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Nanofibers Aplications

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1- Introduction

Nanofibers are defined as fibers with dimensions of 100 nanometers. It can be produced through the processes of interfacial polymerization and electrospinning, and carbon nanofibers are magnetic fibers that are produced through the catalytic synthesis process. [1].

The nanofibers can be generated from different polymers (natural polymers such as collagen, cellulose, fibroin silk and synthetic polymers such as Polylactic acid (PLA), polycaprolactone, (PCL).

1 – Introduction

Synthetic nanofibers (ceramic nanofibers) can be obtained from various types of synthetic materials through the use of electrospinning technology. The most widely used ceramic materials that are characterized by the shape of nanofibers are titanium dioxide (TiO2), silicon dioxide (SiO2), zirconium dioxide (ZrO2), aluminum oxide (Al2O3), lithium titanate (Li4Ti5O12), titanium nitride (TiN). as well as platinum (Pt).The Composition or manufacturing process is often carried out in two stages.

1 – Introduction

The first is to manufacture nanofibers (organic polymer)* by using the traditional electrospinning method. The second is the transformation of polymeric nanofibers consisting of inorganic salts** or organometallic compounds into ceramics using heat treatment. *An organic compound is any chemical compound whose molecules contain carbon except for carbides, carbonates, carbon dioxide, bicarbonates, and cyanates.

**Organic salts are a dense number of ionic compounds with innumerable properties. It was previously derived from an organic compound that has undergone a transformation process that allows it to carry a charge, and also its chemical identity depends on the ions associated with it.

1 – Introduction

Nanofibres are used in many possible technological and commercial applications, including: medicine, protective materials, textiles, filtration, nanofiber wipes that contain antibodies against many biological and chemical hazardous substances, dye K solar cell, pigment required for cosmetics, energy, carriers. (carrier) of many catalysts, the use of micro-energy to power personal electronic devices through the use of electromagnetic nanofibers woven into clothing fabrics.

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2- Nanofibers Applications[2]:

Nanofibers are used in many possible technological and commercial applications, including:

2.1. Medicine: components of artificial organs, tissue engineering, organ transplantation, drug delivery, wound dressing, medical textile materials, cancer diagnosis,

2.2. Protection materials: sound absorption materials, protective clothing against chemical and biological warfare agents, sensor applications to explore chemical agents.

2- Nanofibers Applications[2]:

2.3. Fabrics: sportswear, sneakers, climbing, rain prevention clothes, checkout clothes, diapers.

2.4. Filtration: Use of system filters (heating, ventilation and air conditioning), micro-air particle capture filters, air, oil, fuel for vehicles, for drinking, pharmacy, medical applications.

2.5. Nanofiber napkins containing antibodies against many bio-hazardous and chemical substances.

2.6. Solar pigment cell.

2- Nanofibers Applications[2]:

2.7. The pigment required for cosmetics.

2.8. Energy: lithium-ion battery, photovoltaic solar cell, membrane fuel cells.

2.9. **Transporting (**carrier) for many contributing factors.

2.10. **Use the microenergy to operate personal** electronic devices through the use of electromagnetic nanofibers woven with clothing fabrics.

2.11. **Nanotechnology in Civil Engineering**

2.12. **Acoustic and Thermal Insulation** of Nanocomposites for Building Material

3- Nanofibers Applications in Medicine:

3.1. Nanofibers Applications in tissue engineering

In tissue engineering, a highly porous artificial extracellular matrix is needed to support and guide cell growth and tissue regeneration Natural and synthetic biodegradable polymers have been used to create such scaffolds [2,5] .

3- Nanofibers Applications in Medicine:

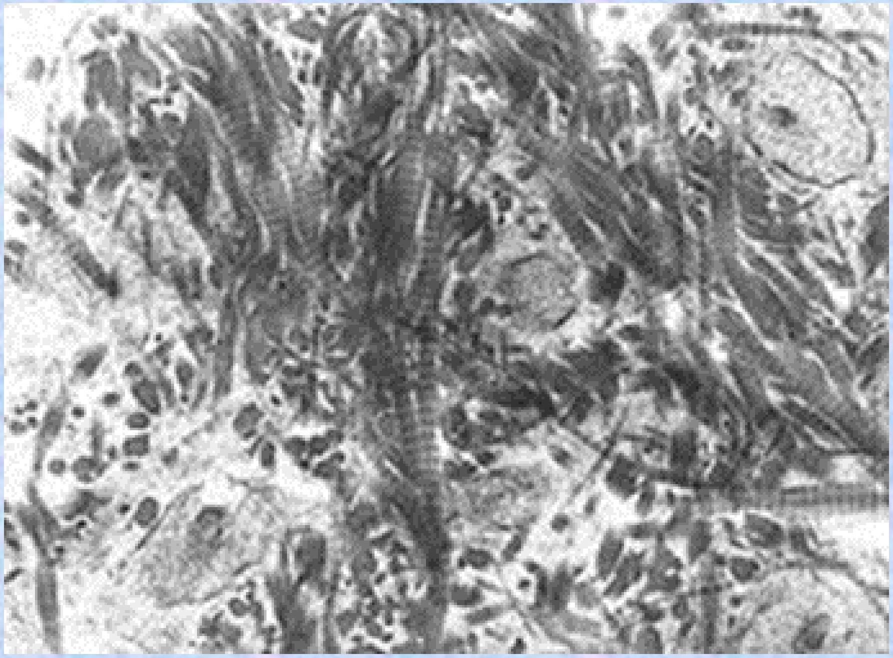

Fig. 1: Bone matrix composed of collagen fibrils. Nanofiber scaffolds are able to mimic such structure.

3- Nanofibers Applications in Medicine:

Nanofiber scaffolds are used in bone tissue engineering to mimic the natural extracellular matrix of the bones[2,6].

The bone tissue is arranged either in a compact or trabecular pattern and composed of organized structures that vary in length from the centimeter range all the way to the nanometer scale.

Tissue engineering is not only limited to the bone: a large amount of research is devoted to cartilage, ligament, skeletal muscle, skin, blood vessel, and neural tissue engineering as well,[2,7].

3- Nanofibers Applications in Medicine:

3.2. Nanofibers Applications in Drug delivery

Drugs and biopolymers can be loaded onto nanofibers via simple adsorption, nanoparticles adsorption, and multilayer assembly.

Nanofibers are under study as a possible drug carrier candidate [2]. Natural polymers such as gelatin and alginate make for good fabrication biomaterials for carrier nanofibers because of their biocompatibility and biodegradability that result in no harm to the tissue of the host and no toxic accumulation in the human body, respectively. Due to their cylindrical morphology, nanofibers possess a high surface area-to-volume ratio.

3- Nanofibers Applications in Medicine:

Preliminary studies indicate that antibiotics and anticancer drugs may be encapsulated in electrospun nanofibers by adding the drug into the polymer solution prior to electrospinning Surface-loaded nanofiber scaffolds are useful as adhesion barriers between internal organs and tissues post-surgery. Adhesion occurs during the healing process and can bring on complications such as chronic pain and reoperation failure.

3- Nanofibers Applications in Medicine:

3.3. Nanofibers Applications in Cancer diagnosis

Although pathologic examination is the current standard method for molecular characterization in testing for the presence of biomarkers in tumors, these single-sample analyses fail to account for the diverse genomic nature of tumors. Considering the invasive nature, psychological stress, and the financial burden resulting from repeated tumor biopsies in patients, biomarkers that could be judged through minimally invasive procedures, such as blood draws, constitute an opportunity for progression in precision medicine.

3.3. Nanofibers Applications in Cancer diagnosis

Liquid biopsy is an option that is becoming increasingly popular as an alternative to solid tumor biopsy[2,8]. This is simply a blood draw that contains circulating tumor cells (CTCs) which are shed into the bloodstream from solid tumors. Patients with metastatic cancer are more likely to have detectable CTCs in the bloodstream but CTCs also exist in patients with localized diseases.

3- Nanofibers Applications in Medicine:

3.3. Nanofibers Applications in Cancer diagnosis

Recently, Ke et al. developed a NanoVelcro chip that captures the CTCs from the blood samples. When blood is passed through the chip, the nanofibers coated with protein antibodies bind to the proteins expressed on the surface of cancer cells and act like Velcro to trap CTCs for analysis. The NanoVelcro CTC assays underwent three generations of development.

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3- Nanofibers Applications in Medicine:

3.3. Nanofibers Applications in Cancer diagnosis

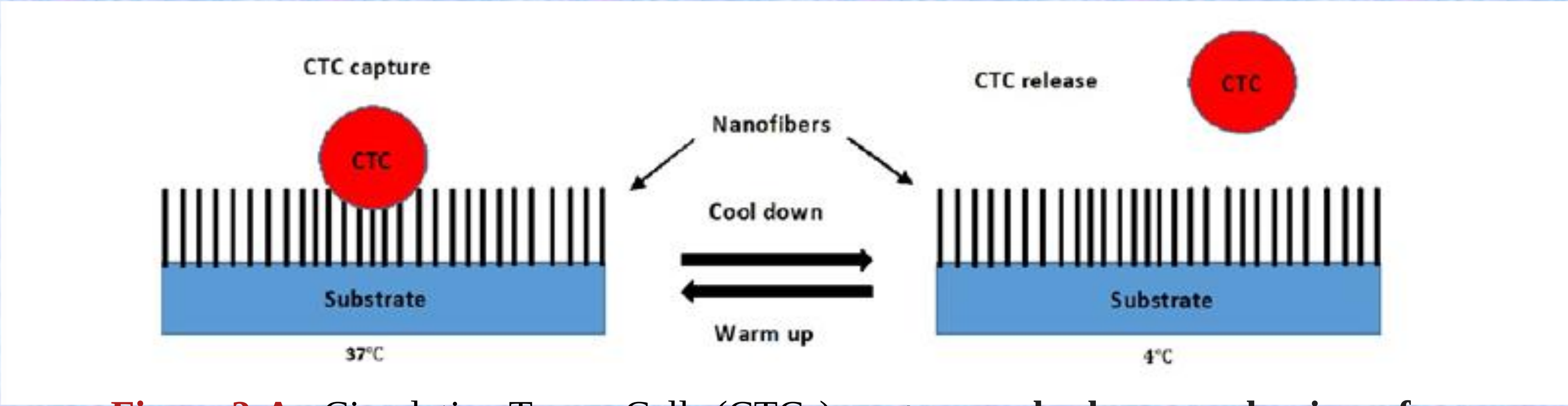

Figure 2-A : Circulating Tumor Cells (CTCs) **capture and release mechanism of third generation Thermoresponsive Chip[2].**

3- Nanofibers Applications in Medicine:

3.3. Nanofibers Applications in Cancer diagnosis

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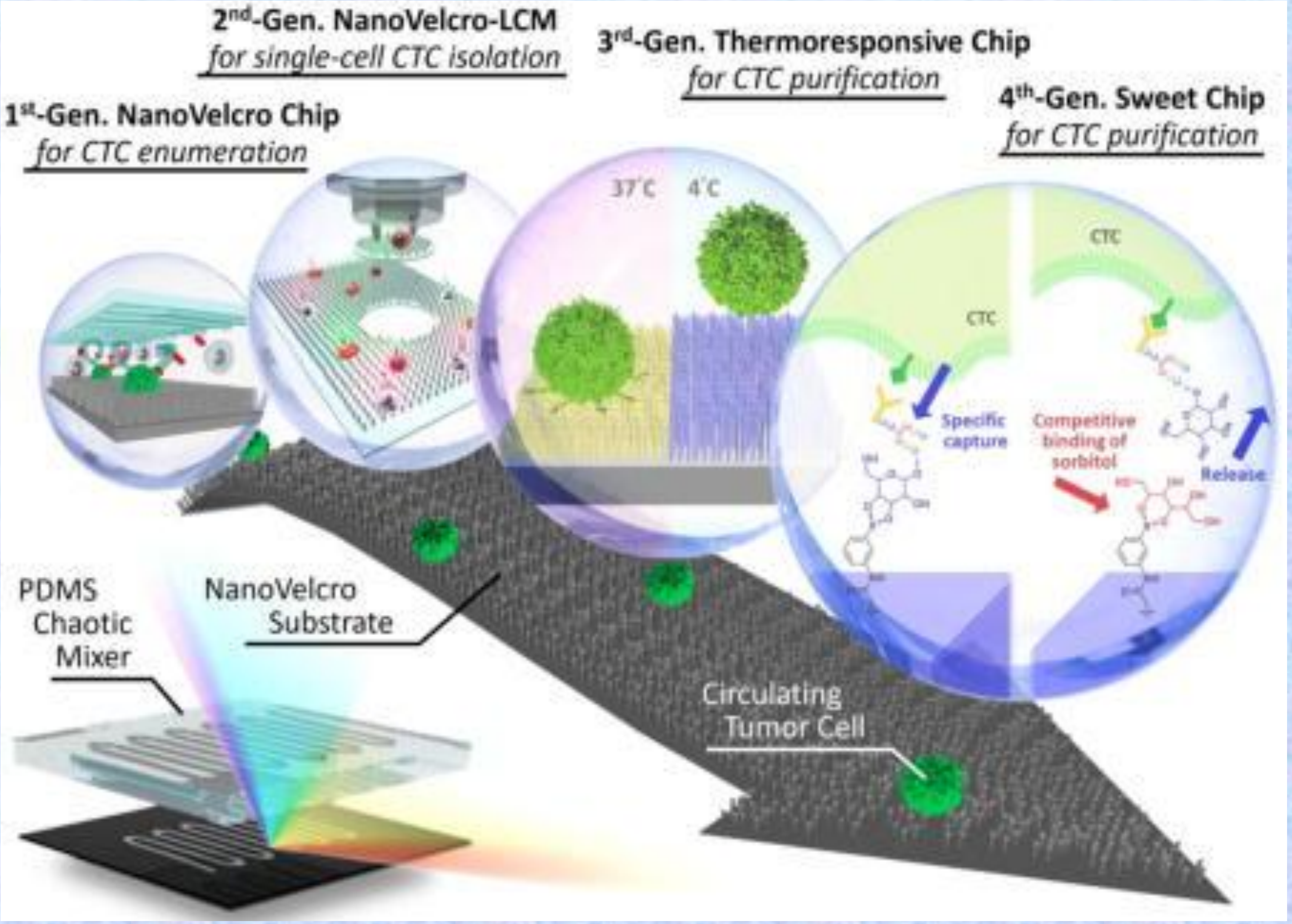

Figure 2-B: **Graphic illustration and table comparison of the NanoVelcro CTC Assays among four different generations.[3]**

3- Nanofibers Applications in Medicine:

3.3. Nanofibers Applications in Cancer diagnosis

The third generation Thermoresponsive Chip allowed for CTC purification. The nanofiber polymer brushes undergo temperature-dependent conformational changes to capture and release CTCs.

4. Nanofibers Applications in Energy

4.1. Nanofibers Applications in Lithium-air battery

Among many advanced electrochemical energy storage devices, rechargeable lithium-air batteries are of particular interest due to their considerable energy storing capacities and high power densities. As the battery is being used, lithium ions combine with oxygen from the air to form particles of lithium oxides, which attach to carbon fibers on the electrode[2].

4. Nanofibers Applications in Energy

4.1. Nanofibers Applications in Lithium-air battery

During recharging, the lithium oxides separate again into lithium and oxygen which is released back into the atmosphere. This conversion sequence is highly inefficient because there is significant voltage difference of more than 1.2 volts between the output voltage and the charging voltage of the battery meaning that approximately 30% of the electrical energy is lost as heat when the battery is charging. Also the large volume changes resulting from continuous conversion of oxygen between its gaseous and solid state puts stress on the electrode and limits its lifetime.

4. Nanofibers Applications in Energy

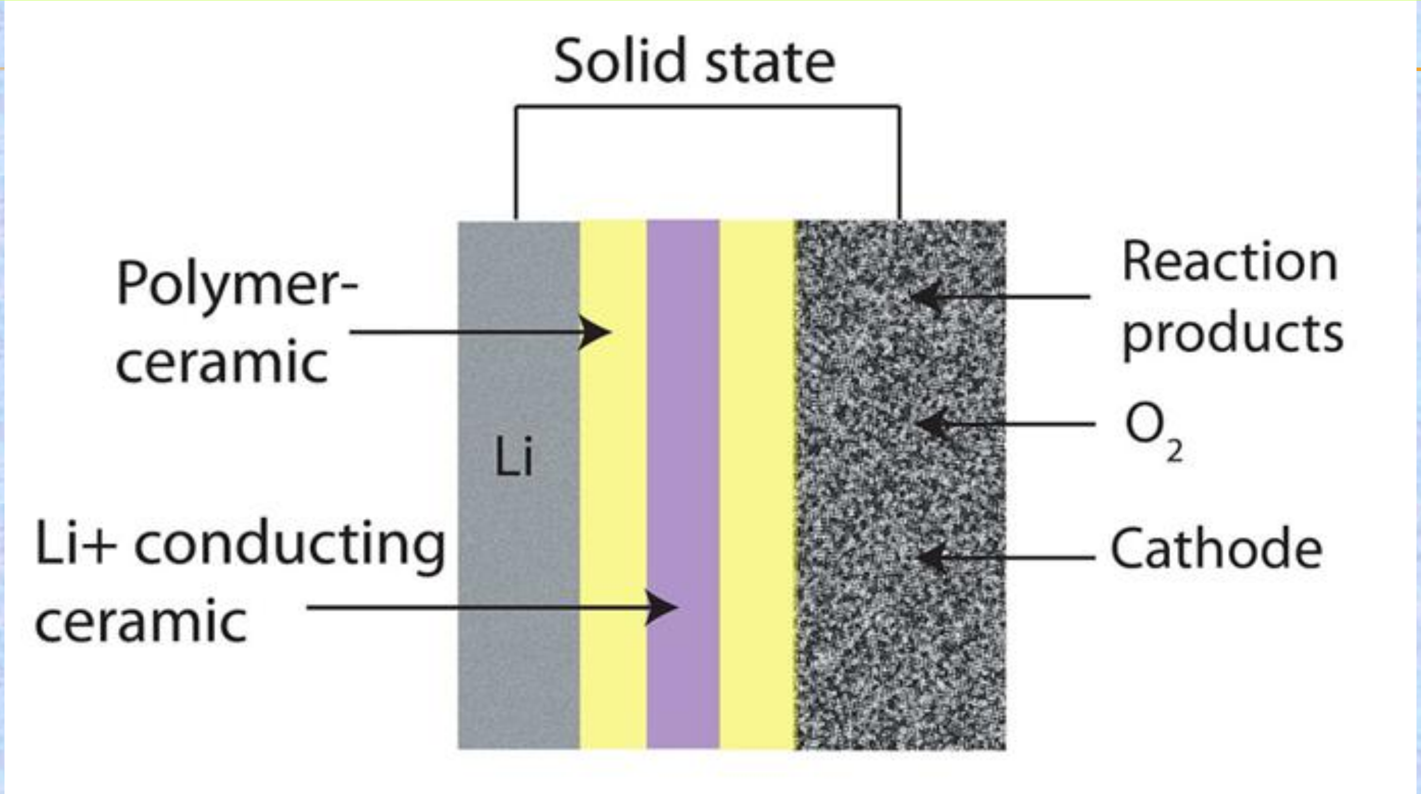

Figure 3: **Schematic of a lithium-air battery. For the nanofiber-based lithium-air battery, the cathode would be made up of carbon nanofibers.[2].**

4. Nanofibers Applications in Energy

4.1. Nanofibers Applications in Lithium-air battery

Binder-free electrospun carbon nanofibers are particularly good potential candidates to be used in electrodes in lithium-oxygen batteries because they have no binders, have open macroporous structures, have carbons that support and catalyze the oxygen reduction reactions, and have versatility.[

Zhu et al. developed a novel cathode that can store lithium and oxygen in the electrode they named nanolithia which is a matrix of carbon nanofibers periodically embedded with cobalt oxide.[2,9].

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4. Nanofibers Applications in Energy

4.2. Dye solar cell

Dye solar cells or Gretzel cells are a class of low-cost solar cells belonging to the thin-film solar cell group [1,10]. It is based on a plate of semiconductors placed between a light-sensitive anode and an electrolyte (the electrolyte or electrolyte is any substance that contains free ions that form a medium that conducts electricity (this cell was invented by Michael Gretzel and Brian Oregan in 1991 [2] and Gretzel won the 2010 Millennium Technology Prize for it).

4. Nanofibers Applications in Energy

Figure 4: Dye sensitized solar cells

4. **Nanofibers Applications in** Energy

Gretzel solar cell [10]:

The Gretzel cell consists of a thin porous layer of titanium dioxide nanoparticles coated with a molecular pigment to absorb sunlight. Titanium dioxide is immersed in an electrolyte solution and a platinum catalyst is located above it. As in conventional alkaline batteries, the anode (titanium dioxide) and cathode (platinum) are placed on either side of the electrolyte.

4. Nanofibers Applications in Energy

Gretzel solar cell [10]:

The pigment particles are very small (of the order of nano) and to capture or collect a reasonable amount of light the thickness of the pigment layer must be relatively large. To solve this problem, nanomaterials are used as a scaffold to hold the pigment molecules in the form of a three-dimensional structure. This increases the number of molecules in any surface of the cell. These scaffoldings (supports) in modern designs are made of semiconductor materials and thus perform a dual function.

5. Nanofibers Applications in Optical sensors

Polymer optical fibers have generated increasing interest in recent years. Because of low cost, ease of handling, long wavelength transparency, great flexibility, and biocompatibility, polymer optical fibers show great potential for short-distance networking, optical sensing and power delivery[2,11].

5. Nanofibers Applications in Optical sensors

Kelly and his team developed a mask equipped with a sensor composed of carbon nanofibers assembled into repeating structures called photonic crystals that reflect specific wavelengths of light. The sensors exhibit an iridescent color that changes when the fibers absorb toxins.

6. Air filtration

Electrospun nanofibers are useful for removing volatile organic compounds (VOC) from the atmosphere. Scholten et al. showed that adsorption and desorption of VOC by electrospun nanofibrous membrane were faster than the rates of conventional activated carbon.

6. Air filtration

Figure 5: Paints and protective coatings on furniture contain volatile organic compounds such as toluene and formaldehyde [2].

6. Air filtration

Nanofibers can be used in masks to protect people from viruses, bacteria, smog, dust, allergens and other particles. Filtration efficiency is at about 99.9% and the principle of filtration is mechanical. Particles in the air are bigger than pores in nanofiber web, but oxygen particles are small enough to pass through.

7. Oil–water separation

Nanofibers have the capabilities in oil–water separation, most particularly in sorption process when the material in use has the oleophilic and hydrophobic surfaces. These characteristic enable the nanofibers to be used as a tool to combat either oily waste- water from domestic household and industrial activities, or oily seawater due to the oil run down to the ocean from oil transportation activities and oil tank cleaning on a vessel.[2].

8. Nanofibers Applications in textile

8.1. Sportswear textile

Sportswear textile with nanofiber membrane inside is based on the modern nanofiber technology where the core of the membrane consists of fibers with a diameter 1000× thinner than human hair. This extremely dense "sieve" with more than 2,5 billion of pores per square centimeter works much more efficiently with vapor removal and brings better level of water resistance.

8. Nanofibers Applications in textile

8.1. Sportswear textile

Nanofiber apparel and shoe membranes consist of polyurethane so its production is not harmful to nature. Membranes to sportswear made from nanofiber are recyclable

8. Nanofibers Applications in textile

8.2. Fabric Finishing by using Nanotechnology[4]

Finishing of fabrics made of natural and synthetic fibers to achieve desirable hand, surface texture, color, and other special aesthetic and functional properties, has been a primary focus in textile manufacturing. In the last decade, the advent of NT has spurred significant developments and innovations in this field of textile technology. Fabric finishing has taken new routes and demonstrated a great potential for significant improvements by applications of NT,

8. Nanofibers Applications in textile

8.2. Fabric Finishing by using Nanotechnology[4]

The developments in the areas of surface engineering and fabric finishing have been highlighted in several papers. There are many ways in which the surface properties of a fabric can be manipulated and enhanced, by implementing appropriate surface finishing, coating, and or altering techniques, using nanotechnology. A few representative applications of fabric finishing using NT are schematically displayed in Figure 6. [4].

8. Nanofibers Applications in textile

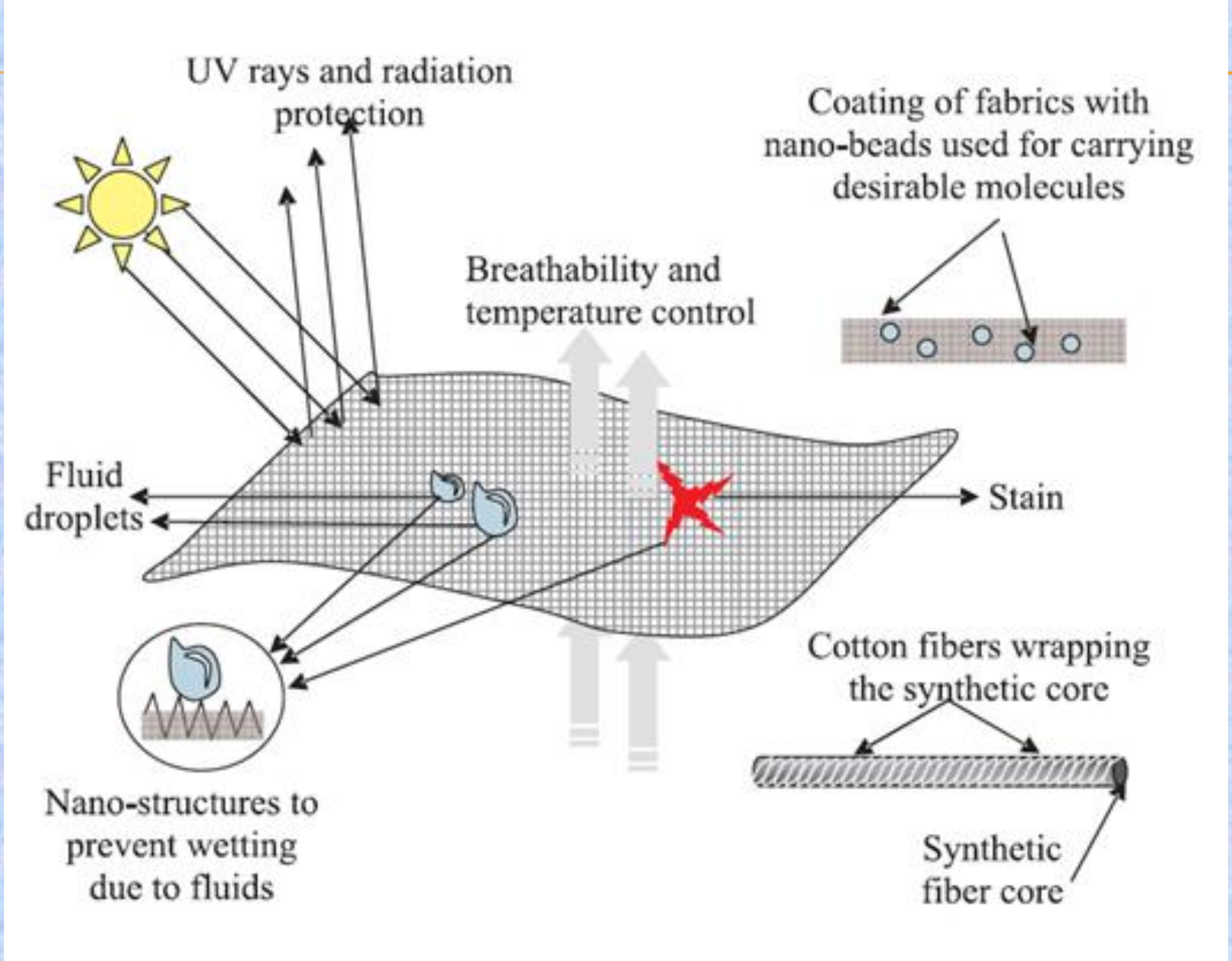

Figure 6: Fabric finishing for enhanced properties and performance[4].

8. Nanofibers Applications in textile

8.3. A Few Representative Textile Products Based on Nanotechnology

Within the last decade, NT-based progress in textile fibers, yarns, and fabric-finishing have led to the development of several new and improved textile products (Figure 7). [4]

8. Nanofibers Applications in textile

Figure 7 : Some representative applications of NT in textiles[4].

9. High-tech nanofibers can help nutrients in foods get their jobs done [12]

New research shows that manufacturing nanofibers can provide new and improved products and delivery systems for nutritional supplements. Nanofibre materials, which are produced by a mechanism known as "electrospinning", have drawn attention in the food industry, as a result of their ability to control the release of chemical elements in these foods within the body.[12].

Figure 7 : Some representative applications of NT in textiles[4].

9. High-tech nanofibers can help nutrients in foods get their jobs done [12]

Figure 8: High-tech nanofibers can help nutrients in foods get their jobs done [12]

https://nasainarabic.net/main/articles/view/high-tech-nanofibres-nutrients-food

Figure 7 : Some representative applications of NT in textiles[4].

10. Self-winding nanofibers

The self-twisting nanofibers were studied at Harvard University. Its effect is related to the balance between elasticity, cohesion and solvent evaporation. Hence, some of the expected applications for it include the following:[1,13]:

- Substances that may alter the optical properties of diamond.
- Capture and release the molecule for eg drug delivery.
- Energy storage.
- Adhesives.

11. Results and Conclusions

1- Nanofibres are considered a revolution of the present and the future, so they must be taken care of in terms of manufacturing technology and multiple applications in all areas of life.

2- Research is currently being conducted to obtain new nanocomposites with properties and characteristics that differ from the original compounds. One of the now known nanocomposites is polymeric nanocomposites.

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Thank YOU

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