



Applied Research On Design Of Smart Clothing Base On ThermoChromic Material

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ABSTRACT

As people having a higher living standard, customers requires higher level on smart clothing. People transfer their attentions from practicality to scientificness based on the requirement of the color of clothes. Therefore, according to the theory that colors change when lights and temperature change, ThermoChromic material that made from chromotropic dyes and chromotropic fibers get widely used in the smart clothing industry. This paper will disclose the research of the design and application of smart clothing based on the study of ThermoChromic material.

Key words: Chromotropic dyes, chromotropic fibers, smart clothing, thermoChromic pigment powders

The function of dyer used to have fibers or other materials color. Now the function has become not enough for the needs of clothing industry as technology improving and the whole society developing. Nowadays the research on expanding the function of dye has been widened in the world. For instance, dye changes color when it is under light or be heated. Technologists use chromotropic materials in daily clothes and textiles, making clothes produce special color changing, which makes customers feel interested and also break the limited function of clothing. Since, through modern technology, chromotropic materials get rapid developed and used widely. It can make colors and patterns of clothing differ under change of lights, temperature and humidity and change the result from regular steady state change to gleam dynamic state.

Colors have become the basis of some signals and a media of information transmission because different colors provide different feelings for people, plus people have the ability to analyze hue and purity of color. Therefore, when people use natural color materials they synthesize a large number of types of dyes and pigments, and apply them into construction materials,

printing and dyeing industry and clothing. The production of color cannot be completed without the actions of lights and matter. People has already found that some color from plants and animals can produce reversible changes under lights. People invented chromotropic materials that change colors when receiving stimulus like sunglasses, energy saving glass, variable ink etc. based on this finding.

DEFINITION AND APPLICATIONS OF CHROMOTROPIC MATERIALS

Chromotropic materials are those materials produce color change as the external environment changes.

Chromotropic materials lead a classification based on how they change colors when receiving stimulus. Basically, they are classified as photochromic material, thermochromic material, electrochromic material, Humidity sensitive chromotropic material, and some other special chromotropic materials like suppress chromotropic material, and solvatochromic materials. This paper will focus on the discussion of thermochromic material and how it be applied in fashion design.

There are two types of thermochromic materials on the market, one is thermochromic ink. The theory of anti-forgery is using those materials change color when the temperature changes. The features of anti-forgery are the feeling when you touch the material or observe the color changing when materials are heated. Take magic cup as an example, the principle is the same as thermochromic materials in the fashion industry, it appears two different colors when you hold it and heat it. Thermochromic ink has three types, they are color-reversible, color-irreversible, and mnemonic. The other type of thermochromic materials is thermochromic pigment powders. This is one of microcapsule materials that changes color repeatedly when the temperature rises and falls. It is widely used in producing a variety of cotton mixed fabrics like cotton and hamb with pigment prints. Producers add sizing into the surface of fabrics to create the functional results from normal fabrics. The appearance is pasty like cheese. It is the mix of high molecular polymer. The process of changing colors follows the theory of physical thermochromism rather chemical pharmaceuticals. Its production passes the test of EN-71 and RoHS, and can be used in food packaging, toy production and those materials allow direct contact with skin. These two types of thermochromic materials are both world-class raw materials, they are both microcapsule materials can changes color repeatedly when the temperature rises and falls. The use of sensor is also helpful. Its function is mainly embodied in collecting the signals and tests of comfort of clothing and providing in-time tests and monitoring which offers body dynamic measurements and monitoring. According to the functions of these two types of materials, they are non-toxic and non-irritating to the human body because toxic substances like mercury and lead do not existed in the constituent of thermochromic pigment powders. Through the changes of color, people can use it to forecast temperature. This paper will expand experiments in the following part.

The application theory of thermochromic pigment powders in smart clothing

Producers apply the theory of thermochromic pigment powders into smart clothing. Thermochromic pigment powder is world-class raw material, it is microcapsule material that can change color repeatedly when the temperature rises and falls. The picture below is an example of thermochromic pigment powder, when the temperature falls, the color gets deeper, when the temperature gets higher, the color becomes lighter.



Temperature falls
Color is darkening

Temperature rises
Color is lightening

The theory of how thermochromic pigment powder works is that microcapsule encloses invisible materials, coloring admixture and temperature controller. The different temperature interval of chromotropic dyes can be made by different choice of temperature controlling factors. Using the temperature change to control color change. It has developed products like low-temperature discoloration, hand-touching discoloration, high-temperature discoloration, change colored to colorless, change one color to another, and change color to another, then change to third color. The reason that thermochromic pigment powder can be thermochromic and changing colors is because when the temperature changes, the state of matter changes physically and chemically as well. There are two successful examples of materials be used in clothes and textiles, one of them is liquid crystal, the other one is discoloration system that contains different materials like electron donor and acceptor. These two kinds of substances must be enclosed by using micro-encapsulation technology to guarantee the safety to the human body and applied into clothes and textiles, and at the same time make sure colors changes when the temperature rises or falls. Through the technology of printing and dyeing the thermochromic pigment powder can be used in textile production. Printing and dyeing technology is having thermochromic pigment powder applied into fabrics by the process of printing and dyeing. Smart clothing has the both functions of sensing and reflecting. Besides being dressed like other normal clothing, it has some other special functions based on the design. For instance, in different seasons, it can be building the connection between people's psychological feelings and color changing by applying the thermochromic pigment powder on patterns to sense the external environment or internal temperature changing and reflecting people's psychological changes according to the temperature changes by setting temperature intervals.

Research of smart clothing design base on chromotropic materials

Design of smart clothing base on chromotropic materials

1. Example of case and research on clothing type

The design below shows the idea of oversize, the designer has considered practicality.



picture 2

- The oversize design is popular in this year. According to the design in picture2 and picture3, they both applied loose style and also guarantee the practicality of wearing. The designer mainly adopts the H type design and do not emphasize female body figure and waist. Overall the design is drop shoulder, and has loose armholes that are convenient for daily activities. And this type of design is suit for both male and female, so normally the design is unisex. In picture3, we can also see the oversize style, it has a long length and a loose waist.



picture3



picture4

The design in picture 4 is more like the daily dress, but it uses the material of TPU. It has a shorter length than the former design and has a higher practicality of wearing than a normal raincoat. Most of fashion design raincoats are more biased in designed daily clothes.

1. Example of case and research on clothing style

This part will focus on those designs have the high practicality of wearing and are convenient for daily activities. The loose design is convenient for daily activities. Since people wear daily clothes inside raincoats, so it is more comfortable when raincoats are designed loose. As to the style of the design, they are similar to daily dressing style but looser and more like sports style. The cloth in the below picture added a zipper at the top and below because of the length of the cloth. The zipper can help to zip down the half bottom of the cloth. When the cloth becomes shorter, it is more convenient when people need to exercise. The design in picture 3 and 4 have adopted the H type design and have hats to avoid getting wet. The third cloth added detailed design and split clipping. It has different colors on the top and bottom, which makes it more stylish. This type of cloth normally has a long length to make sure the lower part of the body will not get wet by the rain. The first and third cloth both have pockets that provide convenience for people and a bigger size of zipper to be easy to zip up and down. On the contrary, small size zipper is hard to deal with raincoats made of TPU material. As to the use of materials, waterproof and hard materials are the safe choices to match raincoats' functions. As to the transparency of the material, designers choose to make colors gradient. The translucent TPU materials were used in upper half of the body and leg part used transparent TPU materials to emphasize layering. And the lower part of the body can be taken apart when people want to exercise.

1. Example of case and research on clothing color

Raincoat design chooses the blue and white in color to make a strong feeling of transparency. Since people are normally acknowledged that raincoats are designed monotonous and are not fashionable as other clothes, designers try to make this raincoat have both practicality and beauty of the design. Choosing blue is because blue makes people feel broad like skyc and ocean with a broad scene and it also symbolizes eternity. Blue also has some psychological implications to people that make people feel relaxed.

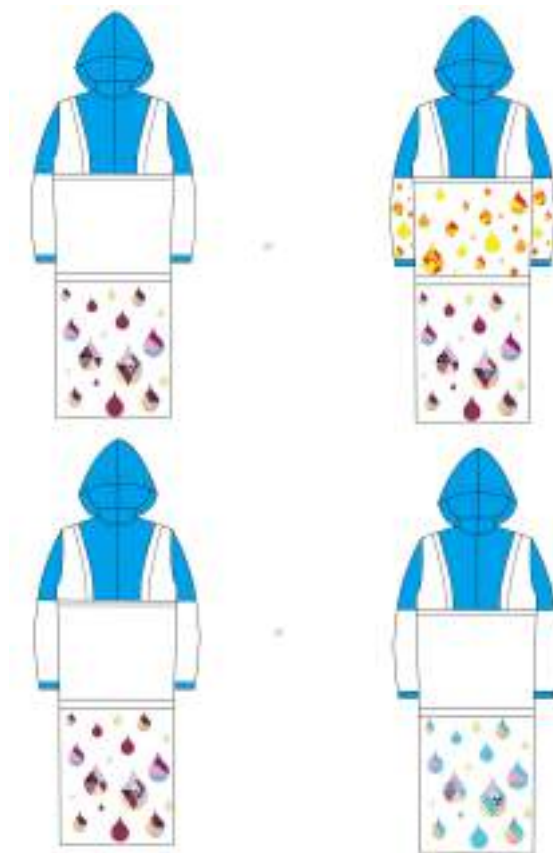
2. Example of case and research on clothing patterns

The inspiration for the design of clothing patterns comes mainly from raindrops to match the style and subject of the cloth. To match the function of chromotropic smart clothing, the patterns of raindrops must be color changeable. Our team members have discreet consideration and serious discussion before we come out the final version of our design. At first, we came up with using leaves changing color to reflect the temperature changing with the plan of 4 colors matching 4 seasons to emphasize the intelligence of the material. However, we overturned it because we were not satisfied with the result of patterns. Our second plan was using concrete childlike patterns like lollipops. After discussion, we came out a small macaron model. It was adorable with a human face and offered with dark and light color choices. But we still repudiated this plan for the reason of mismatch the subject. Finally, we decided to pick raindrops as patterns to design the smart cloth. We started with the shape of raindrops. We changed the shape of traditional raindrops and decided to make it pointed end and chubby to make it more fascinating (see picture 5). To avoid filling colors into raindrop shape being too tedium, we added some designed patterns in the shape to increase some sense of design and taste of interest. We found out it was not good enough that repeatedly use raindrops shape and overlapped the part of pointed ends, so we cut each raindrop into several parts then filled different colors in it. And the last part is color design. Consider the particularity of smart clothing, the patterns need to be color changeable and the colors chosen must easy to be distinguished by people. It must have a wide color changing interval and a large color span to emphasize the humanization of smart clothing rather increase the difficulty of distinguishing the color changes. When the temperature is 22 degrees, the color will change from purple to

blue that changes from warm-toned to cold-toned. When the temperature is 33 degrees, the color will change to yellow from colorless, which is an obvious change of color. It is explained in picture 6.



picture 5



picture 6

Working process of thermochromic material smart clothing

Smart clothing is the combination of several leading technologies, it developed unique ideas and meet the requirement of times development. In addition, the development of smart clothing combines the style, color changes, materials chosen, comfort and hygiene performance of clothes, and also caters to the dressing identity of modern people. Smart clothing's functions can be reached by 4 methods listed below.

1. Make thermochromic pigment powder printed on the patterns. Printing and dyeing is one of the processing methods. It is the generic terms of pre-processing, dyeing, printing, reorganizing and washing.
2. Set the temperature interval. Make it cold-toned when the temperature is 20-35 degrees in summer and warm-toned when the temperature is under 10 degrees in winter. Cold-

toned and warm-toned is a physical category of colors based on psychological illusion. The materiality of color impression is mainly produced by two color systems of cold and warm. Red light, orange light and yellow light produce warm feelings themselves, and give warm feelings when they radiate any colors. On the contrary, purple light, blue light, and green light produce cold feelings. In summer, it is cool when people turn on the fluorescent lamp to instead the incandescent lamp. Colors have the same reactions. For instance, producers use cold colors in the packages of cold snacks and drinks to make consumers feel cool visually. In winter, people can create the warm feelings by using warm-toned curtains.

3. Use sensor in clothing. Its function is mainly embodied in collecting the signals and tests of comfort of clothing and providing in-time tests and monitoring which offers body dynamic measurements and monitoring

CASE ANALYSIS OF SMART CLOTHING BASE ON CHROMOTROPIC MATERIALS

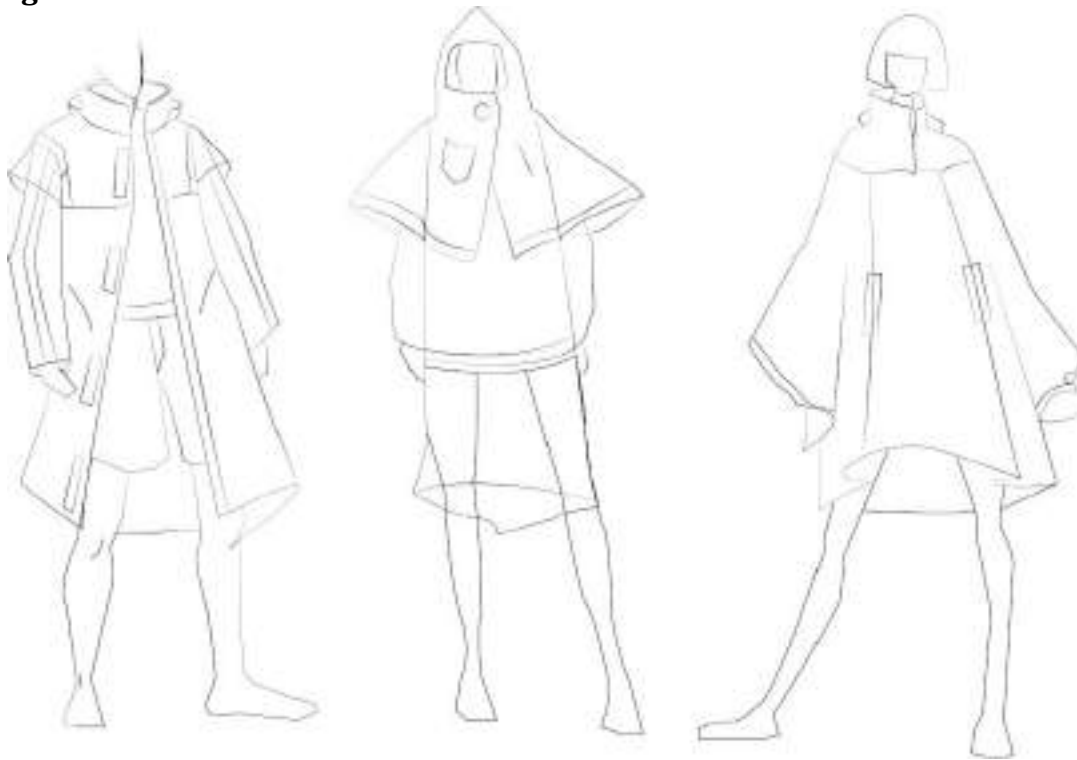
Based on the above rationale, chromotropic smart clothing changes color when external environment changes so that emphasize the connection between color changes and psychological affections. Psychologists found that when people are in a red environment they will accelerate heartbeats, increase blood pressure and be excited and impetuous. But in a blue environment, people will decelerate heartbeats, decrease blood pressure and be calmer. Some scientists found that colors can affect the brainwave. Brainwave is vigilant to red color and relax to blue color. The subject can be changed to the smart raincoat. People generally feel desolate about rainy days. But smart raincoats can bring some pleasant to people. The color changes can make people will more bright and warm.

Design conception: in near future, people's wardrobe will be filled with smart clothing. The huge market demand is obvious and foreseeable. This is because the market is lacking of design for raincoats, and there are precursors want to embody the connection between color change and psychological affections. A color changeable smart raincoat can be applied in a wide range of occasions. It can be used in four different seasons. In summer, the color of raincoats will change to cold-toned for bringing cool feelings mentally, and in winter the color will change to warm-toned to make people feel warmer, for instance. It is proven by scientists' experiments that colors can affect people's moods.

Rendering of design:



picture 7

Design structure:**picture 8****Design plan:**

We added a great sense of fashion in the design with practicality. We focus on the loose style and make it convenient for exercising. To support a strong feeling of transparency, we chose blue and white. As to the materials, we mainly used TPU that is waterproof and quite hard to match raincoats resisting water. When dealt with the transparency we made it gradient to emphasize layering. And the lower layer can also be taken apart. After our plan was approved by our tutor, we started to design the patterns. We prefer to adopt simple and concrete patterns. Since patterns are the central adjustments of our research on smart wearing, we tried our best to make it perfect. After several times of modifications, we started to delineate and improve the rendering.

Patterns design:

We designed the shape pointed end and chubby to make it more fascinating and childlike. To avoid filling colors into raindrop shape being too tedious, we added some designed patterns in the shape to increase some sense of design and taste of interest. See picture 9 and 10.



picture 9



picture 10

A color changeable smart raincoat can be applied in a wide range of occasions. It can be used in four different seasons. In summer, the color of raincoats will change to cold-toned for bringing cool feelings mentally. And in winter the color will change to warm-toned to make people accelerate heartbeats, increase blood pressure and be excited. The picture 11 shows the finished raincoat.



picture 11

CONCLUSION

The purpose of using chromotropic material to make clothes is to provide better experiences for people. Researching and analyzing the practicality and creativity of the smart raincoat makes our team members feel excited. From the single function of keeping out the cold to sorts of functions, people are expecting to use functional clothes to satisfy the needs of modern lives. As fashion designers, we want to improve our ideas by using chromotropic material smart

clothes to reach the purpose of refreshing user experience. Use chromotropic raincoat can change people's feelings about rainy days and bring some pleasant to people. Smart raincoat also builds communication between users and smart fashion productions, and embody the connections between colors and psychological changes to make subtle mental changes happen.

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