

Designing a two-phase glow-in-the-dark pattern on textiles

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Abstract

Although many research projects have explored ways of creating light-emitting fabric displays using LEDs, electro-luminescent wires, and optical fibres, fewer research projects have investigated ways of designing glow-in-the-dark surface patterns using photo-luminescent pigments in textile and fashion design. This may be due to a lack of adequate experimental exploration, as well as a lack of documented information with which to guide textile and fashion designers regarding how these pigments can be used to create such patterns. This article reports on findings based on the design properties and potentials of photo-luminescent pigments with regard to textiles.

Through practice-based research, a series of design experiments were created which demonstrate ways of understanding and working with photo-luminescent pigments when designing glow-in-the-dark patterns for textiles. Through experimentation with plain and complex motifs, the influence of using photo-luminescent pigments on the process of creating of a glow-in-the-dark surface pattern was examined. The results indicated that, since the colours of positive and negative spaces were reversed in dark conditions, it provided an opportunity to create tessellated surface patterns similar to those of patterns created by Maurits Cornelis Escher.

Predicting the effect produced by complex printed patterns was not as easy as predicting that produced by plain printed patterns, stressing the need for tools that allowed the designer to simulate and observe the glow-in-the-dark effect before starting to print. A two-phase pattern was then created, with different expressions in daylight and darkness. For this purpose, each colour of textile pigment paste was mixed with a combination of photo-luminescent pigment and binder, and then printed on to the chosen fabric. The effect produced by the mixture in darkness was a gradation of light, like a tone or value halfway between a highlight and a dark shadow and similar to that produced by a printed, glow-in-the-dark halftone.

These research experiments provide textile and fashion designers with a textile printing method that allows them to create two-phase glow-in-the-dark patterns with identical forms in daylight and darkness, but with two expressions in each. It also offers recipes for print formulation and documents results, offering a new design resource for textile surface pattern designers to promote creativity in design. In so doing, the article provides fundamental knowledge for the creation of glow-in-the-dark surface patterns on textiles.

Keywords: textile and fashion design, photo-luminescent pigment, printing technique, glow-in-the-dark surface pattern

Introduction

The design of a surface pattern serves different purposes, ranging from aesthetic value to function (Terashima, 2009; Cole, 2007; Jacquie, 2001). The pattern is an additive element to the surface that defines a particular appearance (Russell, 2011; Brett, 2005). The fundamental skills required to successfully design a surface pattern include drawing expertise, knowledge of different printing techniques, and the ability to understand the context of the object being designed. Traditionally, the surface pattern design process has involved the designer utilizing the printing technique best suited to the brief of the project (Day, 1999). The introduction of smart colours to textile printing, however, has challenged surface pattern designers, offering a range of colours that can change the expressive properties of textiles. As a result, surface pattern designers need to understand not only how the chosen printing technique works, but also how colours behave under different conditions, and how this may impact on the design process.

Photo-luminescent pigments are similar to traditional textile printing pigments, and can be used to create stunning glow-in-the-dark patterns on textiles. Accordingly, they can give the textile a softer quality by emitting light without using any wires and electricity; i.e., the textile glowed with its own light, as the photo-luminescent pigment stores the energy of sunlight or artificial light and then releases this in the dark. However, many researchers have used LEDs (Michel & IZM, 2008; Buechly, 2013; Layne, n.d.), electro-luminescent wires (Persson & Worbin, 2010; Wingfield, n.d.),

and optical fibres (Deckers, 2013; Jansen, 2013; Krogh, n.d.) to create light-emitting fabrics, as these technologies can be programmed and controlled.

“Klight” (Michel & IZM, 2008) is a motion-sensitive LED dress which senses the wearer's movements and converts these into a light pattern. A related project, entitled “Functional Styling” (Persson & Worbin, 2010), explores the expressive potential of interactive textiles through the use of heat, light, and colour changing along with pressure sensors. Here, three full-scale carpets have been designed which incorporate interactive elements; one of these is a carpet woven from a combination of electro-luminescent wire, wool yarn, and pressure sensors, which cause the carpet to light up in a certain way as a person walks on it. Another research project, “Rhythm exercise” (Jansen, 2013), investigates the visual effects of movement by integrating light into textile structures to form a time-based medium. Eight optical fibre-braided structures are lit by LEDs, and programmed to create moving patterns of white light using a microcontroller digital interface. Each braid has an identical braiding structure, but is connected to a different number of LEDs, thus creating an increasing complexity of moving light patterns within the braided structures.

The above mentioned research projects have concentrated only on ways of implementing LEDs, electro-luminescent wires, and optical fibres into textiles, as well as ways of controlling a light pattern, and so little is at present known regarding how to use photo-luminescent pigments in order to create glow-in-the-dark patterns on textiles. This is due to a lack of sufficient experimental exploration, as well as a dearth of documented information with which to guide textile and fashion designers regarding how these pigments can be applied to create glow-in-the-dark surface patterns. Thus, this article attempts to investigate the design properties of photo-luminescent pigments and the challenges that come with using them to create glow-in-the-dark patterns on textiles, and provides a new design resource for textile surface pattern designers to promote creativity in design thinking (Kimbell, 2009). The findings of this article are expected to assist textile and fashion design practitioners and researchers in developing ways of designing a glow-in-the-dark pattern on textiles.

Luminescent material

Luminescent materials emit light in response to an external stimulus (Bamfield & Hutchings, 2010). Types of luminescence include photo-luminescence (stimulation by visible light or ultraviolet radiation), radio-luminescence (excitation by radioactive substances), X-ray luminescence (stimulation by X-rays), and electrochemi-luminescence (the result of an electrochemical reaction) (Krasovitskii & Bolotin, 1988, p. 3). Of these different types of luminescence, three are often successfully applied to textiles; these take the form of photo-luminescent pigments, optical fibres, and electro-luminescent wire.

Photo-luminescent pigments

Photo-luminescent pigments absorb natural or artificial light, generally that which contains ultraviolet (UV) rays, such as sunlight or UV light, and gradually emit the light. The pigments become highly visible in ambient darkness, creating the effect generally known as “glow-in-the-dark” (Bamfield & Hutchings, 2010).

Photo-luminescent pigments are produced as a powder, which must be mixed with the correct binders so that the pigment attaches to the desired surface. The colour of the pigment in darkness can be yellow, yellow-green, blue-green, ocean blue, orange, or violet, and the time that the pigment glows for is dependent on the quality of the pigment. Once the pigment is fully charged following exposure to UV or another light source, the glow-in-the-dark effect of the photo-luminescent pigments can be repeated without a decrease in performance.

Note that this research project was limited to water-based yellow-green photo-luminescent pigment, due to the fact that although three different photo-luminescent products from three different suppliers were tested, only one of them, which incidentally was of better quality in terms of a stronger and longer-lasting glowing effect, can be successfully applied to textiles.

Exploring the design properties and potentials of photo-luminescent pigments on textiles



To achieve maximum brightness on textiles, water-based yellow-green photo-luminescent pigment and binder were mixed in different proportions and screen-printed on to different colour backgrounds. A 50/50 mixture of pigment and binder on a plain white woven cotton fabric produced the desired glow-in-the-dark effect. The size of the silkscreen mesh was 43 threads per centimetre.

Because only one colour of photo-luminescent pigment was used, the design process was framed for designing two-colour surface patterns. Different motifs (an individual unit of a pattern) were designed in order to examine the use of photo-luminescent pigments in the creation of a glow-in-the-dark pattern on textiles. These were designed to support exploration and demonstrate ways of understanding and working with photo-luminescent pigments. The motifs were divided into two groups, plain and complex; the former were very simple, with no ornamentation or decoration and no requirement for any extra preparation prior to printing (Figure 1), while the latter were elaborately and often excessively ornamented, and required extra preparation so as to convert them into halftones (a printing process in which tone gradation is obtained through a system of minute dots) and produce a rasterbator effect (Figure 2).

First, the chosen plain pattern was printed on fabric. The effect produced by printing the surface pattern with photo-luminescent paste was pale yellow-green in terms of colour, and barely visible in daylight. However, the pattern was clear in darkness and had the same shape as the original sketch, even though the white background was reversed (Figure 1).

Figure 1 shows the result of using photo-luminescent pigments for the plain pattern. From top to bottom; the original sketch of the plain surface pattern, the effect produced by the photo-luminescent printed fabric in ambient daylight, and the effect produced by the photo-luminescent printed fabric in darkness.

Next, the complex pattern was printed on fabric. The surface pattern printed with photo-luminescent paste was also pale yellow-green in colour, and imperceptible in daylight. The pattern was noticeable in darkness, but the effect produced was different from the original sketch (Figure 2).



Figure 2 shows the result of using photo-luminescent pigments when printing the complex pattern. From top to bottom; the original sketch of the complex surface pattern, the effect produced by the photo-luminescent printed fabric in ambient daylight, and the effect produced by the photo-luminescent printed fabric in darkness.

The effects produced by both patterns in darkness when compared with the original sketches indicated that the colours of the positive and negative spaces were reversed in darkness, allowing the creation of tessellated surface patterns similar to those created by M.C. Escher (Schattschneider, 2004). Tessellated surface patterns

are used here to refer to motif(s), which can be fitted together without gaps or overlaps on a two-dimensional plane. Thus, the positive and negative spaces within a surface pattern have their own unique shapes; i.e., the shape of the negative space is determined by the shape of the positive space (see Figure 3).

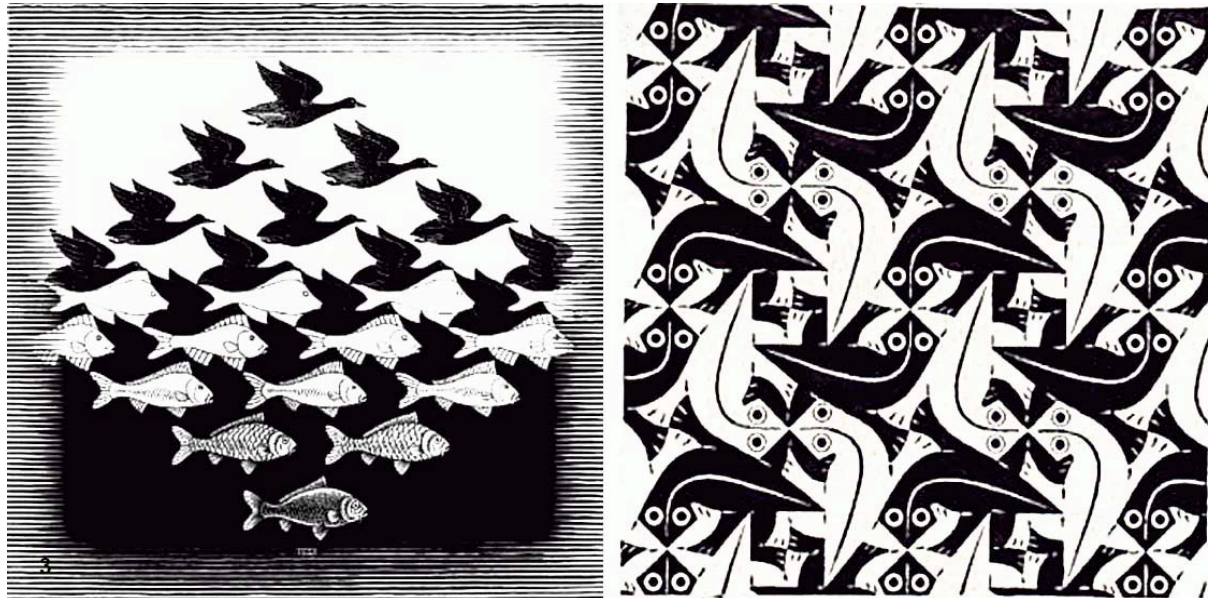


Figure 3 shows tessellated surface patterns. The shape of the negative space is determined by the shape of the positive space. The pattern was taken from *M.C. Escher: Visions of Symmetry* (Schattschneider, 2004).

Predicting the photo-luminescent effect on complex patterns was not as easy as predicting the effect on plain printed patterns, and this difficulty led to the use of a tool that allows one to simulate the glow-in-the-dark effect prior to starting to print. Of all of the tools available in Adobe Photoshop, “Gradient Map” was selected. While quicker or easier ways to invert and adjust the colours as required were available, this sketching tool was chosen as it allows not only the reversal of positive and negative spaces, and adjustment to colours, as is required in order to simulate the desired glowing effect in darkness, but also the ability to mimic the silk-screen printing technique so as to gain a deeper understanding of the behaviour of photo-luminescent pigments in darkness during the printing process.

This tool has been applied in both weaving and printing design projects by undergraduates of the Textile Design programme at the Swedish School of Textiles,

the University of Borås. For the weaving design project, the students were asked to use photo-luminescent yarns in their patterns, and for the printing design project they were asked to print their patterns with photo-luminescent pigments. In both projects, the students used the Gradient Map tool in Photoshop to visualize their glow-in-the-dark surface patterns before starting to weave or print. It seemed that the use of this tool increased the effectiveness and speed of the design process, which usually requires a considerable investment in time and effort, particularly for those who are not familiar with the behaviour of photo-luminescent materials in darkness. Consequently, this experiment has indicated a need for more sketching tools to help students in designing light-emitting woven or printed patterns.

Exploring ways of creating two-phase glow-in-the-dark patterns on textiles

After coming to an understanding of how the fabric printed with photo-luminescent pigment behaved in both ambient light and darkness, I proceeded to create two-phase patterns that would appear differently in daylight and in darkness. Different types of surface patterns were designed, including a four-colour plain pattern and a two-colour complex pattern. The part of the pattern that was to be visible in darkness was printed with photo-luminescent pigment, while that which was to be visible in daylight was printed with photochromic ink. The photochromic ink undergoes a reversible transformation, from colourless to coloured, when exposed to UV radiation (Bamfield et al., 2010, pp. 155–167).

Exposing the printed two-phase surface patterns to UV light and darkness produced different effects (Figure 4). However, the printed surface patterns created a two-phase pattern; one after exposure to UV light, and another in darkness. Without the UV lamp, however, the surface-pattern became invisible in daylight, which was not the desired effect.

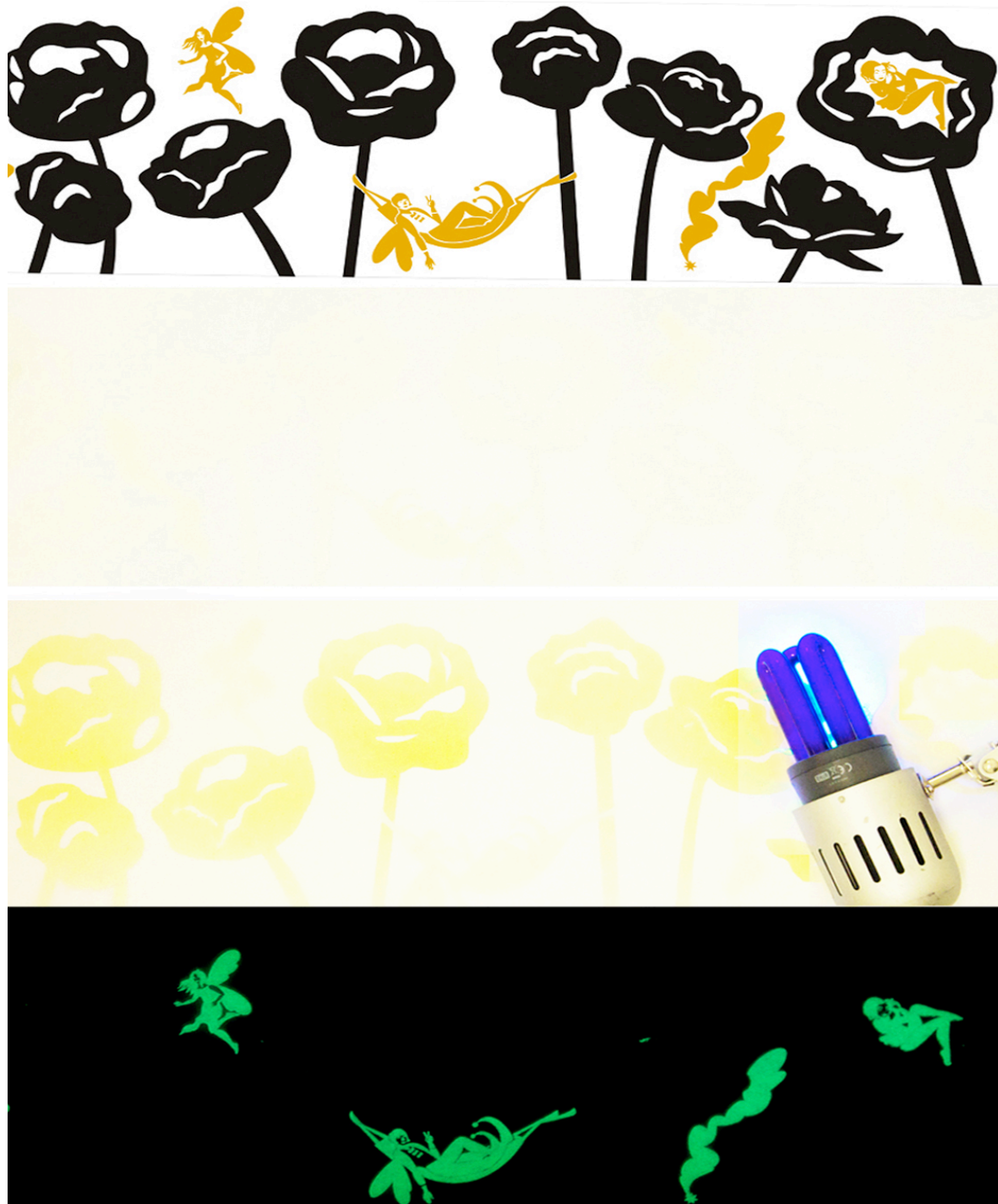


Figure 4 shows how the surface pattern printed with photochromic ink and photoluminescent pigment appears differently in daylight and in darkness. From top to bottom; the original sketch, the effect produced by the printed fabric in ambient daylight, the effect of exposing the print to UV light, and the effect produced by the printed fabric in darkness. The pattern was designed by Tatiana Krupinina.

To obtain a two-phase pattern visible in both ambient light and darkness, 5 grams of different colours of conventional textile pigment paste were added to a 50:50 mixture of binder and photo-luminescent pigment, and printed on the fabric. In darkness, the mixtures created a gradation of light halfway between a highlight and a dark shadow, similar to printed glow-in-the-dark halftone.

Further exploration was conducted through creating a rectangular form divided into ten sections, each of which was given a different halftone percentage, from 10 to 100, and printed with photo-luminescent paste. The effects produced by the mixture of photo-luminescent and conventional textile pigment pastes were compared to those produced by the photo-luminescent paste when viewed in darkness. The effect produced by adding five grams of yellow or pink textile pigment paste to the 50:50 mixture of binder and photo-luminescent pigment was identical to that produced by 50 per cent halftone. Adding five grams of green, orange, or magenta to the mixture produced the same effect as 30 per cent halftone, and adding five grams of blue, red, or black to the mixture produced the same effect as 20 per cent halftone (Figure 5).

Halftone effect produced by the photoluminescent in ambient daylight	Halftone effect produced by the photoluminescent in darknesst	Halftone percentage	the mixture of 5gr pigment with 50gr of binder and 50gr of photoluminescent in ambient daylight	Effect produced by the mixture of pigment and photoluminescent in darkness
		100%		
		90%		
		80%		
		70%		
		60%		
		50%		
		40%		
		30%		
		20%		
		10%		

Figure 5 shows and compares the effects produced by the photo-luminescent paste when viewed in ambient daylight and darkness with the effects produced by the mixture of photo-luminescent and conventional textile pigment pastes in ambient daylight and darkness.

The four-colour plain geometric surface pattern was designed and printed with the recipes discussed above, so as to demonstrate an artistic approach to using the recipes. This resulted in a two-phase plain pattern that had the same form in daylight and darkness, but one expression in daylight and another in darkness (Figure 6). The pattern was taken from the Al-Nasir Muhammad mosque in Cairo, Egypt.

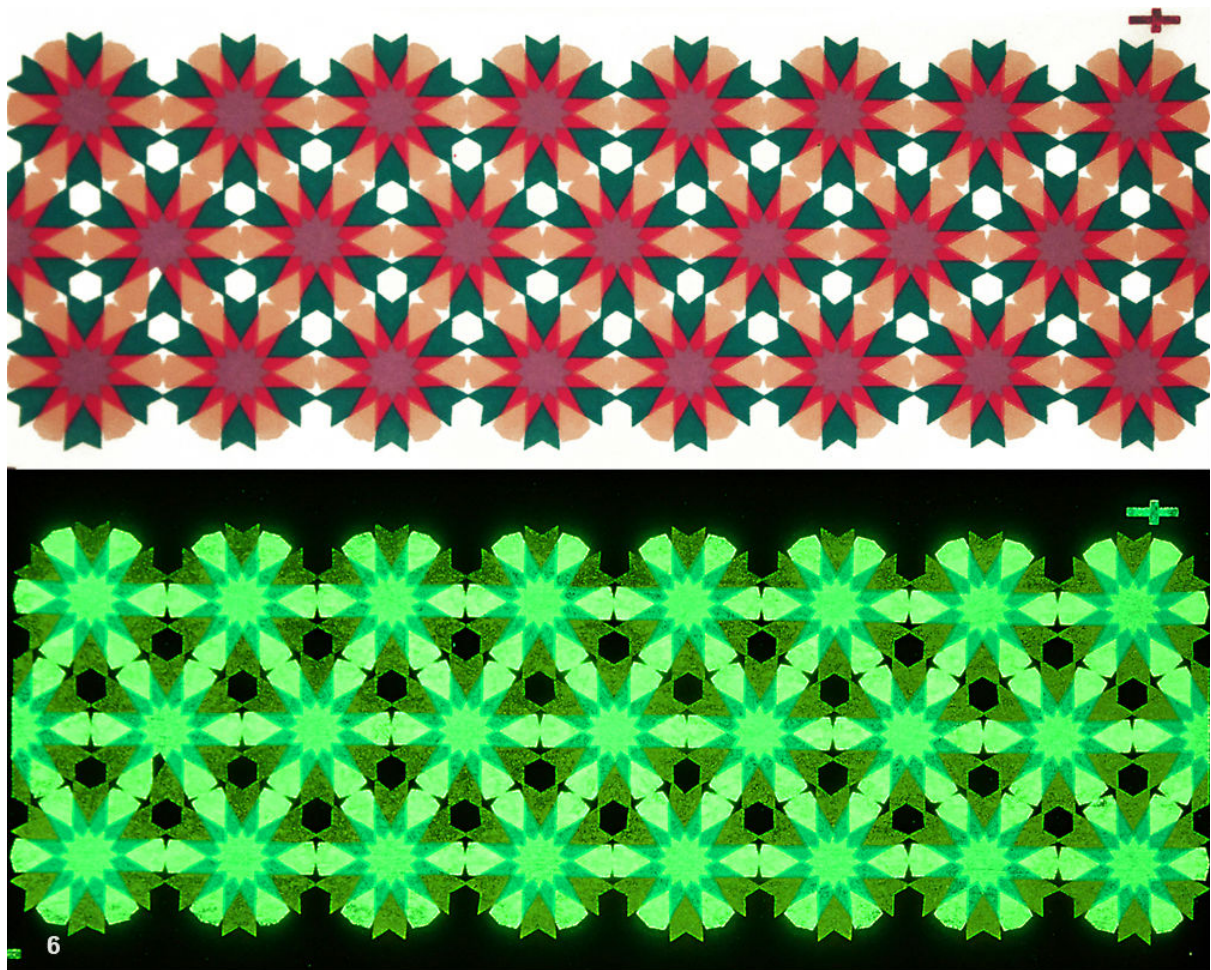


Figure 6 shows a two-phase plain pattern which had an identical form in daylight and darkness, but two different expressions in daylight and darkness. From top to bottom; the effect produced by the printed fabric in ambient daylight, and the effect produced by the printed fabric in darkness.

Discussion and conclusion

This research has examined the design properties and potentials of photo-luminescent pigments when used with textiles as design materials to facilitate understanding and the design of glow-in-the-dark patterns on textiles.

The contribution of this article to the textile and fashion design field is a series of recipes, the result of mixing photo-luminescent pigments and conventional textile pigment pastes, which can be used as new design materials with which textile surface pattern designers may create light-emitting textiles. In addition, it has

proposed a method of printing a two-phase plain pattern with two different expressions in daylight and darkness.

The colours of positive and negative spaces were reversed in darkness, which offers the opportunity to create a tessellated surface pattern in which compacted units define the shape of one another. Thus, there is the possibility to create a glow-in-the-dark pattern on textiles with one expression in daylight and another in darkness. Because the glow-in-the-dark effect produces a subtle glow, the next challenge was to find interesting aesthetic expressions. Through the second series of experiments, the photo-luminescent pigment was mixed with conventional textile pigment pastes. In darkness, the mixtures created a gradation of light, halfway between a highlight and a dark shadow and similar to the effects produced by a printed glow-in-the-dark halftone. This means that one could use the mixtures for printing a pattern without first having to convert the surface pattern to halftones. The significance of this for textile and fashion design is that it may facilitate the creation of a two-phase plain pattern with one expression in daylight and another in darkness; the textile pigment mixed with the photo-luminescent created one expression in daylight, and the photo-luminescent pigment created another expression in darkness.

Further work should focus on the interaction between design elements and principles in a composition, when time or light as a new design variable is involved, as these are dynamic design variables. Light changes during the course of the day, and so it has an effect on how we perceive forms, textures, rhythm, and colours.

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