ADVANCED RENEWABLE NANOMATERIALS FOR SUSTAINABLE DEVELOPMENT

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OUTLINE

INTRODUCTION

At the UN General Assembly, 193 United Nations Member States adopted the 2030 Agenda for Sustainable Development. This initiative is a global call to action by 2030. To achieve sustainable development, **17 Sustainable Development Goals (SDGs)** have been defined, and nanoscience and nanotechnology play a critical role in these goals.

Figure 1. Sustainable development goals.

NANO & NANOSCIENCE & NANOTECHNOLOGY

Nano is an SI prefix and comes from the Greek word for a “dwarf - Nanos”. A nanometre is a billionth of a meter, that is, about 1/80,000 of the diameter of a human hair, or 10 times the diameter of a hydrogen atom.

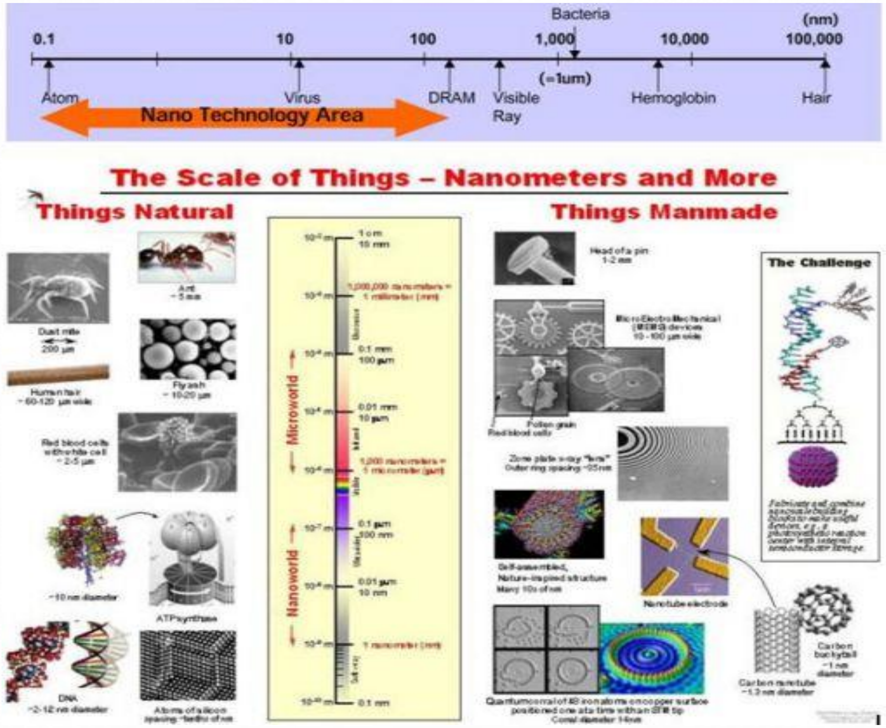

Figure 2. Nano, micro and macro size matters (USA DOE, 2006).

NANO & NANOSCIENCE & NANOTECHNOLOGY

Nanoscience is the study of understanding and manipulation of materials at atomic, molecular, and macromolecular scales.

Nanotechnology is the design, characterization, production, and application of structures, devices, and systems by controlling shape and size at a nanometre scale. The scale of dimensions adopted for the applicability of nanotechnology is between 1 and 100 nanometres (nm).

Nanomaterials are materials that are purposefully designed in a size range of 1 to 100 nm in 1, 2, or 3 dimensions.

Nanotechnology and nanomaterials have a wide range of applications in every area of science and engineering, resulting in higher improvements.

INTERDISCIPLINARY SCIENCE: NANOTECHNOLOGY

With a bright future, nanotechnology is expected to see tremendous growth in a variety of industries, including textile, chemical, and electrical-electronic ones as well as energy, automotive, medical, and food.

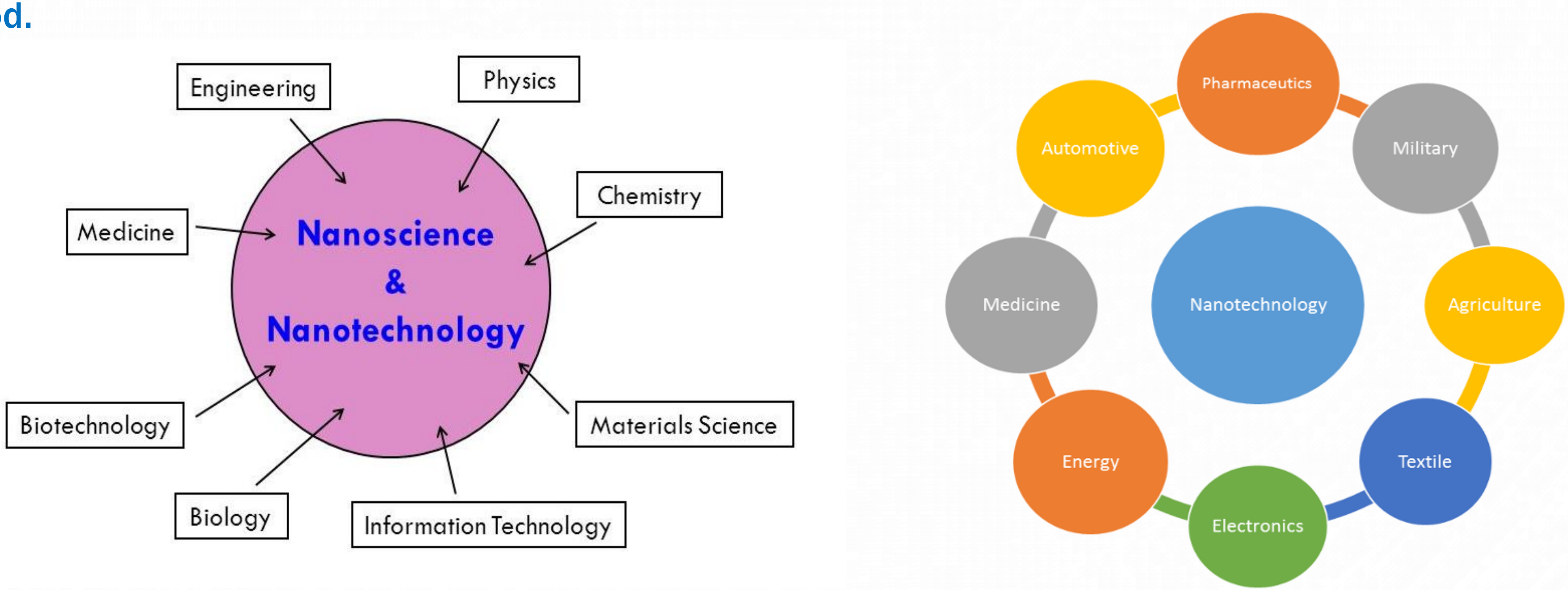

Figure 3. Interdisciplinary science: nanotechnology

ADVANCED RENEWABLE NANOMATERIALS

Generally, lignocellulosic biomass consisting of three main cell wall components, namely, cellulose, lignin and hemicellulose (Lum et al. 2019). Lignocellulosic nanomaterials are nanoscale materials derived from lignocellulosic biomass and having the length ranges from 1 to 100 nm.

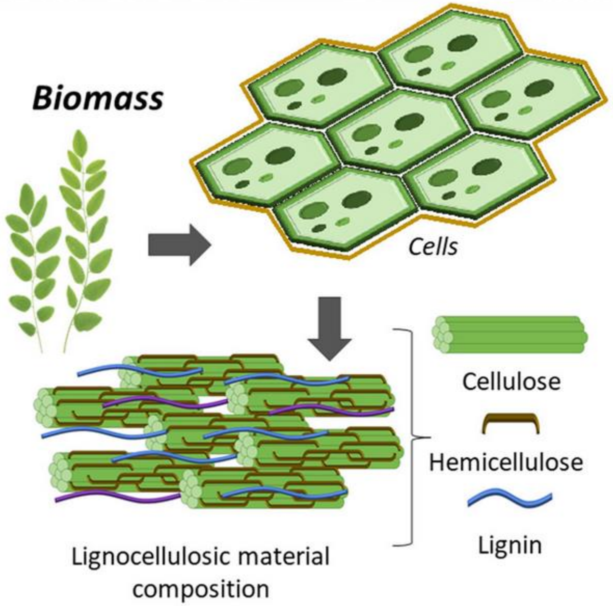

Figure 4. Structure of plant cell wall in lignocellulosic biomass which is consisted of lignin, hemicellulose and cellulose (Saldarriaga-Hernández et al. 2020).

NANOCELLULOSE

The term of nanocellulose (NC) is being used to describe cellulose-based nanomaterials with at least one dimension in nanometer scale. Different terminologies have been used to describe nanocellulose and according to these conditions, nanocellulose can be divided into three main categories: (i) cellulose nanocrystals (CNC) or nanocrystalline cellulose (NCC) (ii) cellulose nanofibrils (CNF), also known as nanofibrillated cellulose (NFC), microfibrillated cellulose (MFC) or cellulose nanofibers, (iii) bacterial cellulose (BC) or bacterial nanocellulose (BNC) (Klemm et al. 2018; Ilyas et al. 2020; Omran et al. 2021).

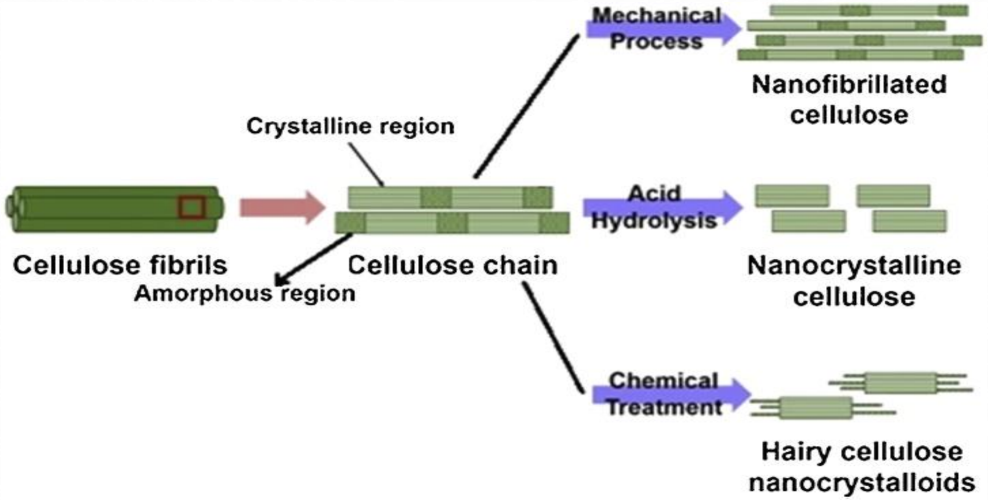

Figure 5. Schematic representation of extraction of nanocellulose from lignocellulosic biomass (Sharma et al. 2019).

NANOCELLULOSE

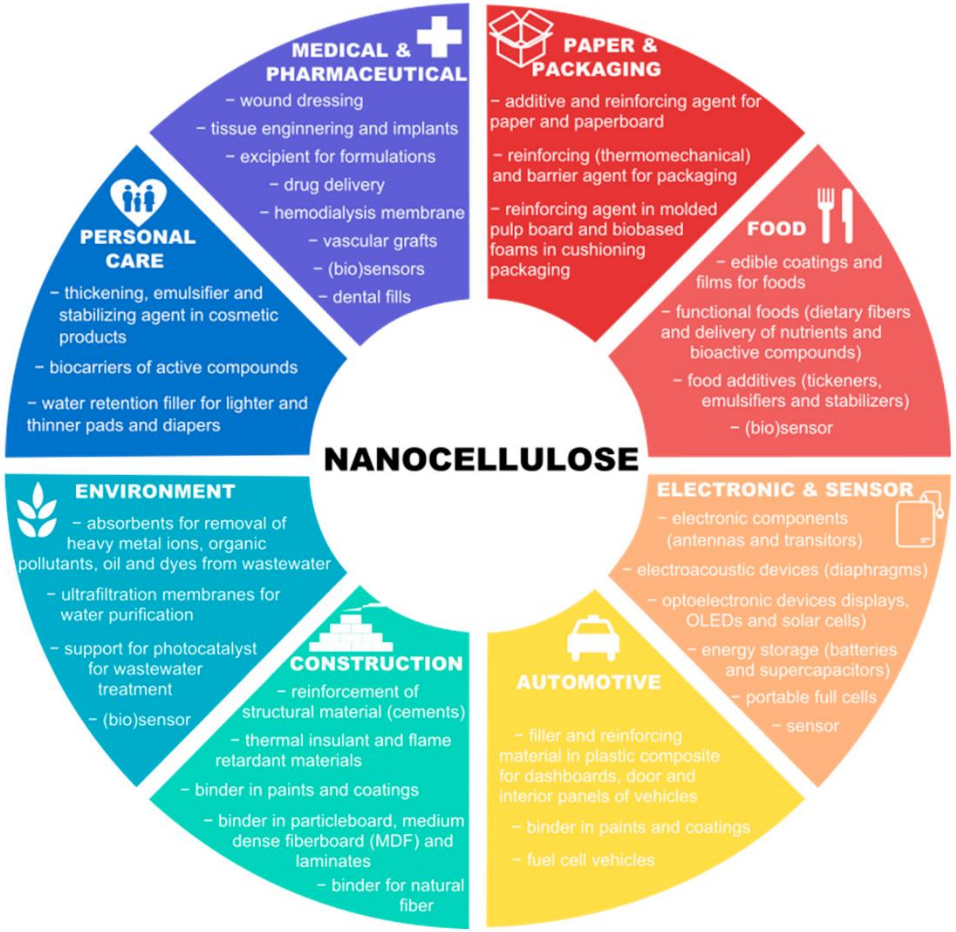

Figure 6. The potential application of nanocellulose in different fields (Michelin et al. 2020).

NANOLIGNIN

Micro and nanosize lignin has recently gained interest due to improved properties compared to standard lignin available today. Depending on the extraction process, a variety of lignin types and ratios of monomer units can be obtained.

Figure 7. Applications of nanolignin (Beisl et al. 2017).

NANOHEMICELLULOSE

Nowadays, hemicelluloses have been used in a wide variety of industrial applications such as biopolymer production, wound dressing, drug delivery and controlled release systems, anti-tumour and antimicrobial applications, or the food industry (Kulicke et al. 1997; Daus and Heinze, 2010; Ferreira et al. 2010; Mikkonen and Tenkanen, 2012; Börjesson et al. 2018; Penttilä et al. 2018; Ye et al. 2018).

In the literature, there is a lack of information about the downsizing of hemicelluloses to the nano scale.

ADHESIVE APPLICATIONS OF ADVANCED RENEWABLE NANOMATERIALS

The use of advanced renewable nanomaterials can enhance the mechanical properties and performance of adhesives by reducing formaldehyde emissions (Candan, 2012; Yildirim, 2019).

Figure 8. Adhesives applications of advanced renewable nanomaterials (Candan, 2020).

ENERGY APPLICATIONS OF ADVANCED RENEWABLE NANOMATERIALS

Advanced renewable nanomaterials have a wide range of uses, including solar cells, energy storage piezoelectric materials, and lithium ion batteries (Lastrado et al. 2020).

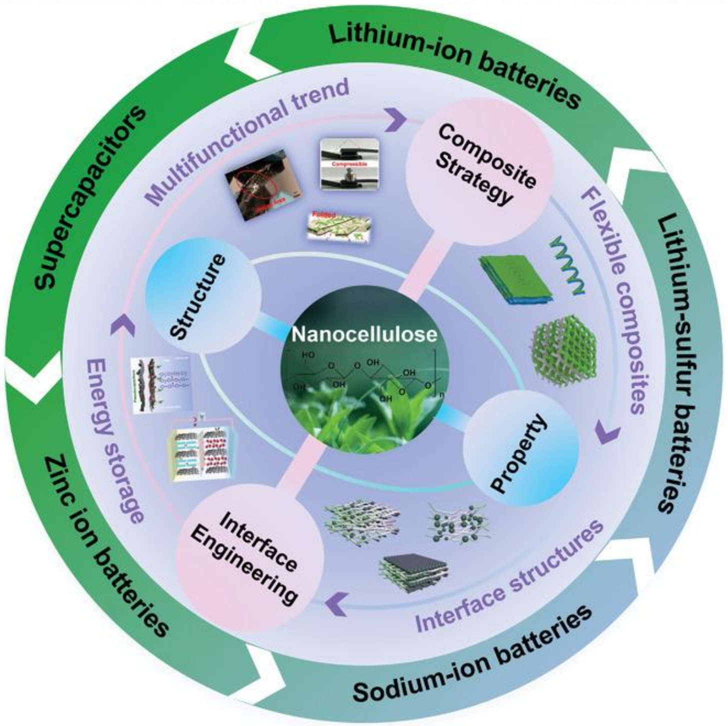

Figure 9. Energy applications of advanced renewable nanomaterials (Xu et al. 2021).

MEMBRANE APPLICATIONS OF ADVANCED RENEWABLE NANOMATERIALS

Nanocelluloses in various forms have been used in water treatment, with membranes and filters receiving the most attention (Mautner, 2020). Advanced renewable nanomaterial-based membranes could help in the purification of drinking water by rapidly removing contaminants (Sharma et al. 2020).

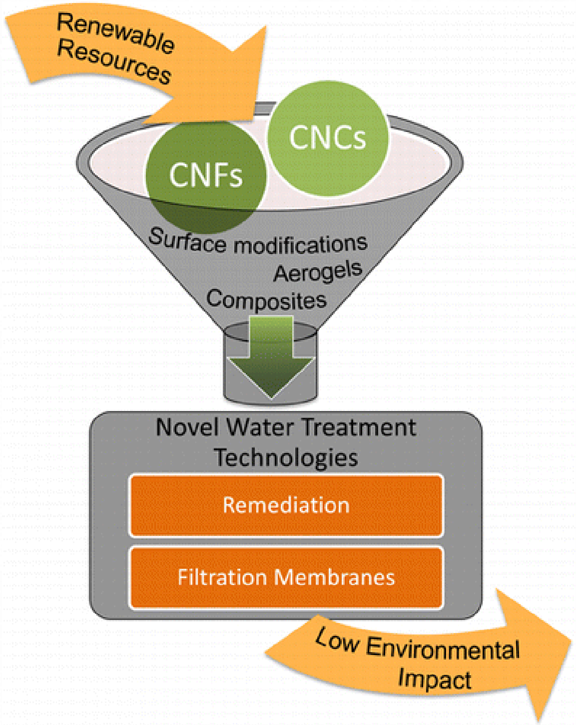

Figure 10. Membrane applications of advanced renewable nanomaterials (Miyashiro et al. 2020).

AUTOMOTIVE APPLICATIONS OF ADVANCED RENEWABLE NANOMATERIALS

Armrest production and under-hood thermal heat barriers, for example, could be produced using advanced renewable nanomaterials.

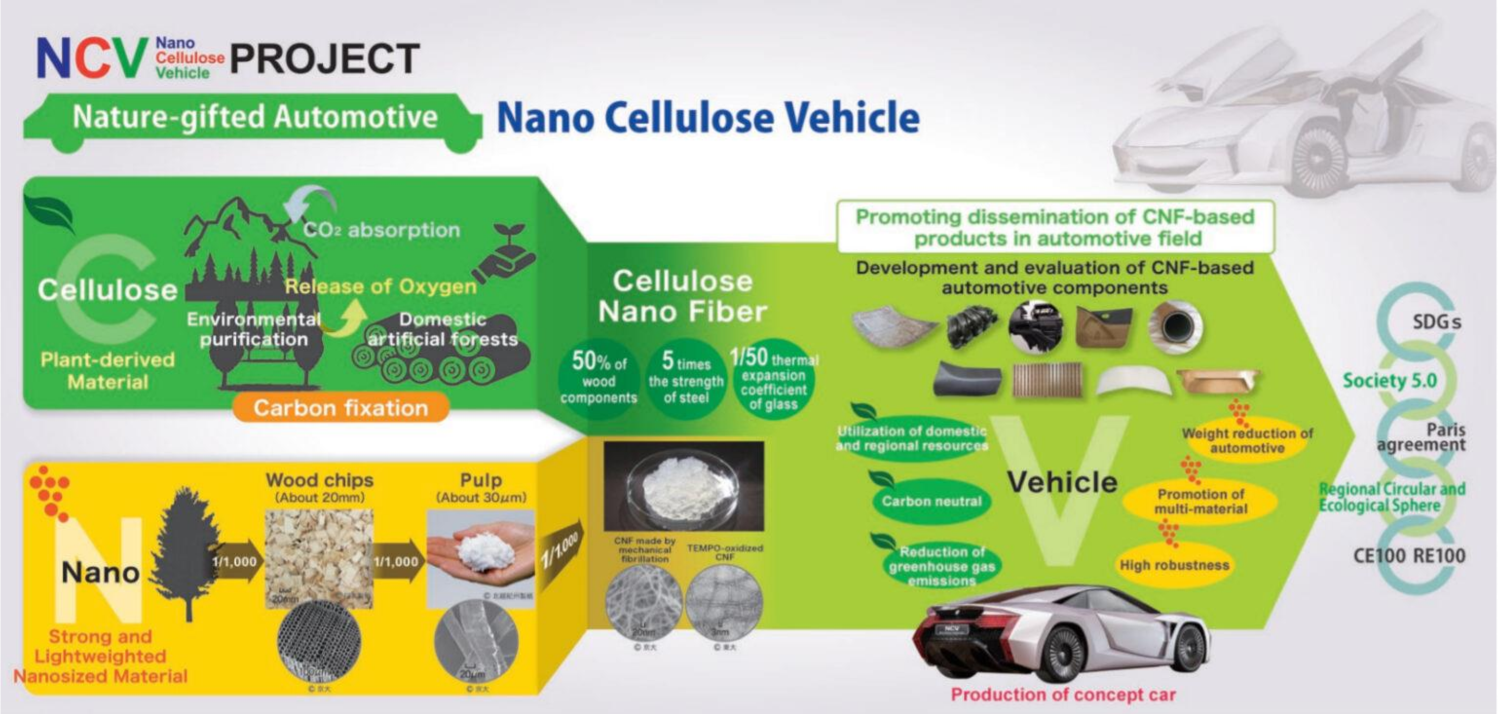

Figure 11. Automotive applications of advanced renewable nanomaterials (Salam Groovy Japan, 2021).

FOOD PACKAGING APPLICATIONS OF ADVANCED RENEWABLE NANOMATERIALS

The usage of advanced renewable nanomaterials has been developed as an alternative to petroleum-based packaging and packaging materials.

Figure 12. Food packaging applications of advanced renewable nanomaterials (Zelfo, 2018).

COSMETIC APPLICATIONS OF ADVANCED RENEWABLE NANOMATERIALS

The main goals of using advanced renewable nanomaterials in cosmetics include effective penetration into the skin for increased product delivery, new color components, transparency, and long-lasting effects (Fytianos et al. 2020).

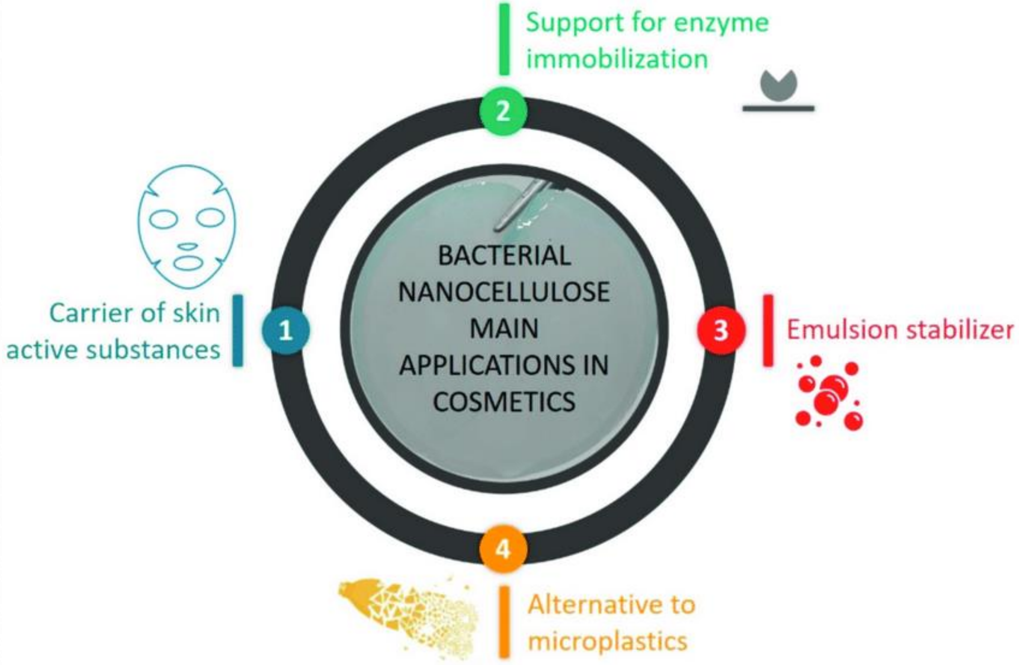

Figure 14. Cosmetic applications of advanced renewable nanomaterials (Almeida et al. 2021).

BIOMEDICAL APPLICATIONS OF ADVANCED RENEWABLE NANOMATERIALS

Medical implants, tissue engineering, drug delivery, wound healing, and cardiovascular applications all make extensive use of advanced renewable nanomaterials (Guise et al. 2015, Sharip et al. 2020).

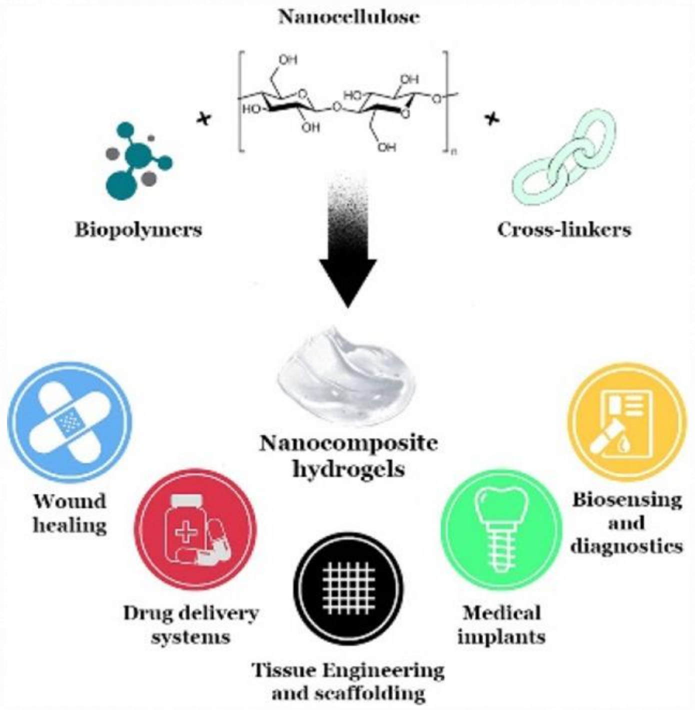

Figure 1. Biomedical applications of advanced renewable nanomaterials (Subhdar et al. 2021).

ELECTRONIC APPLICATIONS OF ADVANCED RENEWABLE NANOMATERIALS

Advanced renewable nanomaterials can be used to create high-value-added products in electronics, such as flexible and transparent displays, electronic circuits, electrodes, and supercapacitors.

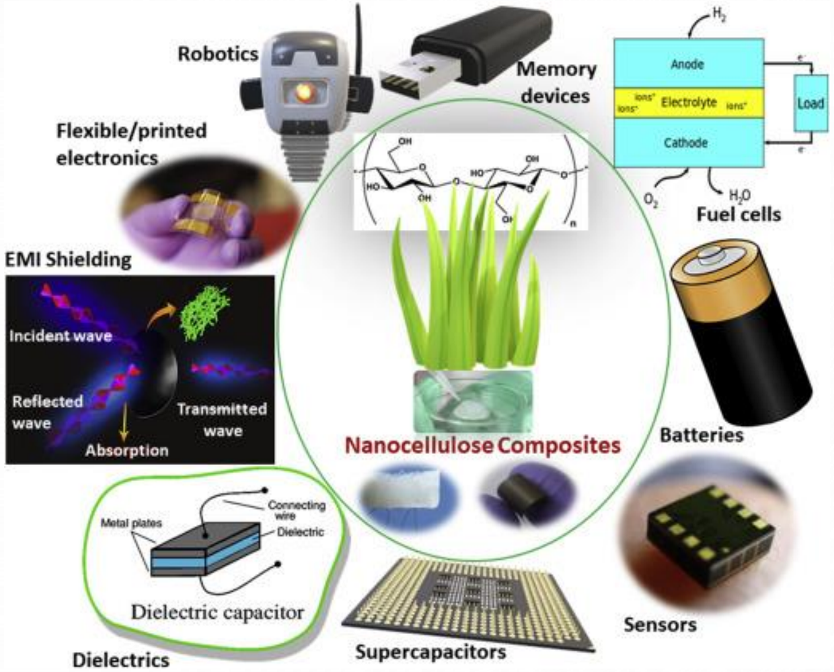

Figure 15. Electronic applications of advanced renewable nanomaterials (Nanowerk, 2019; Nizam et al. 2021).

CONCLUCIONS

- As the tendency to use sustainable and renewable resources in the production of advanced renewable nanomaterials increases, we will begin to see the utilization of nanocellulose and nanolignin in such materials increase.

- The search for novel materials based on renewable lignocellulosic nanomaterials in particular will minimize waste byproducts of the processes, as will the increased interest in environmentally friendly production.

- An adaptation of an advanced renewable nanomaterial produced in the laboratory to a pilot-scale or industrial-scale system is quite complicated, and process engineering techniques should be developed to create a technological infrastructure by reducing costs.

ACKNOWLEDGEMENTS

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Thanks for your attention

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