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A Circular Economy for the Smart Textile

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Introduction

Long time has passed, man does not take from nature what is strictly necessary anymore and also textile has lost the unique primary function to protect. New functions are required to modern textiles: wearing comfort, durability, cleaning properties, optimized functionality for specific applications (workwear, sportswear, medical wear). Textile industry, materials engineering and fashion designer have looked at nature as source of inspiration to develop technical clothing with higher levels of functions and smartness.

The EU textile industry has the environmental and social standards among the most demanding on the planet. Many products break down too quickly, cannot be easily reused, repaired or recycled, and many are made for single use only. At the same time, the single market provides a critical mass enabling the EU to set global standards in product sustainability and to influence product design and value chain management worldwide.

The textile area is predominantly composed of SMEs, with high employment levels. More circular business models should aim at allowing the traditional SMEs in this sector to go through the green transition successfully in order to stay on the market, thus maintaining this employment while ensuring sustainable growth; The green transition in SMEs cannot switch overnight. It is a complex process which requires enabling framework conditions at EU and national level and must be accompanied by specific and targeted measures. Moreover, EU and national legislation should be inspired by the 'Think Small First' principle.

Smart Materials in Textile Engineering

In the last few years, the explosion of nanotechnology as well as of ICT industry has produced smart materials with high potential in the field of textile industry for innovative high-tech applications, covering market segments that are far away from conventional textile world. One of the best examples is the development of new sensing and intelligent cloths. Smart and interactive textiles represent a budding interdisciplinary field bringing together specialists in information technology, micro systems, chemistry and materials engineering, and production technology. The focus of this new area is on developing the enabling technologies and fabrication techniques for the economical production of flexible, conformable and large-area textile- based information systems that are expected to offer more applications for different end users.

The smart and interactive textiles will be highly applied in the next generation of fibres, fabrics and items produced from them. Smart textiles [1] can respond via an active control mechanism for the environmental conditions called stimuli. These systems are constituted by different apparatus and materials such as sensors, actuators, electronic devices [2]. Good examples are fabrics and dyes that will change their colour with changes in pH, clothes made of conductive polymers which give light when they get electromagnetic signals, fabrics which regulate the surface temperature of garments in order to improve physiological comfort, buffering the heat release by mean of phase change materials (PCM) (Figure 1 & 2). Smart textiles can be divided into three categories based on their functions [3].

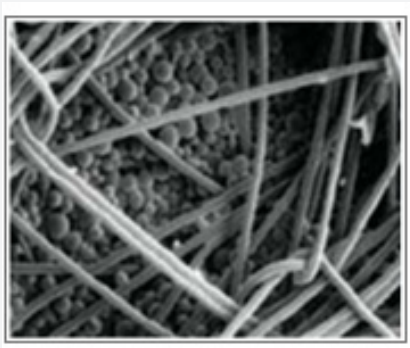

Figure 1: Phase Change Material in textiles.

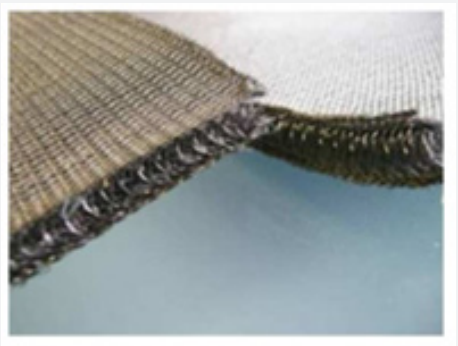

Figure 2: Image of electrically conductive textile for sensor applications.

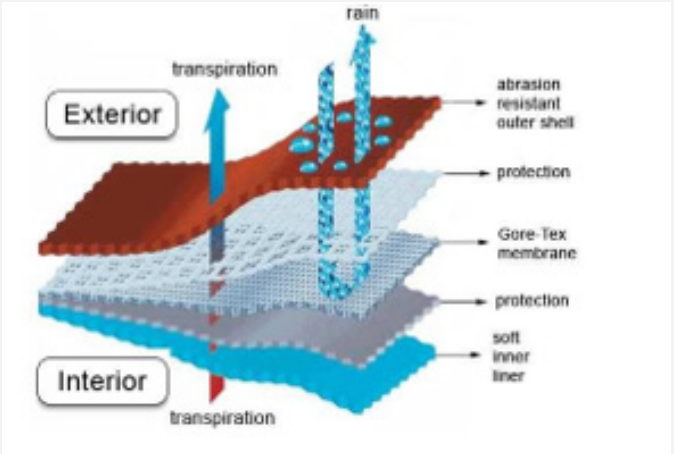

Figure 3: Example of passive smart materials.

a) Passive smart materials (PSM) (Figure 3) are materials or systems which only sense the environmental conditions or stimuli, acting as sensors. They show up what happened on them, such as changing colour, shape, thermal and electrical resistivity. These kinds of textile materials are more or less comparable with high functional and performance textiles. As an example, microfibers present waterproofing properties but at the same time they are permeable to water vapour.

b) Active smart materials (ASM) (Figure 4) are materials and system that can both sense and respond to the external conditions or stimuli [4]. Their prior functions are sensing and reacting to the stimuli. Therefore, they are often constituted by both sensors for environmental conditions and actuators.

c) Very smart materials (VSM) (Figure 5) are materials and systems which can execute triple functions; first, they are sensors which can receive stimuli from the environment; secondly they are able to give reaction based on the stimuli; thirdly they can adapt and reshape themselves accordingly to the environmental condition.

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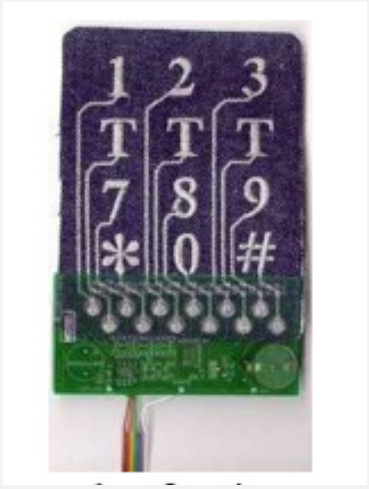

Figure 4: Example of active smart materials

Figure 5: Example of very smart materials.

d) State of the art

Smart materials [5] got full ability to change themselves depending on temperature, pressure, density, or internal energy changes. The amount of energy transferred to make these changes is determined by the material properties. The relationship between the amount of energy required and the degree of the specific change determines the behaviour of all materials, including smart textiles [6]. In technical, high performance and conventional textiles, the relationship between state changement and energy transfer is quite simple. If they get energy or any stimuli from the environment they do not do any change on it. They just resist it or absorb it. For example, the specific heat of a material will determine how much heat is needed in order to change its temperature by a specified amount [7].

This area of smart textiles is very promising to manufacture new clothing that fulfil a wide range of needs, from health monitoring and personal security to new methods of accessing entertainment, culture, communication and expression. They seek to satisfy a mass-customized products that fulfil emotional, sensory and experiential needs. Application of smart textiles can be found everywhere. They are replacing the conventional and the functional ones. Some examples are garments that monitor heart functions, temperature sensing jackets, colour changing fabrics, drug releasing medical textiles, smart fabrics capable to monitor the chemical composition of the body fluids, textiles that measure pulse and immune systems, gloves with microphones, sensors in mattresses, cooling clothes, and others. A lot of SME and Universities are spreading knowledge about development in smart and interactive textile material and textile processes. So new products and services within future textiles are expected to have a large growth in the market.

We do not forget to create conditions and incentives to boost the competitiveness, sustainability and resilience of the European textile industry. Textiles are the fourth highest-pressure category for the use of primary raw materials and water, after food, housing and transport, and fifth for GHG emissions [8]. It is estimated that less than 1% of all textiles

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worldwide are recycled into new textiles [9]. The EU textile sector, predominantly composed of SMEs, has started to recover after a long period of restructuring, while 60% of the value of clothing in the EU is produced elsewhere.

In the light of the complexity of the textile value chain, to respond to these challenges the Commission is working for a comprehensive EU Strategy for Textiles [10], based on input from industry and other stakeholders. The strategy will aim at strengthening industrial competitiveness and innovation in the sector, boosting the EU market for sustainable and circular textiles, including the market for textile reuse, addressing fast fashion and driving new business models. From a first analysis of the contributions received from several European stakeholders, this will be achieved by a comprehensive set of measures, including:

i. Applying the new sustainable product framework to textiles, including developing eco-design measures to ensure that textile products are fit for circularity, ensuring the uptake of secondary raw materials, tackling the presence of hazardous chemicals, and empowering business and private consumers to choose sustainable textiles and have easy access to reuse and repair services;

ii. Improving the business and regulatory environment for sustainable and circular textiles in the EU, in particular by providing incentives and support to product-as-service models, circular materials and production processes, and increasing transparency through international cooperation;

iii. Providing guidance to achieve high levels of separate collection of textile waste, which Member States have to ensure by 2025;

iv. Boosting the sorting, re-use and recycling of textiles, including through innovation, as smart textile for engineering, encouraging industrial applications and regulatory measures such as extended producer responsibility.

Conclusion

Smart textiles and clothing, which use either interactive materials or integrated sensors and IC technologies, offer a totally new and added-value dimension to innovative item having new functionalities. In protective clothing for work and leisure activities, smart solutions can substantially increase the protective, comfort and safety properties, thus have an impact on the work and leisure of the European citizen, and the competitive ability of European manufacturers. Many intelligent textiles are already present in the global market in all kinds of available opportunities and applications including casual clothing, medical textiles, in the military and protective garments, as well as in the expedition of the space.

The existing integration and combination of advanced tools with advanced smart materials create a bright future for dynamic textile market on the entire world. The hybridization of textiles and electronics brought changes in the interactive textiles. The developing field of smart textiles could show a lot of new things in all its applications. A new marketplace for smart and interactive textiles is available, in which they provide new functions and features that can enhance performance and convenience. The integration of the three giants, textiles, electronics and advanced smart materials, will produce as a result new added values to the textile industry contributing to increase the number of employees.

The transition to a more circular and sustainable fashion and smart textile industry cannot take place without sufficient support for innovation and knowledge valorisation. Eco-design can help make the reuse of waste a reality. Any new legislation should be science-based and developed in cooperation with business representatives. Extended Producer Responsibility schemes should start from a balanced approach by which responsibility is shared equally among all actors, up to consumers, involved in the life cycle of a product. From the beginning of 2021, the intention of the Commission is to bring together all the players of the sector to develop eco-design, reuse and recycling by optimizing the management of material, financial and human resources.

As highlighted in the roadmap, the textile industry is a resource-intensive sector in terms of raw materials and water usage with long value chains and a certain environmental impact. However, it is important to take into consideration the different impacts of the various fibres. Especially natural fibres, which are renewable, biodegradable and not produced based on chemicals should be rated differently to synthetic fibres, which don't have those benefits, are resource-intensive and can cause micro plastic pollution. Also, the longer life cycle of luxury natural fibres compared to synthetic fibres should be noted here. Besides that, we agree the promotion of the positive influence of certificates like EU Ecolabel and the importance of traceability, which definitely need to be enhanced.

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