Solar Wear Tattoo: Rethinking Design, Addressing Ecological Sustainability

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Abstract. Environmental issues concern the sustainability of global resources, needed for the survival of human kind. Water is one of the main ecological concerns in terms of maintaining life on earth. Water, which is responsible for the existence of almost, if not, every lifeform on the planet, is also a resource that is widely affected by humanity’s industrial and manufacturing systems. The fashion industry is no exception and, like industrial productions in other areas, requires urgent action regarding the present problem, so that natural resources can be provided to future generations. Water consumed in the creation of materials and products is one concern. Another is the industrial print left on the water during the usage and washing processes on any kind of fashion apparel worn on an aquatic environment was taken into consideration and revised. Recent worldwide happenings brought an emphasis on the urgencies of water-saving. Its use is more wisely applied upon body hydration and hygiene, making it urgent to plan upon strategies of producing fashion products and apparel that provide an eco-friendly approach. Conclusions were drawn through the prospection of existing surfwear models available on today’s market, as well as an introspective revisiting upon the initial project plans compared with the new and more conscious planning towards ecology.

1. Introduction
The present paper was made as part of a research developed in the context of a PhD in Design that also deals with environmental aspects concerning ecological sustainability, directed to the areas of fashion design and textile engineering. A closer look regarding other applicable resources and new ways to create products is needed to achieve sustainability. For this, it is necessary first to analyse the present situation, consider what is needed, and then provide and invent new, better and more efficient solutions.

2. Context of Surfwear and Surf Industry

2.1. Surfwear Products and User Behaviour
Surfwear practices relate to the user’s need for comfort, in an environment where the surrounding natural elements may create a physical sensation of lack of well-being in the users’ body, due to the combination of stillness, waiting for a suitable wave to ride and wet clothes worn during this sport practice. In order for the user to adapt to these adversities, according to geographical latitude and season; having more than one type of wetsuit for surf practice is required to adapt to winter, summer and mid-season weather [1].

2.2. Model of Reference and Other Case Studies
2.2.1. Referencing Models. The diverse types of suit models that exist have different designs and materials to adapt to various temperatures so that the user remains comfortable [2]. Since the invention of the surf suit, achieving popularity and promoted to commercial success by Jack O’Neil (1923-2017) in the 1950 and 1970 decades [3,4], the technology has been evolving in terms of performance and sustainability, with some models having been made in other materials, less harmful for the environment [5,6]. Despite present concerns, some brands show, related to rising global challenges involving natural resources, the search for harder, more resistant materials, in order to produce new fibres, yarns, textiles, and products continues [7].

2.2.2. Model of Reference/Winter Model. Taken into account as a reference model, the Billabong Furnace wetsuit, is a top-grade, high-tech, surf suit. This winter model is described as having a cold-water competition performance, keeping the body warmer with the use of graphene in its neoprene form. In addition, this surf suit is also conceived with a solvent-free, water-based lamination glue, that is more eco-friendly than the traditional version of this product [8].

2.2.3. Mid-season Models. These models are less covered versions of the traditional Long Jane, like the previous model. These mid-season models are referred as alternatives do the full-body coverage wetsuit, equal to the model of reference [5,6,9].

2.2.4. Summer Models. Commonly referred to as bikini surf suits, these models are made in order to provide alternatives to practice surf in warm weather [10]. These models allow the user to maintain the “surfer look”, while practicing surf in summertime at geographical latitudes with warm temperatures.

3. Materials

3.1. Range of Possibilities for the Main Textile
Without further analysing the finishing of the product, such as the ones used in the lamination process of a wetsuit, like the neotape, and the glue [11], as well as those intended for the creation of a solar tattoo work more efficiently, such as silicone [12]; it is necessary to understand other existing possibilities regarding the main textile used, which is estimated to encompass the majority of the product and, therefore must be regarded in detail, due to its protagonism.

3.1.1. Neoprene. Developed between 1930-1931, was the only multifunctional synthetic plastic commercially manufactured of its time, during the pre-Second World War period [13]. Invented by Elmer K. Bolton (1886-1968), from Du Pont labs, based on Julius Arthur Nieuwland (1878-1936) research, chemist professor from Notre Dame University, that made possible the creation of the first synthetic rubber composite of its kind, as well as its processes of mass production [14].
The commercial success of adiponitrile made it possible for the company to expand research development in this science field. Production of other organic compounds such as chlorobutadiene and monovinylacetylene was made possible, and so was neoprene, a substance that needs these elements for its production [13].
DuPont adapted this material for the production of apparel for surf practicing purposes, due to its technically advantageous attributes, such as mobility and insulation [14]. Adaptation was made possible thanks to Hugh Bradner (1915-2008), who invented neoprene foam, a synthetic rubber containing injected nitrogen gas bubbles inside. These bubbles added floatability, as well as upgrading insulation, reducing heat dispersion from the body, to warm water trapped in the wetsuit to the surrounding water in the environment. After many tests made to improve a suit that at the beginning was frail and sticky, Bradner improved the suit with elastic nylon, thin laminated neoprene made more flexible and resistant [4].
Today’s neoprene sponge is made of polychloroprene rubber chips, commonly referred to as neoprene. These are melted, mixed and blown, to create foam, with agents and pigments, predominantly black carbon, cooked in an oven to create volume. To create polychloroprene chips, the manufacturer
responsible polymerizes the monomers, which process consists in reactivating small molecules together in order to produce wide macromolecules, polymers, which composes the rubber. Neoprene applied to sports practice, improves athlete performance, reducing effort, and body energy consumption, providing economic movement, comfort, and swimming competition time track improvement [15].

3.1.2. Polyester. Original polyester is directly connected to the textile revolution concerning performance apparel for sports practice, mainly known through the promotion related to the creation of the S2000 competition suit, making up for 53% of the podium wearers in the year of 1992 [16]. In the present moment, polyester can be called the user’s preferred textile, detaining the majority of the worldwide textile industrial production by 48%. It is made out of chemicals extracted from raw petroleum, which requires refinement procedures to decompose the main resource and, therefore, obtaining PET polymer, from which the polyester fiber results. 70% of PET polymer goes to textile production, 30% goes to PET bottles production [17]. The environmental impact of this fiber's production results in the consumption of a non-renewable fossil natural resource, high consumption of electricity, and the involvement of chemical processes, obtaining a non-biodegradable substance. Despite a negative ecological, recycled polyester is found to be among the less impactful fibers, becoming a viable option to consider, as a reusable material. Produced from used residue, made from the leftovers of PET polymer, post-consumption of both textiles or bottles having this PET polymer in their composition [17]. Essentially hydrophobic, this fiber is most commonly used in activewear for its characteristics of weak absorption, low maintenance, and manufacturing cost [18].

3.1.3. Polyamide. Like Polyester, Polyamide is a synthetic material known as nylon, which has two different typologies: PA6 and PA 66 [19]. As an alternative to its traditional forms, there are the biopolymer materials that, despite being synthetic, are made from renewable natural resources, like corn, sugar cane, and ricin oil, instead of petroleum. These elements are rising in popularity, due to an increasing search for independence from petroleum-based products. Besides polyester, made from biopolymers, which is polylactic acid – PLA and polytrimethylene terephthalate, polyamide 11, or PA 11, commercialized as RilsanR, is a fibre made from renewable sources [17]. Biodegradable polyamide allows for product manufacture that, despite having inferior longevity, allows for a naturally degrading, non-harmful to the environment material, which is a main concern regarding the use of products in aquatic locations and during maintenance, especially concerning washing cycles.

3.1.4. Algae. Cellulose fibres are classified as a man-made fibre subgroup, made from natural regenerated cellulose, extracted from multiple sources. Modal is made from beech, bamboo fibre is made from bamboo, bagasse is a cellulose that comes from the sugar cane, and seacell is made from algae [20]. In detail, rich in carbohydrates, cell walls are common components to various plants and algae, belonging to the important integral process of fibre production. The complex of cellulose syntax (CSC), is the structural component that, besides being a renewable resource, occurs naturally in terrestrial plants. At the present, it is an application mostly explored in the production of fuel, construction materials, paper, and textile fibres. Despite being underdeveloped, studies about cell walls have been increasing, more specifically, those connected to organisms that require a higher understanding of their properties [21].
Adapted from Smith, 1970, this past figure (Fig. 1) allows the understanding of the various divisions of vegetables, having highlighted the algae divisions. Inside different cryptogamic divisions, some of the existing varieties, like green algae [22,23], blue-green algae [24], brown and red [25], are some of the few specimens that have been applied in the development of textile technologies. Besides textile production in itself, natural dyeing is also possible through the application of by-products from chlorophyll, nowadays used in textiles like wool, acetate derivates, and cotton [26]. The opportunities of the present application are not only found in its low environmental impact, as well as on the consequent acceptance by the user, in its potential for providing wider knowledge about environmental awareness [25].

Algae are not only a component to incorporate in apparel due to its sustainability, but also due to how this natural element’s presence in the aquatic biosphere reflects and impacts the state of an aquatic habitat’s health where they are found. Therefore, algae culture could eventually reveal itself as a solution that ensures a double purpose: The cultivation for material production and local water cleansing, which, gradually, contributes to water regeneration as a whole.

4. Analysis and Possibilities

4.1. Reflecting on Materials
In a preliminary analysis, concerning multiple choices of materials for the application, the existence of two polarities, performance and ecology, become apparent, being that one compromises/conditions the other. On one side of the polarity spectrum, concerning performance, neoprene is the most relevant, and on the other end, algae products are found, as observed in the figure below (Fig. 2).

4.2. Analysing Users Needs
When analysing the surfwear market and respective bibliography, it is possible to understand that neoprene is widely used and, perhaps, the most predominant material in this sector. Despite this, we should take into account its characteristics, so that the user’s needs relating to function should be understood and taken into account [27].

4.3. Compromise Between User and Nature’s Needs
As mentioned above, the desired characteristics have been extracted from products that are predominantly made of neoprene [27]. It is understandable that performance suits are desired, especially in a sports competition...
setting, by past examples registered like Fastskin [28], but, perhaps, as a performance suit that is understood as used most of the time in a training or leisure-only context, the use of a more ecologically sustainable model should be taken into consideration, and thinking of ways to promote its use, like aesthetical appealing, versatile and practical design that can provide a more affordable product as well as comfortable.

5. Rethinking Design

5.1. Fundamental Reflection
Rethinking design is urgent. More than ever, the use of clean water is needed for body hydration and hygiene, which has increased since the rise of SARS-CoV-2 throughout the world, known to cause COVID-19 [29], making the use of potable water for this cause, essential to human life. Therefore, saving water in other life aspects is almost mandatory to be thought out, for is a lifesaving resource and should be made available for these physiological needs.

5.1.1. Previous Work Reflection. First steps on this kind of beachwear development started to be thought out for a casual/leisurewear user. The focus was mainly set on the technological fundamentals that allowed for the conception of a solar tattoo on the user’s skin. The first developments also considered ethical views upon ethnical and cultural inclusivity reflected through the themes and palettes of the conceived designs [12]. In this phase, room was left to develop moral and ethical aspects on other fields such as sustainability and sportswear performance upon the already developed research, aiming to improve the final project in terms of product liability, directed to the surfwear user.

5.1.2. Surfwear Reflection. As mentioned in the case study section of this document, surfers use many kinds of suit models to adapt to different temperatures, that vary according to latitude and season [1], therefore, to satisfy the user’s needs there is a market with different models, from different pattern cuttings [5,7,9,10]. Notwithstanding, what if there could be other ways to produce these kinds of products, while saving on material use and time of adaptation to the wearer?

5.1.3. Alternative Construction and Pattern Cutting. In the context of the aforementioned topic, new ways of creating models that provide the desired characteristics mentioned above were conceived, by making movable parts that could be bought and worn separately, allowing the user to more easily afford the desired thermal body-comfort, while sparing the extra textile needed to produce the already existing models separately.

6. Summary
In search of more ecologically sustainable ways to produce apparel for water environments, some solutions found may reveal themselves as reliable, upon testing prototype making, and materials.

In order to create appeal towards an eco-friendlier product, the overall concept and design applied to the rest of the suit’s conception is essential. It is also intended that the product enables the creation of a solar tattoo, including a warning signalling against excessive solar exposition [30].

In addition, more options offered to the user, by itself, is something appealing in its perception [31], so that the removable components, by themselves, might work as an attractive feature that could promote the use of an eco-friendly product.

In conclusion, the different kind of surfwear pattern cutting that allows legs and arms to become an accessory is already, in itself, more eco-friendly, by reducing waste and promoting reusability. Nevertheless, the ultimate eco-friendly product would be one with a biodegradable blue algae material, which the textile’s production could aid with water cleansing. However, it should be noted that all material hypotheses will be considered according to verified applicability, user’s needs satisfaction, as well as other factors that might be detected along with the progress of the present ongoing research.

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