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A Review: Conductive Textiles for the Usages of Renewable Energy

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ABSTRACT

For thousands of years, textiles are associated with human civilization. Nowadays renewable energy sources are one of the crucial factors for humanity. Green chemistry increases the necessity of producing energy-storage equipment more rapidly as time goes on. Today energy and environmental technologies combined with polymer and textile science together to develop technical polymers and textiles. For energy storage and conversion systems, various kinds of devices were developed including supercapacitors, Li-ion batteries, and microbial fuel cells. Those devices can be integrated easily with textiles without affecting their performances. As renewable materials, textiles show great importance to cope with our future energy and environmental challenges. An overview of conductive textiles is discussed in this review paper.

Keywords*: Conductive textile, renewable energy, energy storage, applications.*

1. INTRODUCTION

Clothing is the basement of human society. Record said that from 34,000 Before Common Era (BCE) people used textile-based materials [1]. Initially, the purpose of clothing was to cover the body and shelter. As time goes on, today it is used for fashion as well as showing the standard of people's life [2]. Since then, textiles is produced from natural materials to synthetic compounds and have shown biocompatibility, biodegradability, and bio absorbability which are required for textile materials to interface between skin and electronics. The rapid transformation of materials with the influence of science and technology enables traditional textiles to turn into smart textiles with the ability to collect energy from the human body and its environment. [1].

Nowadays sustainable energy production, storage, management, and consumption shows great importance [3]. Scientists and engineers are trying to develop sustainable and renewable energy for future usages to minimize global warming in case of climate change [4]. Solar, electromagnetic radiation, thermal and mechanical energy can be converted into electric power showing their advantages in particular environments [5]. Among them, chemical storage devices and electrochemical capacitors are the main electrical energy storage systems [4].

Recently, the various device is designed to harvest those energies including triboelectric

Nanogenerators (TENGs), piezoelectric Nanogenerators (PENGs), thermoelectric generators (TEGs), biofuel cells (BFCs), solar cells (SCs), and hybrid generators (HGs) which are built on polymer thin films [1].

Higher power density, quick charge-discharge, cycling life, and safe operation are the important features of supercapacitors having several applications like portable consumer electronics, next-generation electric vehicles as well as large industrial power and energy management systems [6].

For producing flexible and wearable electronic devices showing deformation under bending, stretching, compressing, twisting by maintaining their performance, reliability and integration are also key factors [3]. Nowadays conductive textiles are used in the electronics, automotive, sensing, electro-energy, and packaging sectors [7]. The main question is how to incorporate those devices into garments without changing their comfort and aesthetic qualities [5].

By coating or incorporating or inserting conductive materials within yarns, conductive textiles are produced [7]. By using conductive nanoparticles, conductive carbons, and electrically conducting polymers (ECPs), smart conductive textiles are produced. ECPs is the most suitable and cost-effective among those technique [8]. To integrate electronic components, textile materials may use as a host. Using established methods and materials, the production of conductive textiles will be possible in a wider range. Both screen printing and inkjet printing are common methods used for manufacturing conductive textiles today. Particularly, free space inside woven and knitted fabrics help to integrate active carbon materials into their pore to perform as a textile supercapacitor [9].

Textile supercapacitors have gained attention due to their potential applications in the field of high-tech sportswear, health monitoring systems, and the military [10].

1.1. Why is Renewable Energy Important?

Renewable energy is the source of clean energy. They are different from non-renewable sources in their diversity. Most importantly, they don't exhibit greenhouse gases which are responsible for pollution as well as climate changes. They are also cost-effective compared to non-renewable energy sources [11]. Another reason for choosing renewable energy sources is that non-renewable energy sources cause harm to the planet as well as all living beings. Climate change and physical damage to the environment are also major negative effects caused by non-renewable sources [12].

In this globalization, people are being more and more aware of non-renewable energy sources. Renewable energy is indeed most important in this hour. Scientists and Engineers are trying to find out new ways to use these sources of energy effectively [13].

1.2. Barrier for the Production of Conductive Textiles

One of the main concerns of conductive textiles is toxicity. If we want to integrate conductive materials in textiles, they have to be non-toxic and safe. For long-term usage, replacing and repairing the conductive devices is possible or not without affecting their performance need to consider. Those conductive fabrics need to assure their sensing, actuating, and responding properties at the time of wearing by maintaining comfort fit to the human body. Thus, for future developments, the experts of electronic as well as textile peoples need to work together [14].

2. CONDUCTIVE TEXTILE FOR ENERGY STORAGE

Textile supercapacitors have some important features like higher power and energy density, longer life cycle, quality of being wearable, comfort, and practicality alongside their safety

allowing them to be a powerful candidate for future-generation wearable textiles. Fiber/yarn-

based supercapacitors are ranging from micrometers to millimeters even meters long. A common method is by fabricating fiber/yarn-based supercapacitors to develop conductive textiles [15].

By using the fiber drawing technique conductive yarns were produced having higher strength, excellent conductivity, good corrosion resistance, and thermal stability within flexibility. Reduced graphene oxide, manganese dioxide, and polypyrrole are precipitated over conductive yarns for achieving higher capacitance [16].

Textile-based electrochemical energy storage devices (TEESDs) are also ideal energy supply devices [17].

By following a simple chemical route, cotton textiles are converted into activated carbon textiles (ACTs) for energy storage performing an electric double-layer capacitor (EDLC) [18]. Fabric-based supercapacitors produce in two ways [15]:

1. Constructing woven or knitted textile supercapacitors.
2. Framing fiber or yarn-shaped supercapacitors into fabrics by stitch.

The nickel and nickel-cobalt phosphide particles coated spandex textile (Ni@NiCoP) may be used as stretchable energy storage devices for the application of future smart clothes and wearable electronic devices [19].

2.1. Advantages of Conductive Textiles

There are several advantages of using conductive textiles. Some important of them are listed below [20];

- optimal and consistent electromagnetic reflection properties
- outstanding flexibility and stretching capabilities
- superior durability in the harshest environments
- anti-microbial properties for a range of sanitization applications
- having anti-static characteristics
- corrosion-resistant and ultra-low out-gassing properties
- Available for producing conductive products for commercial and military markets.

2.2. Application of Conductive Textiles

2.2.1. Energy harvesting & storage:

Commercial energy harvesting and storage devices such as piezoelectric, triboelectric, or thermoelectric Nanogenerators are produced by using dye, organic and inorganic polymers [14, 21].

A) Energy harvesting from human motion:

Today a new way is discovered to harvest the energy from human motions for mobile electronic devices to operate without any external power sources by using triboelectric generator (TTEG) technologies [22].

B) Solar cells on textiles:

Nowadays textile-based solar cells have attracted enormous research interest for energy harvesting because of their flexible structures at low cost. Researchers are emphasizing inorganic, polymer-based solar cells with lightweight and flexible in structure as well as easily manufacturable. They also studied dye-sensitized photovoltaic fibers to develop usable solar cells on textiles [23-24].

C) Supercapacitors based on fabric:

Recently supercapacitors (SCs) have shown great attraction as energy storage devices. It is consists of conducting polymers and transition metal oxides and the energy storage mechanism varies from materials used to produce [25].

2.2.2. Sensors:

Due to lightweight, flexibility and the possibility of washing, the necessity of textile-based sensors is rising day by day. For

measuring the strain, pH, humidity, biopotential, and temperature, poly (3,4-ethylene dioxythiophene): polystyrene sulfonate (PEDOT: PSS) is used to produce sensing component [26].

2.2.3. Consumer electronics:

Conductive textiles are used in products such as smartwatches, augmented reality headsets, multimedia players with computing facilities, and smart goggles [27].

2.2.4. Electromagnetic shielding:

Conductive textile is used for electromagnetic shielding effectiveness (EMSE) against electromagnetic interference at a specific frequency. The effectiveness depends on the type of material used, connections of the conductive net, and the frequency of the electromagnetic wave [28].

2.2.5. Other applications

The inherent properties of PEDOT: PSS helps actuators, organic light-emitting diodes (OLED), and antennas to be fabricated on textiles. It is also used as an actuation to integrate into smart textiles [26].

3. CONCLUSION

Nowadays sustainable energy production, storage, management, and consumption show great importance. In this point of view, conductive textiles became popular during the last decade through their application to smart textiles. In this review, an overview of conductive textiles is discussed based on electronic devices as well as their production barrier. Also, the energy harvesting and storage process in the textile substrates were discussed. For the commercial production of textile-based electronic devices, how those parts will be integrated into clothes, their toxic and non-toxic nature and usage in daily life need to consider. If conductive textiles overcome those problems, a new era will come to light in wearable electronic devices.

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