

## **Eco-tech fashion: A visual platform to raise awareness about climate change**

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### **Abstract**

The fashion industry accelerates climate change, and its responsibility is more important than ever. Fashion design practices have greater sustainable potential than commerce. Indeed, fashion designers can be activists through their design practices by choosing sustainable fabrics and creating fashion collections that raise awareness about climate change. To bring new visual impact and functionality, intelligent textiles can be an attractive option for fashion designers.

Previous research has only focused on either strategy for design activism or technological fashion material without bringing these two concepts together. For this, the concept, eco-tech fashion, defined by Scaturro (2008), can help design practitioners to create a novel, innovative, and sustainable collection.

This dissertation created an intelligent textile that reacts to atmospheric CO<sub>2</sub> through its color-changing characteristics. Chemical experiments were conducted to develop this textile, and the first focus group evaluated its practicality and visual appeal. Innovative textile experts shared their insights on the link between design activism and eco-tech fashion. The collection produced from this research is perceived as an attractive form of design activism to warn about environmental crises. The produced video as a campaign video of the collection was viewed by the second focus group and it proved its visual communicative ability to a new audience, the generation Z.

Following the results, this study suggests a new role of the fashion designer as an activist-design practitioner and proves the potential of active-type, intelligent textiles to function as an artistic expression. Moreover, it stresses the importance of visual impact to speak to an audience already committed to changing their behaviors to benefit the planet.

**Keywords** : Intelligent textile, smart textile, interactive textile, design activism, climate change, color-changing, Eco-tech fashion, fashion designer, video communication

**ISBN:** 978-989-54263-2-4

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## 1. Introduction

Over the past 50 years, atmospheric CO<sub>2</sub> levels have risen from 325ppm in 1970 to 413ppm in 2020. Previously, the highest level recorded was 300 ppm during the preindustrial era. If fossil fuels are continuously consumed, and global energy continues at its current growth speed, atmospheric CO<sub>2</sub> will exceed 900 ppm before this century ends (Lindsey, 2020:Online). According to the World Bank (2019:Online), 10% of annual global carbon emissions are produced by the fashion industry, a larger amount than the displacement of 'all flights and maritime shipping' and 'by 2030, the fashion industry will be responsible for 50% of global warming gas emissions.'

Design thinking and craftsmanship applications have a greater potential for sustainable fashion design practice than commerce (Fletcher and Grose, 2012). A fashion designer should be actively involved in making actions rather than avoiding social problems exacerbated by the production and consumption of fashion products (Krippendorff, 2006). Designers can contribute to social innovation and sustainability by participating in contemporary design practice as design activists (Mazzarella et al., 2019). Fuad-Luke (2009:49) claimed that to face the challenge of 'the environmental, social and economic crises in the global, and regional/local, economies,' there is a growing need for new design activists.

Miles (2016) highlighted that art should overturn the social order to raise awareness about climate change. However, there is no research on integrating visual communication with the design activism concept to raise awareness about climate change. Therefore, this dissertation connected design activism with environmental issues and visual communication through practice-based research and secondary research.

Intelligent textiles are evolving in the active sense, such as interactive textiles that can warn wearers in case of danger or rapidly adapt to the wearer's surroundings for their safety. In addition, it also has the potential for fashion design and can be fused with traditional craftsmanship to satisfy novel aesthetic needs through collaborative practice between textile engineers and artists/designers (Syduzzaman et al., 2015; Canavan, 2015). However, no one has focused on fashion design practices with interactive textiles that collect data around the wearer's surroundings, not limited to medical or sports devices.

In this context, the sensibility of eco-tech fashion can help to correlate design activism and intelligent textiles. Scaturro (2008) claimed that eco-tech fashion is the future of fashion by achieving sustainable goals through an

emphasis on the role of technology. This research investigated the potential of eco-tech fashion as a visual communication tool to raise awareness about climate change.

An intelligent textile was developed to warn about the dangers of climate change through chemical experiments. This textile can sense atmospheric CO<sub>2</sub> and express it through color changes. Four interviews were conducted with designers and researchers who specialize in innovative fashion material to link design activism and intelligent textiles.

## **2. Literature review**

### *2.1 Design activism for fashion design and its approach to visuals*

#### *2.1.1 The definition of design activism*

Fuad-Luke (2009:27) claimed that design activism has a great potential to help designers who apply their designs to contribute to positive social changes and defined design activism as:

design thinking, imagination and practice applied knowingly or unknowingly to create a counter-narrative aimed at generating and balancing positive social, institutional, environmental and/or economic change.

Thorpe (2011; 2014:Online) has pointed out that unconventional methods are often used for design activism to provoke changes that are neglected in the social context and advocate for social change even if this occurs through for-profit activities.

#### *2.1.2 Video as visual communication and design activism*

Markussen (2013:40) has claimed that design activism may demonstrate 'an act of communication' by creating visual information. Thorpe (2011) has identified design's ability as a visually powerful tool for a better future that makes more meaningful design activism practices. Blair (2004) also emphasized the power of vision as it adds a story and brings the argument into another dimension. Visuals can bring better communication, sometimes surprising for activist causes and this is an effective and nonviolent way to deliver a message (SFMOMA, 2014:Online, Duncombe and Lambert, 2018:Online).

Miles (2016) investigated whether art contributes to awareness of climate change. He determined that if the artwork has no visual impact, it would not have any noticeable effect. Artwork should interrupt a perception that affirms the social order to raise awareness about climate change.

The relationship between video and activism has shifted with the evolution of social media and with its characteristics as a 'new form of audio-visual immediacy;' video plays an important role as a contemporary communication tool (Chanan, 2011:278). To affect and attract audiences, video and visual artifacts can be effective

tools for social movements; this type of video activism is characterized by 'the material arrangements of artifacts involved' (Askanius, 2019:145).

### *2.1.3 Examples of fashion design activism driven by ecological reasons*

Historically, fashion designers have used the runway as a site of resistance, creating garments that speak about political issues (Tutton, 2019). Banerjee (2008:9) defined fashion designers as 'agents of appropriate change' or 'catalysts for systematic transformation,' protesting against the prevailing unsustainable fashion cycle. The role of a fashion designer has expanded with fashion activism, allowing for creative possibilities that vocalize critical sustainability challenges with a focus on design as problem re-framing instead of problem-solving (Williams, 2018).

Fashion designers are required to find out ways of 'knowing, thinking, and acting of fashion activists' to challenge the current fashion cycle in regard to sustainable practices (Mazzarella et al., 2019:823). There are several illustrative examples of fashion design activism methods by designers who practice sustainable fashion for ecological reasons.

One such example is Bethany Williams, who created a collection with 'recycled fabrics made by an Italian rehabilitation program that teaches people with drug dependencies traditional crafts.' This collection included upcycled denim pieces, hand-knit jumpers, and pants made of deadstock yarns from Wool and the Gang (Kent, 2019: Online).

Another example is Botter by Rushemy Botter and Lisi Herrebrugh. This Grand-Prix winner duo of Hyères created 'fishing nets and the Shell logo (minus the S)' to warn about ocean pollution. They spoke about sea life that lost their habitats in nature and became stuck in plastic bottles or cans (Moss, 2019: Online).

A third example is Hyundai, an automobile manufacturer, which collaborated with six designers to find sustainable ways to create fashion items from discarded materials from cars. For example, Seung-gun Park of pushBUTTON created a vest from airbag materials otherwise destined to go to the landfill. Rosie Assoulin made a tote bag from repurposed seatbelts and carpet fabric (ELLE, 2020: Online).



(from left to right)

Figure1: Look

1 of Bethany

Williams

19FW

(Source:

Singer,

2019:Online)

Figure2: Look 7 of Botter in Hyeres festival (Source: Cardini, 2018:Online)

Figure3: PushBUTTON (Source: ELLE, 2020:Online)

## 2.2 Eco-tech Fashion

### 2.2.1 The introduction of eco-tech and eco-tech fashion

The term 'eco-tech' was first used by Slessor (2001:7) in her book, *Eco-tech: Sustainable Architecture and High Technology*. She introduced eco-tech as:

rationalized industrial processes into building construction to create neutral, flexible, expendable environments that have evolved into an increasingly diffuse and complex style. This concept can embrace wider concerns, including placemaking, social responsiveness, energy use, urbanism and ecological awareness as opposed to High Tech.

Eco-tech fashion was introduced by Scaturro (2008:475) to adapt eco-tech architecture's sensibility to fashion. She defined eco-tech fashion as:

an idea that insists upon the emergence of a sustainable fashion system through an innovative technological framework containing thoughtful manufacturing processes and consumption patterns.

Scaturro (2008:475) claimed that eco-tech fashion emphasizes technological systems that are more democratic and sustainable than the current prevailing technologies. Additionally, Choi (2019) has pointed out that although eco-

fashion and techno-fashion are generally regarded as a conflicting relationship, they can work together to bring sustainability to the fashion industry.

### *2.2.2 Material-driven design methodology and its practices for eco-tech fashion*

Material-driven design commences with material engagement while exploring it, or 'where a material is designed, grown, or developed' (Bak-Andersen, 2018:12). The most significant feature that distinguishes a material-driven design process from a typical one is that while 'designing, developing and manipulating the material,' the designer plays a key role from the beginning rather than selecting a material to fit the form once the design process is already terminated (Bak-Andersen, 2018:12).

Karana et al. (2015) have claimed that a strong comprehension of the material is the most important step during the design process to identify a material's unique characteristics and limitations. The designer can create and evaluate the material's potential through an exploration throughout all stages of the process. Oxman (2010) has highlighted how innovative forms of craft in the past have been created with the development of material science, and the role of the material was not just a substitute of the previous form but its starting point.

As an example, in the fashion industry, Issey Miyake used unfamiliar materials and new technologies. Issey Miyake believed that 'any material can be turned into clothing,' and he used 'Japanese washi paper, horsehair, and raffia.' Miyake continues to develop new materials and methods while practicing traditional techniques and craftsmanship in his fashion designs (Yamanaka, 2016:Online).

The creative director of Issey Miyake, Yoshiyuki Miyamae, has spoken about how he works with the studio to experiment with new technology. For the SS16 collection, the Issey Miyake team invented a new technique called 3D Steam Stretch that 'uses steam heat to shrink thread.' It evolves with the use of materials from nature and color variations (Balmat, 2015:Online). This technology development took over a year, and the team conducted numerous tests to study how many times a consumer would be able to wash the clothing (Howarth, 2014:Online).



*(from left to right)*

*Figure4: Horsehair jacket and shirt, Issey Miyake AW 1990 (Source: Tran, 2016:Online)*

*Figure5: 3D stream stretch dress. (Source: Hoawarth, 2014:Online)*

### *2.2.3 Intelligent textiles for eco-tech fashion and its applications*

Intelligent textiles are generally understood as ‘clothing, footwear or accessories integrate micro/nano-electronic sensors’ or computing components to sense, react, and adapt to changes in their surroundings (Waqar et al., 2015; Timmins and McCann, 2015; Joshi and Adak, 2018:2). This was a general idea that intelligent textiles should include electronic devices that can compute information. However, Syduzzaman et al. (2015) pointed out that intelligent textiles can also be made by incorporating phase change materials or conducting polymers without electronic equipment as long as they can react to external environments via a pre-defined control mechanism.

Interactive textiles are a new field with great potential in the intelligent textiles domain. It can be imagined as a material that can warn wearers in case of danger or sense data to let wearers change their surroundings rapidly for their safety. Interactive textiles have a decorative potential for fashion design and can be fused with traditional craftsmanship to satisfy novel aesthetic needs through collaborative practice between textile engineers and artists/designers (Syduzzaman et al., 2015; Canavan, 2015).

### *2.2.4 Chromic materials and their application to raise awareness of the environmental crisis*

Color provides information and messages about important facts such as occupation, signs, and warnings, and our perception of color is usually influenced by our emotions (Fiesner and Reed, 2014). As an interactive material, chromic materials are the forms of

dyes and pigments that exhibit a distinct color change when exposed to an external stimulus and especially when the change is reversible and controllable (Christie, 2013:3).



This new type of paint, dye, and ink clearly shows its capabilities for transformative effects through its dynamic and responsive nature (Brownell, 2017). These materials have mostly been used in fashion to create eccentric designs with color-changing characteristics.

Viirj et al. (2016) developed a 'bleeding umbrella' that reacts in the presence of acidic rain and shows red streaks on its surface. Acidic rain is accelerated by the incomplete combustion of fossil fuels, which creates a mixture of sulfur dioxide and nitrogen oxide that contributes to rain acidity. The invention gives a contextual connection with acidic rain and pollutants with its strong visuals to the public.

Bowker's PdCl<sub>2</sub> Jacket reacts to carbon monoxide (CO) in the air, and it shows how toxic the air is around the wearer, changing between yellow and black. Bowker's invention intends to raise awareness of global environmental hazards, including human health-related toxins (Brownell, 2017).



*(from left to right)*

*Figure6: Bleeding Umbrella (Source: Viirj et al., 2016)*

*Figure7: PdCl<sub>2</sub> Jacket (Source: Brownell, 2017)*

### **3. Methodology**

#### *3.1 Design activism for fashion design and its approach to visuals*

Literature from various sources was reviewed to understand what design activism is, how fashion designers should engage with debates about the environmental crisis through the design process, and intelligent textiles adapted to this research. Four semistructured interviews with fashion material designers and researchers were conducted to compare different researchers' insights about materials and how they see the current fashion industry's practice about materials and the designer's role.

Explanatory research was applied to develop an intelligent textile for a fashion collection and determine if this collection can be regarded as a meaningful act that raises consumer awareness about climate change. An intelligent textile that senses atmospheric CO<sub>2</sub> was developed through chemical experiments and adopted by the collection to optimize its functionality. The first focus group aimed to study the general awareness of intelligent textiles and sustainable fashion. The second focus group study was conducted to evaluate how effective the produced video is for raising awareness about climate change.

#### *3.2 Research strategy*

##### *3.2.1 Semi-structured interviews*

In this research, four semi-structured interviews of 30 mins duration were conducted with experts in sustainable and innovative fashion textiles, and all the interviews were transcribed and analyzed thematically. The interviews that were conducted in languages other than English, for example Hyerim Kim - Korean and Emma Bruschi - French, were later translated to English. The original language transcripts were also documented to ensure that a bias is not made by the researcher-translator (Temple and Young, 2004).

Sarah Scaturro is the author of 'Eco-tech Fashion: Rationalizing Technology in Sustainable Fashion,' who first defined the term 'eco-tech fashion.' As a pioneer of this research area, she shared her insights to let the researcher gain preliminary information and better understand the concept of eco-tech fashion.

Hyerim Kim is a researcher and professor who studies innovative textiles in Korea and specializes in bio-materials. She was asked to answer questions for a better understanding of innovative textiles and their limitations.

Emma Bruschi is a fashion designer and a winner of the Chanel Métiers d'art prize of the 2020 Hyères festival. Her collection was an exploration of a new weaving technique using straws and naturally dyed materials. She was asked to answer questions regarding the process of the material-driven design method with biodegradable material in slow fashion.

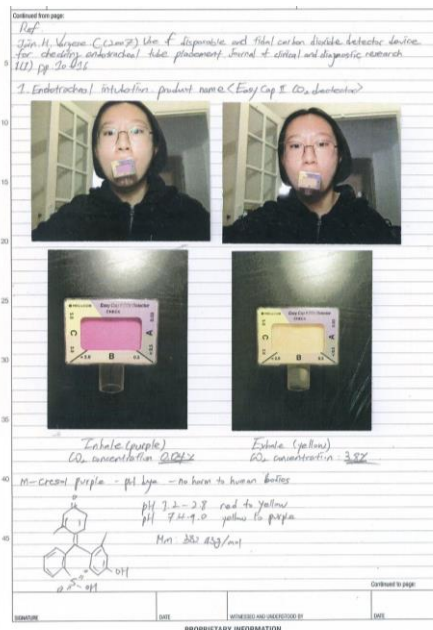
Jen Keane is a material designer who specializes in genetically modified organisms to make fashion accessories. She was asked questions regarding future innovative fabrics and the relationship between the fashion designer and material designer.

### *3.2.2 Chemical experiments*

This dissertation primarily focused on chemical experiments to develop an intelligent textile that raises awareness of climate change. The researcher produced CO<sub>2</sub> reactive chromic dye using commercially available chemicals purchased from online shopping platforms (e.g., eBay, Amazon). The researcher faced limitations of access to a professional laboratory since her institute does not have laboratories. All chemical experiments were conducted in the researcher's apartment. The instruments used for this experiment were rudimentary – a heating plate, a scale, beakers, lab spoons, and an air quality meter.

The starting point came from an invention, a 'CO<sub>2</sub> detector for determining the correct location of an endotracheal tube following intubation of a patient' (Nelcor Puritan Bennett Llc., 2007). Following this patent, the pH dye that can sense atmospheric CO<sub>2</sub> in a buffer solution, m-cresol purple, was chosen as the material to be included in the recipe. To find the recipes to make the material to detect atmospheric CO<sub>2</sub> and find appropriate substrates, patents and scientific journals were reviewed. The recipe and process were documented in the laboratory notebook (Bak-Andersen, 2018).

In the beginning, experiments were conducted to explore the materiality of a pH dye. The applicable recipe for the material was found, and different fabric pieces were dyed to find the best performing material. The performance of the intelligent textiles was measured with an air quality meter to define which level of CO<sub>2</sub> turns this textile's color from purple to white and white to yellow.



(from left to right)

Figure8: Lab notebook #1 (Source: Jung, 2020)

Figure9: Lab notebook #2 (Source: Jung, 2020)

### 3.2.3 Practice-based research

As practice-based research, silhouettes and styles came from modern lab coats of female scientists. The research began with Marie Curie and Irene Curie, the mom and daughter, two nobel-prize winner scientists, who researched radioactivity during their lifetime. Since the fabrics of lab coats are mainly cotton, different woven cotton fabrics are purchased from C.Pauli, a German GOTS certified organic cotton supplier to gain more sustainability as a base material. A tonal palette was chosen to optimize the design intention of CO<sub>2</sub> reactive dye.

A campaign video was filmed in multiple locations in Ile de France to make a mood transition by changing backgrounds from grey monotone modern architecture to green garden. A scene that shows a color change depending on the CO<sub>2</sub> concentration is planned with a glass box to control the air quality of it, and the models in the collection were standing still till the color changed from purple to yellow to purple again.

### 3.2.4 Focus group

First group is composed of 6 participants, a demographic group of millennials living in France who are born between 1990 to 1996. Its discussion was conducted on the 7th of December 2020 at 14:30 in the theory room of Istituto Marangoni Paris. Before starting the discussion, participants could see, touch and try freely the collection created by this dissertation project on mannequins. The researcher demonstrated how these gloves react to atmospheric CO<sub>2</sub> and demonstrated the color change with a simple experiment. After the demonstration, the researcher asked six questions regarding intelligent textiles and sustainability and discussed them with the participants.

Second group is composed of 6 participants, a demographic group of generation Z living in France who are born between 1997 to 2000. This discussion was conducted on the 26th of September 2021 at 15:00 by Zoom meeting. Before starting the discussion, participants watched a campaign video and listened to the brief presentation of the collection. After watching 90 seconds of video, the participants were asked to answer the questions regarding the message of the video and how the media impacted them to learn about social issues.

### *3.3 Research limitations*

According to each interviewee's interests, the five same questions were asked of them, and 2–3 interviewees answered each question to generalize the findings. Each interviewee was asked to answer 1–2 customized questions as well, and, consequently, these questions were answered by a single interviewee; it might be hard to generalize their findings because different interviewees were asked to answer different questions (Wilson, 2014).

This research conducted two focus group researches, which include relatively young generations, millennials and generation Z, living in France. This cannot generalize its discussion to all generations.

With limited access to a professional laboratory, the researcher was encouraged to use commercial materials easily found on the internet. Most materials were purchased from online platforms like eBay, Amazon, and a pharmacy. The purity of these materials is not high enough to conduct chemical experiments; thus, the accuracy of the measurements is not guaranteed. Access to professional instruments was limited, as well. This made the size of the CO<sub>2</sub> reactive part of a garment relatively small. Since the instruments are not intended for accurate measurements, inaccurate data was inevitable.

## **4. Results**

#### *4.1 Semi-structured interviews*

##### *4.1.1 The attitude of the fashion industry toward sustainable fabrics*

When asked about the fashion industry's attitude toward sustainable fabrics, the interviewees have seen a positive change in the industry. However, two interviewees pointed out that greenwashing should be avoided, and more information should be provided to consumers.

Kim (2020) made an optimistic forecast about the textile industry that it would be more likely to use eco-responsible fabrics, such as recycled polyester and organic cotton, and consumers are more likely to purchase items that are less harmful to the environment since this situation is accelerated by the global pandemic issue that recalls the responsibilities of human activities that brought this difficult situation. Both Keane (2020) and Scaturro (2020) agreed that there more awareness has been raised about environmental issues and the pollution created by the fashion industry to the public and people from the industry; however, both interviewees were concerned about the lack of information, a concern which Scaturro (2020) explained through the example of bamboo fabric:

“I had this lovely bamboo sweater, and it was so soft and lustrous. (...) it is actually totally manmade. (...) It is like a viscose kind of process where they have to dissolve all the cellulose and then just reconstitute it and spin it out. How is that any more natural?”

##### *4.1.2 Innovative textiles in the future*

Each interviewee made different forecasts when asked what kind of innovative fabrics people will wear.

Although Kim (2020) agreed there is an evident potential with intelligent fabrics, she was skeptical of current intelligent textiles. To overcome the current problem that intelligent textiles face, commercialization, a greater functionality should be applied on traditional functions of fabrics, comfort, and protection. Keane (2020) envisioned the potential of performance fabrics and has been skeptical regarding the living organisms for fashion products, although, in many fields, including architecture, living organisms are used as innovative material. Scaturro (2020) paid attention to technologies that can enhance the sustainability of fabrics. For example, non-woven fabrics may be developed according to the zero waste concept, and this idea will be applied from the polymer level.

It is clear from the responses that innovative textiles are expected to become more popular in the future. However, each interviewee had different predictions regarding what kind of innovative fabrics will be developed.

#### *4.1.3 The designer's role in the development of innovative textiles*

Keane (2020) and Bruschi (2020), as designers interested in innovative textile designs, pointed out the importance of the designer's role in the development process.

The greater potential can be realized through collaborations between fashion designers and material scientists/engineers in developing innovative textiles, although it was rare to see this type of collaboration so far in the fashion industry (Keane, 2020). While Bruschi (2020) stated her presence as a fashion designer to focus on materials first in the design process, the sources of materials and how they are processed should also be considered to create sustainable fashion along with craftsmanship. Bruschi (2020) did not use the correct term of "material driven design method"; however, her previous collections can be recognized as material-driven design projects since she explored raw materials to make fashion collections by collaborating with local artisans.

#### *4.1.4 Design activism with choosing sustainable fabrics*

Kim (2020), Bruschi (2020), and Scaturro (2020) agreed that choosing sustainable fabrics can also be activism for fashion designers. No matter how many eco-friendly materials are developed, if designers do not choose them, there is no way to deliver them to the consumer (Kim, 2020). As Bruschi (2020) pointed out, giving priority to sustainable fabrics can be an obvious choice for young designers. All kinds of choices by designers can be a form of activism, such as choosing materials, whom they work with, and how to advertise them (Scaturro, 2020).

#### *4.1.5 The potential of CO<sub>2</sub>-reactive intelligent textiles*

All participants recognized the potential of CO<sub>2</sub>-reactive intelligent textiles as a form of activism to raise awareness about climate change.

Bruschi (2020) and Kim (2020) took this as a practical and attractive tool to be aware of the consumer's environment. Kim (2020) indicated that this type of textile could be seen as an active type of intelligent textile and

its practicality as a dye without computing devices. Scaturro (2020), as a researcher who defined the term “eco-tech fashion,” agreed that its definition could be extended when this type of intelligent textiles can send messages about climate change. Keane (2020) pointed out that the message of its invention should be tailored carefully for its audience.

#### *4.2 Chemical experiment*

Chemical experiments succeeded in developing a CO<sub>2</sub>-reactive chromic textile to be used to collect this research. The formulated dye is applied to organic cotton because of its hydrophilic nature, and, as design activism, using sustainable fabrics can be encouraged in this dissertation. This CO<sub>2</sub>-reactive intelligent textile shows purple color in low CO<sub>2</sub> air (0.04–1%) and a bright, white color in high CO<sub>2</sub> air (1–10%). In extremely high levels of CO<sub>2</sub> in the air (~10%), it turns a yellow color. The range of CO<sub>2</sub> reaction is not close to the breathable air range(0.04-1%), thus the range should be moved to use the textile in real life more practically. However, this material was washed off after rinsing with water. This research should be studied further for its commercialization to enhance its lifetime.

#### *4.3 Practice-based research*

##### *4.3.1 3D-development and silhouette research*

The process of silhouette development is documented in the research book under the form of laboratory notebook. As the elements of lab coats for women are implemented to the collection, it is a form of homage to female scientists who are committed to science even under dangerous environments like high CO<sub>2</sub> air pollution. All items are developed as a ready-to-wear collection of the spring-summer season. It includes three outfits with 1 vest, 2 dresses, 1 shirt and 3 pants.

##### *4.3.3 Video as a visual communication tool*





(from left to right)

Figure10:  
Glass box scene of a campaign video #1

(Source:

Jung, 2020)

Figure11: Lookbook #1 (Source: Jung, 2020)

Figure12: Lookbook #2 (Source: Jung, 2020)

To show how the developed intelligent textiles react to CO<sub>2</sub>, a short video was filmed of the collection. The researcher aimed to bring an artistic articulation of a message by visualizing the presence of CO<sub>2</sub> in the air. The models wearing the produced collection were in the glass box of which CO<sub>2</sub> concentration was controlled by the researcher to show a rapid color change. The locations of this video were switched from a grey color modern architecture to a small garden in Paris to create a positive message.

The movie has been distributed through Youtube, one of the largest video streaming platforms to make the public aware of climate change and its wider impact (Hermida and Hernández-Santaolalla, 2018).

#### 4.4 Focus group

The first focus group research found that all participants have not tried intelligent textiles. All participants related sustainability in the fashion industry to eco-responsibility and ethics. Five participants answered that they try to change their behaviors by recognizing climate change by using fewer plastics, buying eco-responsible products and high-quality products, and not shopping at fast fashion brands.

Participants answered positively to the question: What do you think about color-changing fabrics? Is it something you want to wear? Four participants answered that the color range of color-changing textiles was important. One

participant answered that the color range does not matter. Thus, it is understood that color range is an important feature for color-changing fabrics from the customer's perspective.

Four participants said they expected fabrics to be comfortable, and three participants expected durability. One participant expected stylishness from fabrics. Three participants expected to see this textile from artistic fashion items rather than basic items, and two participants wanted more accessible items with this textile. One participant pointed out that the design intention should be related to the textile characteristics.

It is clear from the responses that the participants were interested in intelligent fabrics; however, it has to have the functionalities of traditional textiles, not only aesthetics but also durability and comfort.

The second focus group research found that most participants understood the message of the video is to warn about climate change by visualizing the presence of CO<sub>2</sub> in the air. Some participants pointed out that the video is abstract and not clear enough to understand what it means if there is no explanation in advance about the collection. Most participants captured the scene of models in the box and color-change as the strongest scene as it represents the current status and issues that the society should give more attention. Some participants read the positive message of the video from the transition between different locations, into the greener place.

For the question : what kind of media is the most effective tool to raise awareness about climate change, the answers vary. One participant answered that it is clothing because it is the closest object to the human body. Three participants answered that social media can be a powerful tool with focusing on how Gen Z consumes short videos whereas one participant answered that photography with text can be a more democratic tool to advertise the message to all generations.

Most participants answered negatively about how effective the campaign videos are about raising awareness about social issues. They pointed out that fashion campaign videos are usually for selling more products and gathering more clients of younger generations. One participant shared her positive image about one company, a second-hand marketplace, about its ecological value, whereas another participant criticized a cosmetic brand that uses 'greenwashing' to sell its organic products.

## **5. Discussion**

### *5.1 Intelligent textiles*

The results indicated that this study successfully developed an intelligent textile as design activism to raise awareness about climate change. Until now, previous publications related to technology and sustainability and focused on sustainable practices or materials themselves. Therefore, this study brings activism to raise awareness about climate change with an intelligent textile that can detect high CO<sub>2</sub> concentration surrounding the wearer, and this is the first approach as a fashion garment, not a medical device.

Even though consumers are not yet familiar with intelligent fabrics, the purple to yellow color range of the invention of this study is visually appealing. Most first focus group research participants expected to see this type of textile in the original designs of garments. Due to the decorative potential for fashion design, an intelligent textile is expected to bring new aesthetic needs from previous studies (Syduzzaman et al., 2015; Canavan, 2015). Following this argument, Kim (2020) paid attention to the practicality of the invention, as a dye without computing devices usually applied on intelligent fabric, and as an interesting form of activism. On the other hand, most of the focus group participants mattered all shown colors for chromic materials with a reason for styling. If all the colors of the developed intelligent textile, purple, white, and yellow, are not appealing enough, the effect of this collection in terms of visual communication may vary according to the personal tastes of individuals.

The material-driven design method is well suited for this type of fashion design project that is accompanied by material exploration as the designer can take a key role to design from the beginning to create an innovative form of craft rather than simply select a material to fit the designs (Bak-Andersen, 2018; Oxman, 2010). Fashion designers can create sustainable fashion with a clear understanding of the sources of materials and how they are processed while focusing on materials from the beginning, and their roles are not limited as product designers but include their potential as activists with consideration of all steps of production, marketing, and transportation before products are delivered to customers (Bruschi, 2020; Scaturro, 2020). In this context, it is understood that a designer's role can be extended without limitations. For innovative textile development, collaborations between fashion designers and materials scientists/engineers are encouraged (Keane, 2020).

Nevertheless, the researcher faced limitations during chemical experiments due to limited access to professional laboratories. Its functionality should be measured with more advanced instruments. Additionally, the dye was

washed off after washing this textile a single time. The commercialization can be discussed once this textile is enhanced to endure multiple washes.

The CO<sub>2</sub> concentration range that activates color change (>1%) is too deviated from the breathable range (0.04 ~ 1%) and to make it more practical for ready-to-wear, the range has to be controlled.

## *5.2 Design activism*

The produced collection is a series of artifacts of design activism, and the results demonstrate the correlation between eco-tech fashion and design activism. Through practice-based research, design practices created a counter-narrative to raise awareness about climate change (Fuad-Luke, 2009). The artifacts are meant to support the claim that design activism is an effective communication method (SFMOMA, 2014:Online, Duncombe, and Lambert, 2018:Online). The secondary research from Miles (2016) also highlights the visual impact of artwork to have a noticeable impact on climate change. The focus group confirmed the visual impact of the collection as they found the color-changing material as an attractive form of activism that reacts to atmospheric CO<sub>2</sub>.

Through practice-based research, a ready-to-wear collection with original designs was created, and Scaturro (2020) found the aesthetics of the developed intelligent textiles as a “couture idea” since the idea is novel. The majority of the focus group expressed the desire to see the developed intelligent textiles from original designs as well.

The second focus group study demonstrated that the produced video gives a metaphorical and intense message about climate change. The short video (<90s) distribution to social media is preferred by generation Z however, most participants found the commercial campaign videos deceptive as the companies usually aim for their commercial success.

The interviewees agreed that the designer could also take on the role of an activist in the phase of sustainable fabric choices because no matter how many eco-friendly materials are developed, if designers do not choose them, there is no way to deliver them to the consumer (Kim, 2020; Scaturro, 2020). The sustainable fabric choice is obvious for young designers like Bruschi (2020). However, Scaturro (2020) and Keane (2020) are concerned about greenwashing issues, and they mentioned more accurate information regarding how the fabrics are processed, should be delivered to consumers. Kim (2020) argued that to create a sustainable, intelligent textile, using sustainable fabrics as its base material can be the easiest way to achieve sustainability. Following these findings

from interviews, this study used organic cotton to determine if the formulated dye can be applied to sustainable fabrics to make an intelligent textile.

To speak about climate change through design activism, the message should be accurate for the targeted audience (Keane, 2020). The audience of the collection is mostly people who employ eco-responsible practices in their everyday life. Most of the focus group participants are aware of pollution issues related to the fashion industry, and they are trying to change their habits to be eco-conscious consumers. These findings show that the color-changing CO<sub>2</sub>-reactive intelligent textiles can speak to an audience seeking environmentally friendly products and educated about climate change.

### *5.3 Eco-tech fashion*

The results prove that this dissertation achieved a new form of eco-tech fashion that relates a technology for intelligent textiles and environmental activism for the first time. Previous publications that used the concept of eco-tech fashion focus on the materiality of design practice to bring about sustainability through technology (Scaturro, 2018; Choi, 2019). However, this study brought a design activism concept to evoke conscious environmental crises not limited to sustainable materials. The idea was approved by Scaturro (2020), the author of 'Eco-tech Fashion: Rationalizing Technology in Sustainable Fashion,' who defined the term 'eco-tech fashion' for the first time.

This study was conducted by the sole researcher in every step, including the development of intelligent textile; however, this type of research can be advanced by collaborating with fashion designers and material scientists/engineers (Oxman, 2010; Keane, 2020).

The role of fashion designers is not limited to product design. However, it takes an activist to consider all steps of design, production, and transportation (Scaturro, 2020), and while the designer is building a concrete concept of eco-tech fashion as social activism, collaborations with material scientists and engineers have a greater potential to create the eco-tech fashion than more conventional ways of collaborations; designers demand the forms of materials they want from textile engineers (Keane, 2020).

## **6. Conclusion**

Consumers are well aware of the pollution issues of textile products, and they want stylish fashion products that are also ecological and ethical. In this context, the role of fashion designers can be extended to activists with their design practices rather than mere product designers.

This research aimed to raise awareness about climate change through an activist-fashion designer with intelligent textiles through eco-tech fashion. Integrating eco-tech fashion's sensibility can be a novel approach for design activism since previous research focused on the materiality of textiles rather than messages to warn about environmental crises. Consumers are also ready to wear garments with strong messages to evoke social change as well. Despite the ethics and innovative function of the developed intelligent textile, to be chosen by consumers in the fashion industry, original designs should contain innovative textiles. The original silhouettes of the collection were developed through practice-based research. Hence, it indicates how practical the practice-based research is for fashion designers to create original designs.

Interactive textiles have not been commercialized yet since it usually accompanies computing devices and batteries. With no need for batteries or conductors, the practicality of dye was adapted for the developed interactive textile of this study. Especially since it is reactive to atmospheric CO<sub>2</sub> colorimetrically, respondents from semi-structured interviews agreed that it could indeed raise awareness about climate change without abandoning practicality. By using organic cotton as a base material, sustainability is also integrated with the textile. However, the focus group demonstrated that since color preferences depend on personal taste, the color range of color-changing material is the most important feature for intelligent textiles.

The researcher of this study had to develop an intelligent textile solely through chemical experiments. Limited access to professional laboratories was the main difficulty while conducting the study. For fashion design practitioners, collaborations with material scientists/engineers should be encouraged for this type of research, and they will have a greater potential to develop more advanced materials.

The topic requires more in-depth research, and a video survey can be recommended to better understand how consumers perceive the collection of this research and how effective the produced campaign video is as a visual communication tool. More focus groups with different demographic participants can be recommended to generalize the topic from the findings better.

Further research should consider the functionality of intelligent textiles more. Moreover, consumers expect comfort and durability from textiles; developing new intelligent textiles with the functions of conventional textiles can be a challenge.

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