. Kinetic Energy Storage (KES) analysis indicates that ink jetting and curing of photochromic ink stiffen the textile handle, but this effect diminishes after ten washing cycles. Scanning Electron Microscope (SEM) analysis reveals that the ink layer does not significantly alter the textile's structure in terms of porosity and breathability. Despite a decline in color performance after washing, the photochromic print remains effective and has minimal impact on the textile structure. The reduced stiffness of the host matrix enhances color yield, accelerates dye kinetics, and improves resistance to abrasion and washing. Some samples exhibit increased color values after repeated washing cycles [5]. This phenomenon may be attributed to the loosening of the binder structure on the fabric post-washings, creating a more conducive environment for the photochromic dye's color change by eliminating the binder's film effect on the microcapsule surface and increasing microcapsule disaggregation.

The impact of the wavelength of sunlight on photochromic textiles is significant because the wavelength determines the energy of the light photons hitting the photochromic molecules within the textile [1]. The wavelength of sunlight directly influences the color-changing properties of photochromic textiles. Different wavelengths carry varying energy levels, triggering specific photochemical reactions in the embedded molecules. Shorter wavelengths, like UV-B or UV-C, often induce more vivid color changes but may lead to quicker degradation, while longer wavelengths like UV-A may offer a more stable but less intense response. In the case of most photochromic dyes, the absorption of light prompts a rearrangement of atomic bonds within a colorless or faintly colored molecule, a process known as photoisomerization. This transformation yields a structure that exhibits intense coloration. The specific wavelengths of light required for this reversible conversion vary depending on the dye but commonly fall within the UV range for commercial photochromic dyes. For instance, certain naphthopyrans demonstrate optimal responsiveness to UV-A radiation within the 350–380 nm wavelength range, whereas some spirooxazines can be readily activated by blue light around the 410 nm region. The pronounced photochromism induced by sunlight with dyes containing a substantial UV component is notable. Conversely, artificial light sources like tungsten filament bulbs, which emit minimal light at these wavelengths, prove less effective in activating photochromic dyes. Furthermore, it is found that cotton's UV-reflective properties result in a higher degree of photo-coloring compared to polyester [1]. The extent of photo-

coloring is influenced by factors such as dye concentration and the wavelength profile of the UV radiation. Thus, Designers must balance these factors to achieve desired color effects, durability, and user experience in diverse environmental settings.

Temperature can significantly affect the performance of photochromic textiles, as it influences the speed and reversibility of the photochemical reactions responsible for color change [1]. Higher temperatures generally accelerate these reactions, leading to faster color fading and potentially reducing the lifespan of the photochromic effect. Conversely, lower temperatures slow down the reactions, prolonging color change and enhancing durability. Therefore, designers must consider temperature fluctuations in the intended application environment to ensure optimal and consistent performance of photochromic textiles.

From the literature review provided, it's evident that photochromic dyes play a transformative role in the realm of dynamic fashion. By incorporating these dyes into fabrics, they endow textiles with the remarkable capability to undergo color changes when exposed to sunlight or UV radiation. This innovation revolutionizes traditional notions of fashion by introducing dynamic elements that respond dynamically to environmental stimuli, creating engaging and interactive clothing experiences for wearers. This innovation enables the creation of garments and accessories that adapt to environmental conditions, offering both functional and aesthetic benefits. Whether it's clothing that shifts hues with the intensity of sunlight for added UV protection or interactive designs that evolve with the wearer's outdoor activities, photochromic textiles provide a platform for endless creativity and practical applications in fashion and beyond. Thus, after having a detailed study about the definition, application and the properties of photochromic dyes, the project aims to develop a summer women's wears design collection using the colour-changing dyes and also to understand its commercial viability. This thus helps in developing an innovative and trendy design collection and understand the consumer's views, opinions and feedback on it.

Photochromic dyes have been applied in textiles by haute couture designers around the world, especially in runways and fashion shows, but however it has not been used much by the Indian designers, thus developing garment collection using photochromic dyes will be an innovative and effective move. Developing a design collection using photochromic dyes presents a unique opportunity for innovation, consumer awareness, and understanding commercial viability in several ways. Firstly, incorporating photochromic dyes into a design collection showcases a commitment to pushing the boundaries of traditional fashion by introducing dynamic and interactive elements. This innovation not only captures the attention of consumers but also stimulates curiosity and conversation around the intersection of technology and fashion.

Moreover, developing a design collection using photochromic dyes offers a compelling avenue for innovation in the fashion industry. Also, leveraging photochromic dyes in a design collection provides valuable insights into consumer

preferences and market demand, facilitating a deeper understanding of the technology's commercial viability. Through consumer feedback, sales performance analysis, and collaboration with industry partners, designers can gauge the appeal of photochromic fashion and identify opportunities for further innovation and refinement. This hands-on approach to market testing not only informs product development decisions but also helps designers strategically position their collections for success in the competitive fashion landscape, ultimately driving awareness, engagement, and growth within the photochromic fashion market.

## 2. Methodology

### A. Research about Photochromic Dyes

Photochromic dye is not a dye that is known to all. So, first information about the dye was collected from various sources like internet, articles etc. The history, evolution and properties of the dye was also studied. Moreover, the dye composition, the impact of wavelength or intensity of temperature, intensity of ultra-violet rays was also studied in detail.

### B. Theme Selection

To develop a design, theme selection is a pivotal step, as it sets the tone, direction, and overarching concept for the entire endeavor. A summer casual (category) design collection for women was selected. The design boards such as research board, mood board, inspiration board, colour board, story board, client research and client board were to be developed as per the theme.

### C. Development of Design Boards

Developing boards in a design project is crucial as they serve as visual roadmaps, guiding the creative process from conceptualization to realization. By compiling visual references and conceptual ideas onto boards, designers can effectively communicate their vision to stakeholders, collaborators, and team members, fostering alignment and understanding.

### D. Sourcing of Dye and Fabric

In the design process, sourcing photochromic dyes and fabrics involves a meticulous approach to ensure quality, functionality, and compatibility with the project's requirements. Firstly, sourcing photochromic dyes involved researching suppliers known for producing high-quality photochromic compounds that undergo reversible color changes upon exposure to light. Moreover, fabrics with a smooth surface and good light penetration are preferred to optimize the color-changing effect. Collaboration with reputable textile manufacturers or suppliers was an essential step to obtain fabrics that meet quality standards and align with the project's design objectives.

### E. Developing Design Collection

Developing a design collection is paramount in the design process as it serves as the creative culmination of conceptualization, research, and ideation. It enables us to translate our vision into tangible, cohesive expressions of style and innovation. By curating a collection of garments or

products that embody a unified theme, aesthetic, and narrative, we as designers can showcase their creativity, craftsmanship, and brand identity.

### F. Garment Construction

Garment construction is pivotal in the design process as it transforms conceptualized designs into tangible, wearable pieces. It encompasses the technical execution of patternmaking, cutting, sewing, and finishing, ensuring the functionality, comfort, and durability of the garments. The quality of garment construction directly impacts the fit, drape, and overall aesthetic appeal of the final product, influencing the wearer's experience and satisfaction. Moreover, skilled craftsmanship and attention to detail during construction elevate the perceived value of the garments, distinguishing them in a competitive market.

### G. Design Collection Photoshoot:

The garment photoshoot is a pivotal aspect of the design process, offering the opportunity to showcase the creations in a visually compelling and impactful manner. It involves meticulous planning, coordination, and execution to capture the essence of the garments and communicate their design narrative effectively.

### H. Post-Design Survey

A survey was conducted using Google forms in order to collect information regarding the awareness of photochromic dyes among people. Moreover, their thoughts, opinions about the factors such as design, pricing and future purchase decision were also enquired. This helped us get to know more about potential consumer needs and interests. The market potential analyzed too. We thus got an idea on how to develop products as per consumer's taste and interest. Post-design surveys are thus valuable tools in the design process as they provide designers with crucial feedback and insights from their target audience. These surveys allow designers to assess the effectiveness of their designs, understand consumer preferences, and identify areas for improvement.

Method of sampling: Specific Random Sampling. A total of 183 people was enquired. They were selected based on the potential consumer basis.

## 3. Results and Discussion

After following the steps in the methodology, the following results were obtained and are being discussed here.

### A. Designing

The summer casual garment collection was designed as per the theme "Beachy Bliss". "Beachy Bliss" was chosen as the theme as shown in figure 1 for the casual summer dress collection due to its ability to capture the essence of carefree coastal living and evoke a sense of relaxation and joy. The theme resonates with the target audience's desire for easy going, summery styles that reflect the playful vibes of beach vacations. By integrating photochromic dyes into the collection, the garments undergo a magical transformation under sunlight, mirroring the changing colors of the seaside landscape.



Fig. 1. Theme

**B. Development of Boards**

The following boards were developed based on the theme "Beachy Bliss".

**1) Research Board**

The research board for the "Beachy Bliss" theme is shown in the figure 2(a), for the casual summer dress collection utilizing photochromic dyes and serves as a comprehensive visual exploration of coastal inspiration and summer aesthetics. It features images of sandy beaches, azure waters, vibrant sunsets, and lush palm trees, capturing the essence of carefree beach living. Additionally, the board includes references to beachwear, resort fashion, and seaside activities, providing insights into the textures, colours, and silhouettes associated with beach culture. Research into photochromic dyes reveals the potential for dynamic color transformations that mimic the changing hues of the seaside landscape under sunlight. Overall, the research board serves as a foundation for design inspiration, guiding the selection of materials, colours, and motifs that embody the "Beachy Bliss" theme and create an immersive summer experience for wearers.



Fig. 2(a). Research board

**2) Inspiration Board**



Fig. 2(b). Inspiration board

The inspiration board for the "Beachy Bliss" theme is shown in the figure 2(b), for the casual summer dress collection using

photochromic dyes encapsulates the vibrant spirit and laid-back charm of beach living. It features a curated selection of images inspired by coastal landscapes, including sandy beaches, rolling waves, and sun-kissed shores. The board also incorporates elements of colour to evoke the carefree vibe of summer vacations. Additionally, the inclusion of photochromic dye samples and color swatches highlights the innovative technology that will bring dynamic color transformations to the garments, mirroring the ever-changing hues of the seaside environment.

**3) Mood Board**

The mood board for the "Beachy Bliss" theme is shown in the figure 2(c), for the casual summer dress collection infused with photochromic dyes embodies the carefree spirit and vibrant energy of coastal living. It features a harmonious blend of soft pastel tones and vibrant hues inspired by the sun, sea, and sand. Images of sandy beaches, crashing waves, and swaying palm trees evoke a sense of relaxation and tranquillity, while playful pops of color reflect the joy and excitement of summer vacations.



Fig. 2(c). Mood board

**4) Story Board**

Story boards help communicate ideas, plot points, and visual concepts to collaborators and stakeholders, facilitating effective brainstorming, planning, and production processes. They provide a clear roadmap for bringing a project to life, ensuring consistency in storytelling and visual coherence. Whether used in film production, advertising campaigns, video game design, or graphic novels, storyboards play a crucial role in transforming ideas into tangible creative expressions as shown in the figure 2(d).



Fig. 2(d). Story board

**5) Colour Board**

The color board for the "Beachy Bliss" theme is shown in the figure 2(e), for the casual summer dress collection with photochromic dyes captures the vibrant and serene hues of

coastal landscapes. Soft pastel shades reminiscent of sunrise and sunset, such as sandy beige, sky blue, and golden yellow, evoke the tranquil ambiance of the beach at dawn and dusk. Vibrant pops of color inspired by the sea and flora, including turquoise, aquamarine, and lush green, infuse the collection with the playful energy of a day spent by the shore.



Fig. 2(e). Colour board

### 6) Fabric Board

The fabric board for the "Beachy Bliss" theme is shown in the figure 2(f), for the casual summer dress collection with photochromic dyes curates a selection of textiles that embody the relaxed, breezy vibe of coastal living. Light and airy fabrics such as cotton voile, linen, and lightweight jersey are chosen for their breathability and comfort, perfect for warm summer days. Textures inspired by the beach, such as soft wovens resembling sand or textured cotton as reminiscent of ocean waves, add tactile interest to the collection.



Fig. 2(f). Fabric board

### 7) Client Research Board



Fig. 2(g). Client board

The client research board for the "Beachy Bliss" is shown in the figure 2(g), for the casual summer dress collection with photochromic dyes compiles insights and preferences specific to the client. It incorporates feedback and input from client regarding her desires for summery, beach-inspired styles that

evoke a sense of relaxation and joy which is shown in figure 2(h) and figure 2(i). By incorporating client feedback and preferences, the research board serves as a valuable resource to create a collection that resonates with the client's taste and meets her expectations for "Beachy Bliss" inspired collection.



Fig. 2(h). Client research



Fig. 2(i). Client style

### C. Design Range

A design range refers to a collection of products or creations that share a cohesive aesthetic or thematic connection. In the realm of fashion, interior design, graphic design, and product design, a design range encompasses a variety of pieces that are designed to complement each other while also offering diversity within a particular style or concept. Creating a design range involves careful consideration of factors such as color palettes, materials, shapes, patterns, and themes to ensure coherence and consistency across the collection. Design ranges are essential for brands and designers seeking to offer customers a comprehensive and versatile selection of products that reflect their unique design ethos and cater to various tastes and needs.

The design collection board for the "Beachy Bliss" as shown in the figure 3(a) and 3(b), theme features eight designed garments infused with the magic of photochromic dyes, capturing the essence of carefree coastal living and summer escapades. Each garment embodies the breezy elegance and vibrant spirit of beach life, with flowing silhouettes, soft fabrics, and dynamic color-changing effects. Inspired by the sun, sea, and sand, the collection offers a playful mix of pastel hues, ocean-inspired blues, and golden sunsets, evoking the tranquil beauty of seaside landscapes. From flowy maxi dresses to playful rompers and chic beach cover-ups, the garments are designed to transport wearers to sun-kissed shores and leisurely days by the water. With innovative photochromic technology enhancing their allure, these digital designs promise to bring the magic of "Beachy Bliss" to life in every stitch.



Fig. 3(a). Design Board-1



Fig. 3(b). Design Board-2

D. Garment Construction

A total of four designs were selected for the final garment construction as shown in the figure 4(a) and 4(b). Four unique styles were chosen to portray the colour changing photochromic prints in a beautiful and elegant manner. The following designs with design description are given below. Garments selected from a design range offer a curated selection of clothing pieces that embody the overarching aesthetic and vision of the collection. These garments are carefully chosen to represent the diversity and versatility of the design range while ensuring cohesion and harmony in style. Each selected garment reflects the unique characteristics of the collection, such as its color palette, patterns, materials, and design detail



Fig. 4(a). Design Description-1



Fig. 4(b). Design Description-2

E. Dyeing and Fabric Details

The photochromic dye components used are organic in nature. It is imported from the United States and produced in an environmentally friendly manner where there is zero discharge or zero waste process. Product type used to print is Silk flex acrylic polymers. Photochromic blue and photochromic yellow were used.

The dye is an imported Silkflex Unaxol dye. More details of the dye are given below. Acrylic polymer photochromic dye, with a weight percentage typically ranging between 50-60%, is a specialized material engineered for its unique light-sensitive properties. Comprising acrylic polymers infused with photochromic molecules, this dye undergoes reversible color changes upon exposure to ultraviolet (UV) light. When activated by UV radiation, the molecules within the dye undergo a molecular rearrangement, resulting in a visible color change. Details are given below in figure 5.

3. Composition/information on hazard ingredients

Chemical characterization  
Description: Aqueous dispersion of acrylate polymer and pigments.

Product Name	Elastisol Clear S. Matt		
Composition	Chemical Type	CAS No.	% By Weight
Polymer	Acrylic	9003-01-4	50 - 70
Others	Water	7732-18-5	30 - 50

Dangerous components: No special hazards have to be mentioned. Occupational Exposure limit (s), if available, are listed in section 8.

Fig. 5. Dye composition

Also, the photochromic dyes used here is highly certified for its top-quality and production. Certifications given for this chemical dye are GOTS, OEKO TEX Standard 100 and ZDHC. 1) OEKO-TEX® STANDARD 100

The OEKO-TEX® STANDARD 100 certification serves as a hallmark for textiles that have undergone rigorous testing to ensure they are free from harmful substances. This certification sets a high standard for textile safety, encompassing the entire production process from yarn to the finished product. Each item carrying the STANDARD 100 label has undergone thorough safety assessments to verify its compliance with safety standards.

Key aspects of the OEKO-TEX® STANDARD 100 certifications include:

- Confirmation that the certified article poses no harm to human health.
- Comprehensive testing of every component, including threads, buttons, and accessories, against a stringent list of over 1,000 harmful substances.
- Stricter requirements for human ecology and laboratory tests for items with more intensive skin contact.
- Utilization of globally standardized test criteria to ensure consistency and reliability.
- Adherence to international requirements and regulations, ensuring global recognition and acceptance.
- Regular review of limit values for harmful substances, with updates made at least once a year to reflect the latest scientific knowledge and regulatory developments.

In essence, the OEKO-TEX® STANDARD 100 certification provides consumers with confidence that textiles bearing this

label have undergone thorough testing and adhere to strict safety standards, thereby ensuring their safety and peace of mind.

### 2) *The Global Organic Textile Standard (GOTS)*

The Global Organic Textile Standard (GOTS) stands as the foremost global standard for the processing of organic fibers, encompassing ecological and social considerations. It establishes stringent environmental and social criteria across the entirety of the organic textiles supply chain, with the objective of guaranteeing the organic status of textiles from the harvesting of raw materials to environmentally and socially responsible manufacturing practices. GOTS certification necessitates adherence to rigorous criteria in various domains, including organic fiber content, eco-friendly processing methods, and equitable labor practices. By obtaining GOTS certification, textile products provide consumers with a credible assurance of organic integrity, thereby fostering trust and confidence in organic textile goods on a global scale.

### 3) *ZDHC MRSL- Zero Discharge of Hazardous Chemicals Manufacturing Restricted Substances List*

The ZDHC MRSL, or Zero Discharge of Hazardous Chemicals Manufacturing Restricted Substances List, serves as an exhaustive inventory of chemical substances prohibited or restricted in the manufacturing procedures of textiles, leather, and footwear. Established by the Zero Discharge of Hazardous Chemicals (ZDHC) group, its primary objective is to eradicate the discharge of harmful chemicals into the environment, thereby safeguarding water sources and preserving human health. The MRSL outlines permissible concentration limits for various chemical substances, promoting safer and more sustainable practices across the supply chain. By adhering to the ZDHC MRSL, brands and manufacturers can reduce their environmental footprint and contribute to a safer and healthier industry ecosystem.

### F. *Dyeing Method*

Screen printing method was used in the dyeing process. Screen printing dyeing is a versatile and popular technique used in textile design and production. It involves transferring ink or dye onto fabric through a silk mesh screen, creating vibrant and long-lasting prints. The process commences with the production of a stencil, typically crafted from a fine mesh screen coated with a photosensitive emulsion. This stencil is then positioned atop the fabric, after which ink or dye is administered onto the screen and pushed through its exposed sections using a squeegee. The dye infiltrates the fabric solely in areas permitted by the stencil, yielding a print that is both intricate and accurate in detail. Screen printing dyeing allows for a wide range of colours, patterns, and effects, making it suitable for both small-scale artisanal projects and large-scale industrial production. Its durability and versatility make it a preferred method for creating high-quality, customized textiles for fashion, home decor, and commercial applications.

Screen printing is often preferred for photochromic dye applications due to its ability to achieve precise and consistent prints, which is crucial for ensuring the effectiveness of photochromic effects.

Reasons why screen printing is favoured for photochromic dye.

- **Controlled Ink Application:** Screen printing offers meticulous control over the ink deposition onto the fabric, guaranteeing uniform coverage and intensity of the photochromic dye. This level of control is crucial for maintaining consistent color-changing effects throughout the printed surface.
- **Fine Detail:** Screen printing can achieve fine details and intricate designs with sharp edges, making it suitable for creating complex patterns or graphics with photochromic dye. This precision is important for maintaining the integrity of the photochromic effects and ensuring they are accurately represented in the printed design.
- **Durability:** Screen printing results in durable prints that can withstand multiple washes and prolonged exposure to sunlight, which is essential for preserving the photochromic properties of the dye. The ink is applied in thick layers, ensuring that the photochromic effects remain vibrant and long-lasting over time.
- **Versatility:** Screen printing is adaptable to a broad spectrum of fabrics, spanning cotton, polyester, and blends, thereby providing flexibility in material selection for photochromic dye applications. This versatility empowers designers to opt for the most fitting fabric to meet their unique design needs while capitalizing on the benefits of screen printing.

### G. *Fabrics used*

The fabric used for photochromic dyeing was plain non-textured and stable fabrics, especially cotton. Pure woven or knitted cotton can be used. Pure woven cotton fabric in white color was selected so that the dye can be absorbed properly, and the designs can be seen clearly. Five metres of pure woven white cotton fabric was used for the dyeing process.

Pure woven cotton is often considered ideal for photochromic dyeing due to several factors:

- **Absorbency:** Cotton has excellent absorbent properties, allowing it to readily absorb photochromic dyes and retain vibrant colours after dyeing. This absorption ensures that the dye penetrates the fibers evenly, resulting in uniform coloration and consistent color-changing effects.
- **Breathability:** Cotton is a natural fibre known for its breathability and comfort, making it suitable for garments worn in warm climates or during summer months. Photochromic dyeing does not compromise cotton's breathability, ensuring that the fabric remains comfortable to wear even after dyeing.
- **Durability:** Cotton fabrics boast durability and strength, rendering them ideal for everyday wear and frequent washing. Photochromic dyes exhibit excellent adhesion to cotton fibers, ensuring enduring color-changing effects that resist fading or diminishing in intensity even after numerous laundering cycles.
- **Compatibility:** Pure woven cotton is compatible with

various dyeing techniques, including photochromic dyeing. Its smooth surface and natural texture provide an ideal canvas for showcasing the dynamic color-changing effects of photochromic dyes, resulting in visually striking and captivating garments.

#### H. Prints and Colours

The designs were selected and forwarded to the industry where the dyeing was carried out. The following designs as per the theme were selected. The designs that can be printed were limited in terms of designs and size of the screen. The screen size mentioned was 28 inches in width and the length can vary. Thus, the fabric was sent in the given measurements. Moreover, the colours that can be used were limited such as blue, yellow, purple, red, orange. The colour transformation was from colourless in indoors to colours under UV rays or sunlight. The colours chosen were teal blue and sandy yellow as per the theme "Beachy Bliss".

Blue and yellow are quintessential shades for a summer collection, evoking the essence of sunny skies, sandy beaches, and refreshing ocean waters.

The vibrant warmth of yellow captures the energy and radiance of summer, while the cool tranquillity of blue mirrors the clear skies and serene seas. Together, they create a dynamic and refreshing color palette that instantly brings to mind leisurely days spent under the sun. The following prints were selected and forwarded to the dyeing unit. The first one was polka dots of teal blue shade as shown in figure 6(a) and the other was the breezy floral print of sandy yellow shade as shown in figure 6(b). Photochromic blue and photochromic yellow were used.

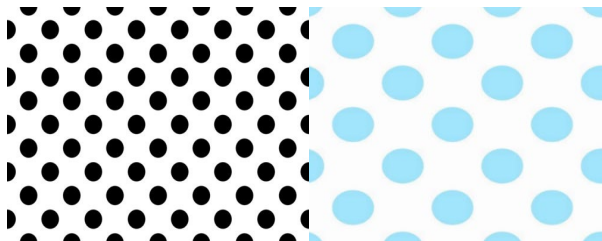


Fig. 6(a). Print-1 Polka



Fig. 6(b). Print-2 Floral

#### I. Photoshoot

Capture the enchantment of daylight with our stunning photoshoot featuring garments dyed with photochromic dyes. These innovative pieces come alive in the sun's glow, exhibiting vibrant and effective color changes from 11 am to 4 pm when the UV rays are at its strongest. Delight in their dynamic hues and captivating transformations as they gracefully adapt to the

changing light. Please note that while these garments are exceptionally effective during daylight hours, their photochromic properties gradually fade after 4 pm.

#### 1) Garment 1 Photochromic Collar

Introducing our stunning summer dress featuring a captivating photochromic color-changing collar. This elegant piece effortlessly transitions from day to night as the collar transforms hues with the touch of sunlight or UV light. Crafted with an elegant textured cotton breathable fabric, it's perfect for warm days, while the enchanting color shift adds a touch of magic to your ensemble. Embrace the beauty of nature's light with this chic and versatile dress, making every moment under the sun a stylish affair. In this summer dress made of breathable cotton fabric, the collar is made of photochromically dyed fabric with floral prints which change from white or colourless as shown in figure 7(a) to yellow printed fabric under sunlight or UV light. This bold and colour changing collar is a statement piece that adds to the overall beauty and look of the garment.



Fig. 7(a). Indoor colourless collar to outdoor yellow coloured collar Transformation-1



Fig. 7(b). Indoor colourless collar to outdoor yellow coloured collar



Fig. 7(c). Full garment transformation

#### 2) Garment 2 Photochromic Co-ord set

Step into the spotlight with this radiant summer co-ord set featuring mesmerizing photochromic color-changing accents. This elegant ensemble effortlessly captures the essence of



summer with its playful yet sophisticated design. The top and shorts are a perfect combination for a perfect summer vacation which is comfortable as well as dazzling with their ability to transform hues under the sun's gentle touch, adding an enchanting flair to the overall look. Crafted from lightweight and airy cotton fabric, it ensures comfort while exuding timeless elegance.

Effortlessly chic, the top boasts a subtle color shift under the gentle touch of sunlight or UV light, adding an ethereal charm to your look. Paired with coordinating shorts, this ensemble offers both style and comfort for warm summer days. Crafted from lightweight and breathable fabric, it ensures effortless movement and sophistication. Embrace the magic of the season with this versatile coord set, designed to make every summer moment unforgettable with its timeless allure. Moreover, the garment changes from completely colourless in indoors to a classic all over blue polka printed fabric under sunlight or UV light which is magical to watch for the eyes as shown in figure 8.



Fig. 8. Indoor colourless co-ord set to printed polka blue coloured set in outdoor

3) *Garment 3 Photochromic Layered Dress*



Fig. 9. Indoor colourless layered frock to printed polka blue coloured frock in outdoor

Indulge in the allure of summer with enchanting layered dress, adorned with delicate photochromic color-changing accents. Effortlessly chic, this dress exudes timeless elegance while embracing the playful magic of light. The layered design adds dimension and movement, while the subtle color shift under sunlight or UV rays captivates with its ethereal beauty. Crafted from breathable fabric, it ensures comfort on warm days while making a bold style statement. Embrace the whimsy of nature with this sophisticated yet whimsical piece, perfect for

any summer occasion. The cotton dress has a simple neckline with no sleeves making it a perfect summer wear. The dress is a triple layered one with the final special layer that changes from complete colourless white fabric in indoors to a classic all over blue polka printed fabric under sunlight or UV exposure as shown in figure 9.

4) *Garment 4 Photochromic Jumpsuit*

Elevate the summer style with this exquisite jumpsuit, featuring captivating photochromic color-changing details. Effortlessly chic, this jumpsuit embodies the essence of summer with its sleek silhouette and playful design. The subtle color transformation of the yoke part under sunlight or UV light adds a touch of enchantment, making each wear a unique experience. The yoke part changes from complete colourless white fabric in indoors to a classic all over blue polka printed fabric under sunlight or UV exposure as shown in figure 10. The V-neck pattern and the flared bottoms make a perfect combination along with the colour changing prints in the yoke part. The blue bottom paired with colour-changing yoke adds to the overall look. Crafted from lightweight and breathable fabric, it ensures comfort while exuding sophistication. Embrace the beauty of nature's light with this versatile piece, perfect for any summer outing.



Fig. 10. Indoor colourless yoke to printed polka blue coloured yoke in outdoor

J. *Costing*

Table 1  
Garment costing

S.No.	Items	Cost per meter/Kg	Total Cost
1	Cotton Fabric: White (4 meters)	Rs. 120/- per meter	Rs. 480
2	Textured cotton Fabric: 2 meters	Rs. 130 per meter	Rs. 260
3	Dye (1 Kg)	Rs. 6000 per Kg	Rs. 6000
4	Tailor Cost: 4 garments	Rs. 500 per garment	Rs. 2000
		<b>TOTAL</b>	<b>Rs. 8,740</b>

The table 1 outlines the cost breakdown for producing garments, including materials and associated expenses. It itemizes the costs of cotton fabric, both white and textured, along with dye and tailoring services. The cotton fabric is priced at Rs.120/- per meter for white and Rs.130/- per meter for textured, totalling Rs.480/- and Rs.260/- respectively. Photochromic dye, accounts for a total of Rs.6000/- per kg. Tailoring costs, at Rs.500/- per garment for 4 garments, amount to Rs.2000/-. Overall, the total cost for the production of the garments is Rs.8,740/-. This summary provides a concise overview of the expenses incurred in creating the garments, facilitating better financial understanding and management of the production process.

In terms of how this cost is justified by incorporating photochromic changes, it's essential to consider the added value and market appeal that photochromic textiles can bring to the garments.

**K. Post-Design Survey**

Post-design surveys are pivotal for gathering feedback directly from users or customers regarding the effectiveness and satisfaction with a design. By engaging users in the design process, surveys foster a sense of involvement and demonstrate a commitment to meeting their needs. Additionally, they serve as benchmarks for future designs, enabling designers to track progress and mitigate potential risks early on. Ultimately, post-design surveys facilitate data-driven decision-making, ensuring that designs evolve to deliver optimal user experiences.

In this survey conducted online through google forms, responses from around 183 respondents were collected and the data was interpreted. The data shows diverse responses from the samples.

**L. Post-Design Survey Interpretation**

**1) Age**

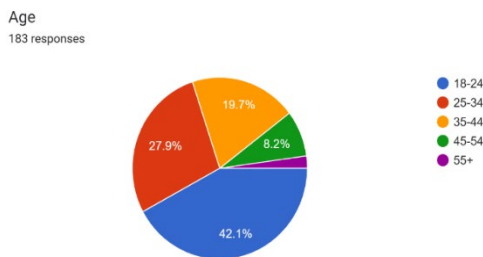


Fig. 11(a). Age

The obtained data from figure 11(a) shows that respondents who are in the age category of 18-24 are in the majority (42.1%) followed by people of age group 25-34 (27.9%) followed by age group 35-44 (19.7%) and then the age group of 45-54 about 8.2% and the rest of age category 55 and above.

**2) Place**

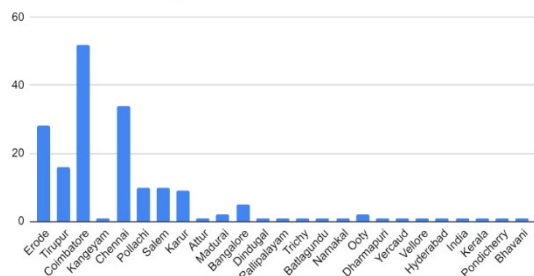


Fig. 11(b). Location

The obtained data from figure 11(b) shows that the major respondents are from Tamil Nadu where about 28.4% are from Coimbatore, 18.6% from Chennai, 15.3% from Erode, 8.7% from Tirupur, 5.5% from Salem and 5.5% from Pollachi followed by Karur, Bangalore, Madurai and other cities.

**3) Education Qualification**

The analysis from figure 11(c) reveals that among the participants, 48.6% have a master's degree, 42.1% have a

bachelor's degree, 4.9% have a doctorate and rest of them are 10<sup>th</sup> or 12<sup>th</sup> graduates.

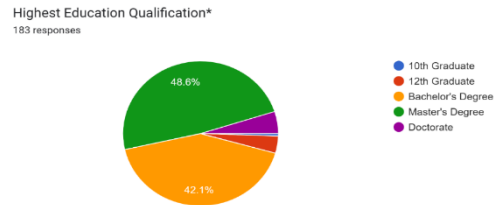


Fig. 11(c). Education qualification

**4) Annual Family Income**

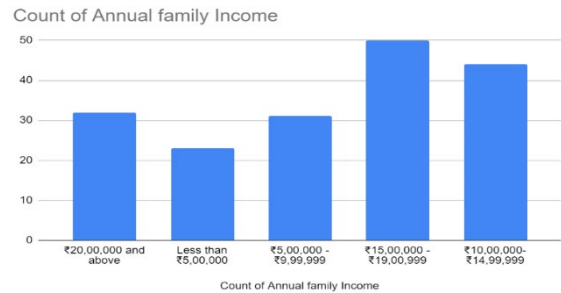


Fig. 11(d). Annual income

The data analysis from figure 11(d) reveals that among the participants, about 27.8% have an income of between Rs.15,00,000-Rs.19,99,999, about 24.4% have an income of Rs.10,00,000 to Rs.14,99,999 and about 17.8% have an income of Rs.20,00,000 and above and about 17.2% have an income of Rs.5,00,000 to Rs.9,99,999 and the rest 12.8% have an income of less than Rs.5,00,000.

**5) Familiarity of Photochromic Textiles**

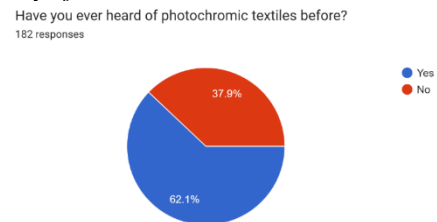


Fig. 11(e). Familiarity

The data analysis reveals from figure 11(e) that among the participants, majority of them of about 62.1% of them are aware of or heard of photochromic textiles before whereas about 37.9% are not aware of the same.

**6) Garments preferred to be dyed with photochromic dyes**

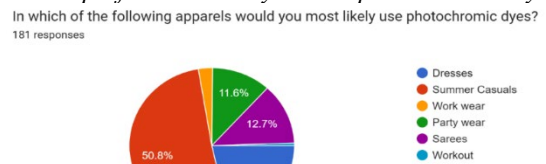


Fig. 11(f). Garments preferred

The data analysis from figure 11(f) reveals that among the

participants, majority of them of about 50.8% of prefer summer casuals whereas about 21.5% prefer dresses whereas about 12.7% prefer sarees followed by party wear which is 11.6% and then the rest prefer work wear and workout wear.

7) Factors influencing decision making

What factors would influence your decision to purchase photochromic textiles? 5- Strongly Agree 4- Agree 3- Neutral 2- Disagree 1- Strongly Disagree

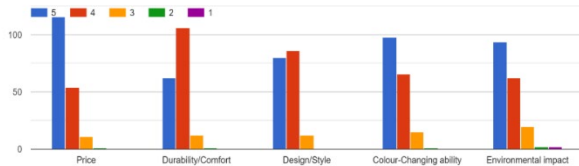


Fig. 11(g). Factors influencing

The data analysis from figure 11(g) reveals that among the participants, majority of them more than 100 respondents consider price as the major factor influencing decision followed by durability/comfort and the they are influencing majorly by Colour-changing concept and environment impact also, then finally they consider design/style important too.

8) Initial impression of the Design concept

How would you rate your initial impression of the design concept? 182 responses

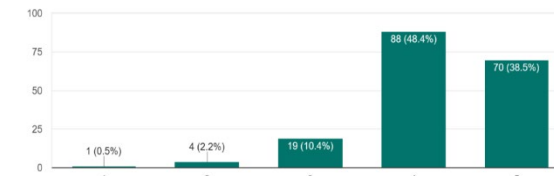


Fig. 11(h). Design concept

The data analysis from figure 11(h) reveals that among the participants, majority of them (48.4%) have rated 4 which is they find the concept interesting whereas about 38.5% of them find it very interesting followed by 10.4% of them who find it neutral and the remaining 2.7% find it not very interesting.

9) Rating of the garment designed – style 1

On a scale of 1 to 5, how visually appealing do you find the photochromic/Colour-changing garment designed (style 1) above? 183 responses

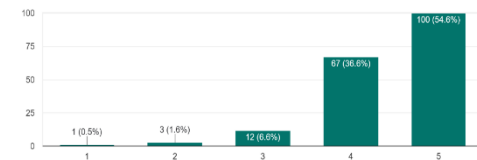


Fig. 11(i). Rating of style-1

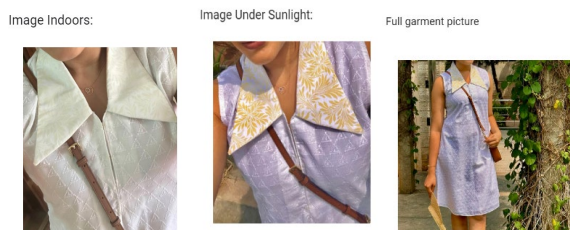


Fig. 11(j). Indoor-Outdoor transformation-1

The data analysis from figure 11(i) and 11(j) reveals that

among the participants, majority of them (54.6%) have rated 5 which is they find the garment designed very appealing whereas about 36.6% of them find it appealing followed by 6.6% of them who find it neutral and the remaining 2.1% find it not very appealing. Thus, the garment designed is preferred by majority of the respondents about more than 100 respondents out of 183 have liked the garment designed.

10) Rating of the garment designed – style 2

On a scale of 1 to 5, how visually appealing do you find the photochromic/Colour-changing garment designed (style 2) above? 182 responses

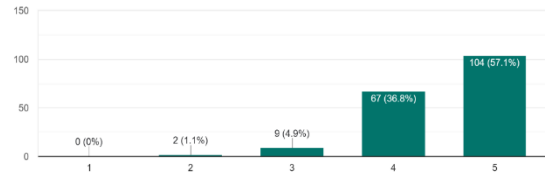


Fig. 11(k). Rating of style-2



Fig. 11(l). Indoor-Outdoor transformation-2

The data analysis from figure 11(k) reveals that among the participants, majority of them (57.1%) have rated 5 which is they find the garment designed very appealing whereas about 36.8% of them find it appealing followed by 4.9% of them who find it neutral and the remaining 1.1% find it not very appealing. Thus, the garment designed is preferred by majority of the respondents about more than 150 respondents out of 183 have liked the garment designed.

11) Satisfied with the colour-changing effect or not

How satisfied are you with the color-changing effect of the photochromic garments? 178 responses

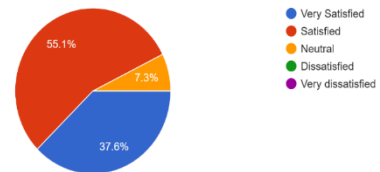


Fig. 11(m). Satisfaction

The data analysis from figure 11(m) reveals that among the participants, majority of them (55.1%) are satisfied with the Colour-changing effect of the garments where as 37.6% are very satisfied with it and about 7.3% are neutral in their decision. Thus, majority have them are satisfied and there are nil respondents are not satisfied with the same.

12) Price Willing to pay

The data analysis from figure 11(n) reveals that among the participants, majority of them (51.9%) are willing to pay

Rs.2000-Rs.3000 for the photochromic garments designed whereas about 27.9% are willing to pay Rs.3000-rs.4000 for the garments and about 18.6% are willing to pay Rs.1000-Rs.2000 and the remaining 1.6% are willing to pay around Rs.4000 and above.

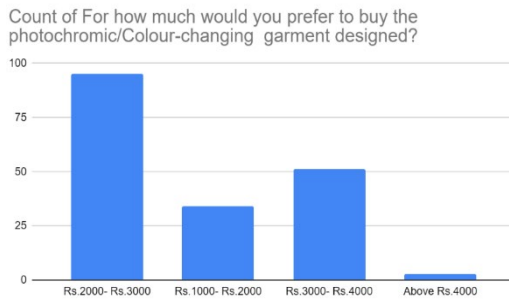


Fig. 11(n). Price

### 13) Future Buying Decision

Would you be interested in trying innovative photochromic garments in the future?  
181 responses

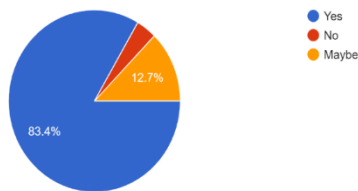


Fig. 11(o). Future Purchase

The data analysis from figure 11(o) reveals that among the participants, majority of them (83.4%) have said “yes” and they are willing to purchase photochromic garments in the future whereas 12.75 have answered “maybe” and are thus not sure about their decision whereas about just 7% have answered “no” and are not willing to buy the same.

### M. Inference

The overall analysis of respondent data unveils intriguing insights into the reception of photochromic textiles. Predominantly comprising individuals aged 18-34 from Tamil Nadu, with varied educational and income backgrounds, the sample reflects a diverse demographic. Despite this diversity, a majority are not only aware of photochromic textiles but also express interest in them, particularly favouring summer casuals and dresses. Price emerges as a significant influencing factor in garment selection, along with considerations for durability, comfort, and environmental impact. Impressively, the majority find the color-changing effect appealing and express satisfaction with it. This positive sentiment extends to their willingness to pay, with a notable portion willing to invest Rs.2000-Rs.3000 for these innovative garments. Importantly, the overwhelming majority (83%) exhibit a strong inclination toward purchasing photochromic garments in the future, indicating a promising market potential. Overall, the data portrays a receptive audience eager to embrace the innovation and functionality offered by photochromic textiles, suggesting a favourable landscape for their integration into the fashion market.

### N. Scope of the products developed:

#### 1) Commercialization

The commercialization of garments featuring photochromic dyes presents an exciting opportunity for businesses to captivate consumers with innovative, color-changing textiles. Through strategic marketing, branding, and retail partnerships, companies can highlight the transformative nature of these garments, appealing to environmentally conscious consumers seeking sustainable fashion options. By educating consumers about the unique properties and care requirements of photochromic garments, businesses can enhance product understanding and drive demand. Leveraging social media and influencer partnerships can further amplify awareness and generate excitement around this emerging trend. With careful pricing strategies and product differentiation, companies can successfully commercialize photochromic garments and carve out a niche in the competitive fashion market.

#### 2) Scope for Retailers

Garments developed using photochromic dyes offer retailers a unique selling proposition in the competitive fashion market. These innovative textiles attract consumer attention with their dynamic color-changing effects, making them stand out on shelves and online platforms. Retailers can leverage the novelty of photochromic garments to drive foot traffic to stores and increase online engagement. By showcasing these products prominently and highlighting their transformative properties in marketing campaigns, retailers can create buzz and generate excitement among customers. Additionally, the exclusivity of photochromic textiles, coupled with their environmental certifications, appeals to eco-conscious consumers, providing retailers with a niche market to tap into. Overall, integrating photochromic garments into their offerings allows retailers to differentiate themselves, enhance brand image, and capitalize on evolving consumer preferences for sustainable and innovative fashion choices.

#### 3) Scope for Consumers

For consumers, garments infused with photochromic dyes offer an exhilarating and interactive fashion journey. These textiles present a distinct avenue for expressing personal style and ingenuity, with colors that metamorphose in response to sunlight or UV exposure. Beyond their aesthetic appeal, the eco-friendly production process and certifications associated with photochromic dyes resonate with consumers who prioritize sustainability and ethical sourcing in their purchasing decisions. The adaptability of photochromic garments, suitable for various occasions ranging from casual wear to special events, positions them as a versatile addition to any wardrobe. Moreover, the novelty aspect of owning clothing that reacts to sunlight injects an element of amusement and fascination into the wearing experience, amplifying consumer satisfaction and engagement. In essence, photochromic garments empower consumers to make bold fashion statements while simultaneously aligning with their values of sustainability and individuality, thus offering a gratifying and meaningful fashion experience.

#### 4. Conclusion

The convergence of technology and fashion has birthed a new era of innovation, with photochromic dyes emerging as a transformative element in the garment industry. From their humble beginnings as sun-sensitive materials to their current incarnation as dynamic color-changing fabrics, photochromic dyes have evolved to captivate the imagination of designers and consumers alike. Through this research and design project, we can explore the meaning, evolution, application, and commercial viability of photochromic textiles. For this, extensive research on photochromic dyes was carried out followed by the development of a design collection based on a “Beachy Bliss” theme. Boards such as mood board, inspiration board, research board and design board were developed on the theme followed by garment construction and photoshoot. Then an extensive post-product survey was conducted to analyse the commercial viability of the photochromic dyes on the garments. The post-product survey conducted has yielded compelling insights into the commercial viability and potential of photochromic textiles in the fashion market. The survey revealed a significant level of consumer awareness and interest in photochromic garments, indicating a growing market demand for these innovative products. Moreover, the survey demonstrated a strong willingness among consumers to invest in photochromic textiles, underscoring their perceived value and appeal.

In conclusion, the exploration of photochromic textiles in fashion reveals a world of possibilities waiting to be unleashed. It highly benefits the retailers and manufacturers of photochromic dyes as they have huge market potential in the future. Furthermore, education and awareness initiatives are pivotal in enlightening consumers about the advantages and potential of photochromic garments, thereby stimulating demand and adoption. Strategic collaborations between fashion brands, textile manufacturers, and technology companies can

further expedite the scaling up and commercialization of photochromic textiles, paving the way for new avenues of growth and market expansion. Embracing creativity, collaboration, and forward-thinking, stakeholders in the fashion industry can harness the transformative capabilities of photochromic textiles to sculpt a future where garments transcend mere adornment, serving as catalysts for imagination and self-expression.

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