Electronic Textiles and Future Challenges

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Abstract:

The development of textiles was closely related to the major inventions that shaped societies. With the progress of digital technologies, clothes began to appear as a new kind of high-tech products by interfering with electronics. In light of this, this research aimed to clarify the definition and concept of e-textiles (electronic textiles) within various disciplines, and its impact on the successive developments in various fields, which allowed the introduction of many modern and multiple terms. Moreover, the research aimed to reach an understanding of the concept of e-textiles, which is a type of smart clothing in the scope of functional clothing. It also tackled the manufacturing of e-textiles and their electrical properties, and concluded with the future challenges facing e-textiles and the textile industry. The research aims to adopt a theoretical framework on e-textiles, its concept, objectives, the requirements for its basic structure, and the benefits it achieves, in addition to identifying the challenges it faces. While the importance of the research is the enrichment of the little Arab intellectual output in this field, it aimed to motivate fashion and textile specialists to work hard to overcome the difficulties that may hinder the manufacture of e-textiles and start their implementation, given its contribution to keeping up with recent developments in the clothing industry. The research applied the descriptive and analytical approach which involves collecting data, including reviewing scientific papers published from 2000 to 2020 that focused on monitoring and analyzing smart clothing or textiles. The research has reached several results, the most important of which is that e-textiles and e-clothing face great challenges, including the reliability of electronics and textile connectors during washing, storage, safety and security in the privacy of data given the increased risk of privacy violation and product sustainability. This may be a result of its quick development as well as the need for cooperation between various disciplines to find an integrated manner for developing e-textiles.

Key Words:

Smart Clothes, Wearable Electronics, Wearable Technology.

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Introduction:

For thousands of years, clothes have been used for coverage and protection, but they have remained one of the major aspects of human technological advances, as the developments of textiles are closely related to the major inventions that shaped societies (Hughes-Riley, Dias, & Cork, 2018, p. 5). With the advancement of digital technologies, clothing began to represent a new type of high-tech product by interfering with electronics (Ismar, Kurşun Bahadir, Kalaoglu, & Koncar, 2020). It has already unlocked the potentials for having clothing for defense, sports, medicine and health surveillance (Hughes- Riley et al., 2018, p. 9) as well as its role in the development and support users' jobs, which provided higher efficiency in performing the tasks. Smart clothing - of all kinds and levels - represents the future of the textile and clothing industry and electronic industry. Since the convergence between these two industries brings great opportunities and challenges, it attracts a great attention and investment of various fields (Suh, Carroll, & Cassill, 2010). In light of this, IDTechEx indicated that the e-textile market is expected to reach more than 1.4 billion US dollars by 2030, in the report entitled "*E-textiles and Smart Clothing 2020-2030: Technologies, Markets and Players.*"

The report also demonstrates the diversity represented in covering a wide range of materials (including metals, polymers, fibers, yarns, textiles (either they are tricot, woven, embroidered, non-woven) and emerging materials and accessories (sensors, connectors and interface for traditional electronics, etc.) used today, as shown in the following figure:

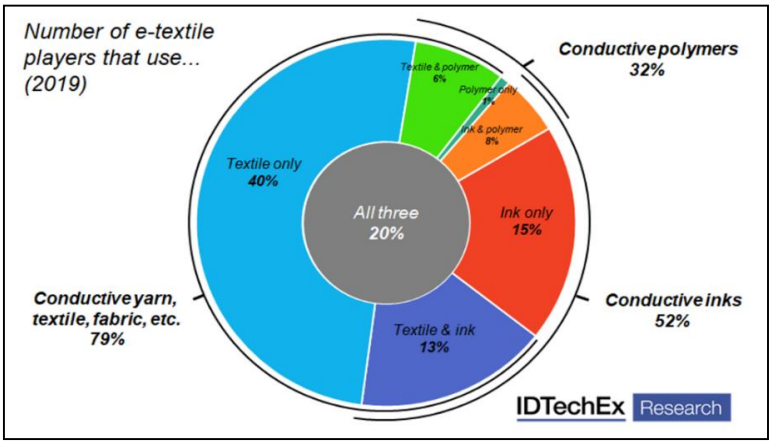

Figure (1) E-textiles and Smart Clothing 2020-2030 (IDTechEx Research, 2020)

Considering the global indicators that show the high market value of demand and production of electronic clothing and textiles, which is a type of smart clothing, and as a result of the rapid developments in the world, the problem of how to keep up with scientific and technical progress has emerged. Hence, the study problem stems from the researchers' hypothesis that despite the increase and growth of e-textiles industry, it is not of such a good quality that makes it easily accessible; and that the vision towards the concept of e-textiles and its importance in the clothing industry is not clear in the minds of many specialists in this field.

The research problem can be summarized **in the following questions:**

1. What are the stages of e-textiles development?
2. What are the technologies involved in e-textiles industry?
3. What are the electrical properties of e-textiles?
4. What are the challenges facing the manufacture of e-textiles?

Research Aims:

This study seeks to achieve the following aims:

1. Analysis of the stages of e-textiles development.
2. Identification of the technologies involved in e-textiles industry.
3. Identification of the electrical properties of e-textiles.
4. Identification of the challenges that may prevent the integration of electronics in textiles.
5.

Research Significance:

1. Enhancing awareness of e-textiles to open a path for more experiments and scientific research to unify the different disciplines.
2. The research is a response to technological developments in the field of e-textiles.
3. A contribution to the enrichment of the Arab library in the field of e-textiles research.

Research Methodology:

The research applied the descriptive approach by conducting an analytical study that focused on monitoring and analyzing smart clothing or textiles.

The theoretical framework of the research:

Smart textiles term refers to a broad, interdisciplinary field of research that combines design, textile technologies, electrical engineering, and information and communication technology in order to develop new products that are relevant to specific aesthetic, functional and technical requirements. (Mecnika, Hoerr, Krievins, Jockenhoevel, & Gries, 2014a) Therefore, there are multiple terms and definitions relating to the concept of smart clothing or textiles. It is also important to review how researchers view smart clothing as research objects and how different disciplines define the intelligence integrated into products based on various research models (Suh et al., 2010). Thus, it must be made clear that smart clothing lies at the intersection of design research, physiology, and textile technology, while electronic wearable textiles are manufactured using a variety of materials with different manufacturing methods. The materials and manufacturing methods chosen are always adapted with the final application. This makes e-textiles an interdisciplinary field of research (Fernández-Caramés & Fraga-Lamas, 2018).

Textiles are among materials that are mostly used by people and have recently acquired an array of new functions by integrating electronic components. The first examples of e-textiles date back to the use of luminous bands in the ballet La Varandole in 1883 (Guler, Gannon, & Sicchio, 2016).

Scientists regarded 2000 as a pivotal year in the development of smart textiles and smart clothing, when they were first introduced to the market in larger quantities as well as the introduction of Sensatex smart shirt for monitoring vital human functions as one of the first products in the US market. Recently, significant progress has been made due to the smaller size and lower cost of electronic components, and the potential of integrating electronics with clothing (Hughes-Riley et al., 2018).

Technologies of e-textiles manufacture and characterization

E-textiles are mainly manufactured from traditional textiles that have been modified using various chemical or structural treatments to provide unconventional reactive performance

properties. (Elmogahzy, 2020) The following figure shows the hierarchy of textile structures within its progression from long chain polymers to the final textile product.

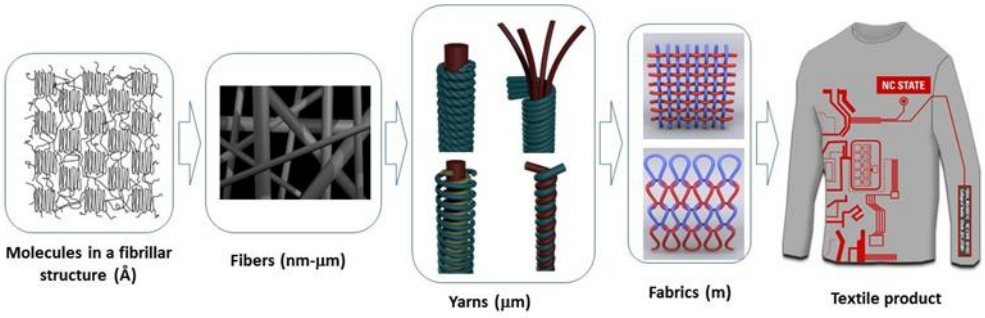

Figure (2) Hierarchy of textile structures as they progress from long chain polymers to the final textile product. (Agcayazi, Chatterjee, Bozkurt, & Ghosh, 2018)

The direct introduction of conductive yarns into textile and tricot manufacturing, sewing and embroidery systems are methods for manufacturing e-textiles. Besides, coating and printing solutions for electrical conductivity on the surfaces of knitted, woven and non-woven fabrics are alternative methods of e-textile manufacturing. (Ismar, Kurşun Bahadir, et al., 2020, p. 5)
It is noteworthy that wearable e-textiles would not be possible without electrical components, such as electrodes and internal connectors (Gonçalves, Ferreira da Silva, Gomes, & Simoes, 2018) as well as sensors, actuators, data processing, power source and communication interface. They must be comfortable, durable, reliable, and washable to withstand clothes ordinary maintenance. In addition, the power supply must be flexible, lightweight, and self-renewable (Bonaldi, 2018).

Generally speaking, e-textiles comprise the following components:

- Sensors to detect environmental and physical factors.
- Data processing unit to collect and process the obtained data.
- A source of energy.
- Power and signal interconnections.
- A communication device that establishes a wireless communication connection with a nearby base station. (M Stoppa & Chiolerio, 2016)

On the other hand, e-textiles face new challenges to combine with technologies, since the electrical connections must fully support the product's functionality, and at the same time provide comfort to the user. Connections should also have the expected durability of textile materials and the ability to withstand repeated flexibility concerning wearing out and harsh washing (Tyler, 2013, p. 507). Therefore, we find that the second primary concern for electronics in textiles is the reliability of electronics, textile connectors, and textile connections during washing, twisting and stretching, wearing and so on, given that the reliability requirements strongly depend on the application. Multipurpose technical textiles are a special case that is difficult to generalize; therefore, a specific applied analysis of the various requirements must be undertaken (Linz et al., 2007). The most prominent of these challenges are summarized below:

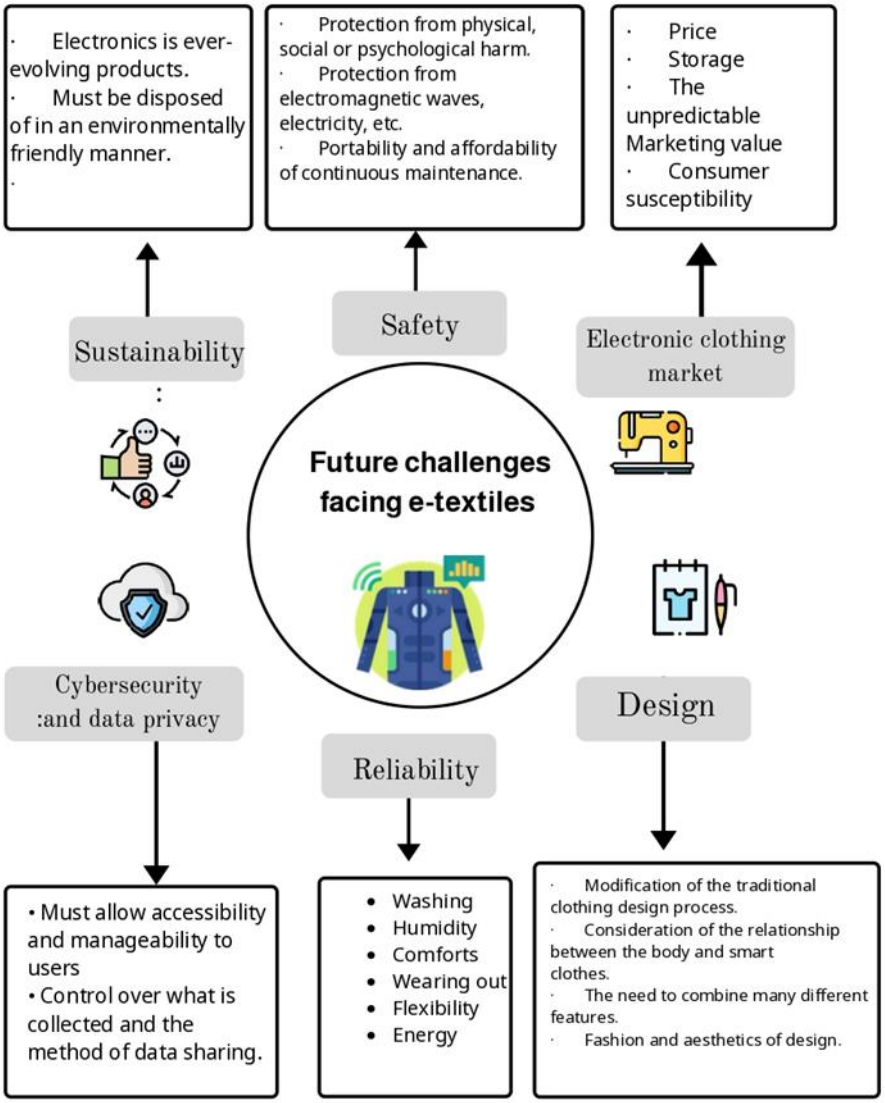

Figure (3) Future challenges facing e-textiles from the researcher's point of view

Summary of Results:

1. Smart clothing is at the intersection of design research, physiology, and textile technology. Whereas electronic wearable textiles are manufactured using a variety of materials with different manufacturing methods, the materials and manufacturing methods chosen are always adapted with the final application. This makes the e-textile an interdisciplinary field of research.
2. The necessity to conduct more scientific studies to unify the concept of e-textiles among the various disciplines, to serve as guidelines for specialists who implement new applications.
3. The potential product groups for e-textiles can be divided into five main groups:

- Sports clothes
- Medical clothing
- Everyday clothing
- Personal protective equipment
- Military clothing.

4. Wearable e-textiles are gaining great attention due to their easy and flexible use in our daily life with a variety of emerging applications.
5. Despite the large number of academic and industrial laboratories that have prototypes, there are very few products available in the market. This is due to the current lack of standards and norms including e-textile testing procedures.
6. Textiles and electronic clothing face great challenges, including:
- Reliability of electronics and textile connectors, as electronic wearable textile products should meet stretch and bend properties, as well as ease of care and washability.
- Safety and security
- Design
- The market value of e-textiles is unpredictable given the consumer susceptibility and industry requirements, including storage.
- Cybersecurity and data privacy
7. The sustainability of textiles and electronic clothing is one of the most important challenges that haven't been resolved yet.

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