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CRYSTALLINE NANOCELLULOSE: AN OVERVIEW

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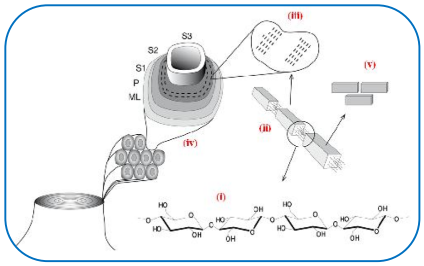
ABSTRACT :

Cellulose is a biomass found in nature and is readily available. The complex and structural interaction of cellulose allows for different types of nanostructured celluloses such as nanocrystalline cellulose and microstructure cellulose. More recently, a review in literature disclosed the isolation and use of cellulose nanoparticles for several applications. Recently nanocellulose and its applications have gained strong attraction both in research and in industrial sectors thanks to its attractive characteristics, such as good mechanical properties, high surface area, rich alteration hydroxyl groups and 100% eco-friendly natural properties.



KEYWORDS : *Nanocellulose; Nanocrystalline & Nanoparticles.*

INTRODUCTION

Cellulose is a biopolymer found naturally in, for example, plant cells such as wood and cotton. It is the most abundant polymer in nature and the principal component in the cell wall of plants and trees.[1-3] Cotton has approximately 90% cellulose, the highest content in plants, compared with wood which contains approximately 40%–50% cellulose. Nanoscience is the study of nanometer materials with new and enhanced characteristics, which can include all fields of physical and chemical science. Nanomaterials show unique properties.New concepts of nanocomposites and nanoglasses are also being investigated with special emphasis on ceramic composites to increase their strength and toughness. While no nanochristalline material components are used now in any application, the potential for applications seems to be great in the near future.[4-6]

Nanocrystalline materials have most often greater properties than traditional coarse-grained poly-cristalline materials. Nanocrystalline materials exhibit increasing hardness/strength, greater diffusiveness, enhanced ductility/strength, lower density, reduced elastic module, increased electrical resistivity, higher specific heat, higher coefficient of thermal expansion, lower thermal conductivity and higher soft magnetic properties than standard, coarse-grained materials. Recent findings on these characteristics have been addressed with a specific focus on mechanical properties.

A simple image is only now emerging of the structure of nanocrystalline materials. In recent studies using spectroscopy, electron microscopy with high resolution, and computer simulation methods, it is clear that the grain borders structure is the same in nanocristalline as in ground grain material, although earlier studies indicate that the grain borders structure in both raw and nanocristalline materials is very different in nanocyste materials This aspect and grain production are critically examined.[7-10]

The cellulose polymer is a linear homo-polysaccharide together with D-anhydroglucopyranose gadgets (AGU) related collectively by using β-1,4-glycosidic bonds. Every different agu is grew to become a hundred and eighty° with appreciate to its neighbor and AGU subsequent to each other shape a cellobios unit, the smallest repeating unit within the polymer (Fig. 1).

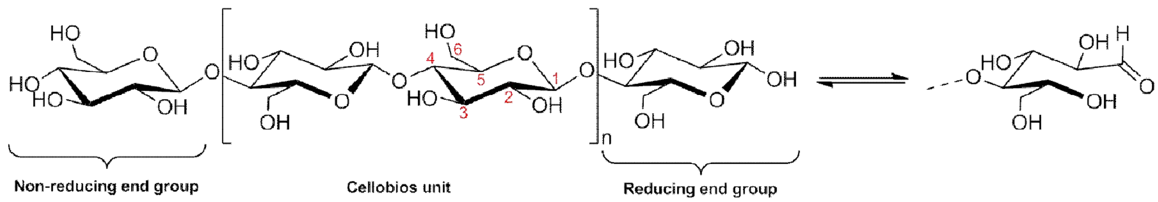


Figure 1. The molecular structure of a cellulose polymer

NANOCELLULOSE

When cellulose fibres or crystals have at least one dimension within the range of the nanometer, nanocellulose, or different names of nanocracy, whiskers or rods, nanofibrils or nanofibres. In 2011, the TAPPI published a roadmap for the creation of international nanocellulose standards in which the following abbreviations have been identified: nanocellulose cellulose (CNCs), nanofibril-cellulose (CNF), and microfibril-cellulose cellulose (CMFs), the designation used throughout this examination. Nanocellulose's sustainability and mechanical properties include high volume surface to volume ratios, high tensile strength and rigidity, high resilience and strong electrical and thermal characteristics. The healthy handling and consumption of both cellulose and nanocellulose was considered.[11]

A few utility areas for nanocellulose are listed underneath:

1. Paper, paper and packaging: The enhancement of fibre-fiber bond strengths and a strengthening impact on papers is one of the applications for nanocellulose in the paper and paper boards industry.
2. Composition materials: the use of nanocellulose in biocomposites is advantageous and has many special properties .
3. Food industry: the use of nanocelluloses in food products as thickeners or stabilizers can form emulsions and dispersions.
4. Non-cellulose has strong absorption properties and can for example be used in tissues, non-woven products or diapers. medicinal products.
5. Films, painting, cosmetics, motor cars, etc.

Depending on the source and procedure, for example, there are various kinds of nanocellulose. Different sources of cellulose have different characteristics as well as different appearance proportions (L/d, where length is L, and diameter is d).

CELLULOSE NANOCRYSTALS (CNC):

Cellulose nanocrystals (CNCs) are normally approximately 2-30 nm wide and can be hundreds of nanometers long and shaped in acidic cellulose fibre hydrolysis, where the most available, unresolved sections are degraded selectively. Since the non-cristalline regions act in microfibrils as structural defects, it is responsible for the transverse cleavage of microfibrils in acidic hydrolysis into short monocrystals. The acid spreads into non-crystalline sections of the cellulose fibre at the early stages of the hydrolyse and hydrolyzes the glucose connections. After these glycosidic bonds are hydrolyzed more readily accessible in the polymer and eventually, the reduced finishing group and the surface of the nanocrystals are hydrolyzed. The longer the hydrolyzing of the glycosidic bonds is for the acid, the more gradual the reaction. The hydrolysis of the nanocrystals and of the reduction ends would cause the nanocrystals to be charged according to the acid used. By using a solution of 64 wt percent sulfuric acid the nanocrystal surface contains 0.5%-2% sulphate groups. Due to charged sulphate groups, when diluted into water to particular concentrations, CNC becomes stable colloidal dispersion.

NANOCRYSTALLINE CELLULOSE:

Because of its needlelike structure, high surface area, high appearance relation (length/diameter), high crystallinity, nanoplasmic size, high strength, rigidity, low density and high negative charges, the nano-cellulose cells (NCC) have a number of remarkable optical, chemical and electrical properties which lead to unique behaviour. NCC is customizable for different applications because of its high chemical reactivity, in addition to the thermal stability, which enables applications with high temperatures. In addition, they also have large OH surface groups that actively bind hydrogen through the interconnection with the nonpolar matrix.[3-4]

The fermentation of low-molecular-weight sugars is performed using *Acetobacter* species bacteria for the bottom-up biosynthesis approach. In the meantime, nanocrystalline cellulosis is induced chemically by extracting amorphous regions with the top-down method. The chemical or mechanical treatments, or a mixture of these two treatments, include enzyme therapy, grinding, hydrolysis with high-pressure TEMPO-mediated oxidisation, microfluidisation, cryocrushing and ultrasonification with high strength.

CHEMICAL MODIFICATION ON NANOCELLULOSE:

Sulfate groups can span the nanocrystal surface during the hydrolysis of cellulose, starch or chitin. If hydrochlorinic acid is used in place, after the esterification reaction with sulfuric acid may bind the sulphate groups to the surfaces of the nanocrystal. This will regulate the quantity of charged groups on the surface of the cellulose crystal. The properties of nanocrystal or nanofibers may be modified and regulated in unique ways by using chemical modifications to nanocrystals or nanofibres.[2-3]

Much of the literature discussing nanoparticle chemical modification aimed to enhance the interaction between nanocrystals and different polymer patterns. Improving the compatibility could boost the mechanical characteristics of composite materials and enriching the mechanical features of the significant composite material by a little nanocellulose to a polymer matrix.

BIOBASED COMPOSITES:

Nanomaterials are subject to various reviews as reinforcements of composite materials and the tremendous significance of nanomaterials in composites is attributed to the numerous benefits of biobased nanomaterials. Some of the advantageous properties with biosource nanomaterials are given below.

- Nature's natural resources
- worldwide assets availability
- Low cost in comparison with other reinforcement materials of nanometer scale
- Low manufacturing energy consumption
- Low densities relative to other nanomaterials, e.g. metal or glass fibres used for reinforcement
- High strength, high rigidity, high E-modulus
- Strong electrical and heat characteristics
- Chemical alteration of the properties of nanocellulose can result in a change to nanocellulose's compatibility with different polymer matrices.

Composite materials are commonly used in various applications today and include a polymer matrix and a reinforcing filling material. Often synthetic fillers are used, such as glass fibre, carbon and aramid.

APPLICATIONS OF CNC

Due to many perfect strength properties, light transmission, gas barrier, and others, CNC applications were based on optical, electrical, composite and other fields: CNC applications.

1. CNC Reinforcement Composites

As the environment in which nanocomposites were formed, the effects of CNC include high force, low density, high biological degradation, green renewability, crystallinity, porosity and interphase impacts became increasingly evident.

2. Barrier Films

The CNC-modified composites have attracted interest in applications of barrier films with potential use in filtration and packaging because they have waterproof and barrier-resistant functions[6]. The research focused primarily on how water vapour and oxygen are prevented from entering the envelope.

3. Biomaterials

For its biodegradability, high biocompatibility and nontoxicity, CNC has been used in biomedical scaffolds, strain sensors, separation of oils and water, medical exceptors, wound dressings and other biological materials.

4. Other Applications

The versatile energy storage system was rendered by use of the MWNT nano-wire arrays of the CNC as a promising material for energy application. The structure was usually based on a single sheet of cellulose paper (separator), made of ionic liquid and CNC room temperature (electrode). Zhu et al. demonstrated, in the areas of visible and almost-infrared wave-length regions, that the CNC nanopapers were applicable for light-emitting diodes (LED), and found, that CNC matrix LEDs are highly transparent. In addition, the CNC matrix was sufficiently flexible to be roll-to-roll compatible.

CONCLUSION:

This review identified nanocellulose as a material with extraordinary properties to be used to strengthen paper or composite materials and its importance in society. In addition, it has been possible in the areas of packaging, paper and paperboard, the food, medical and hygiene products, painting, cosmetics, etc. to use nanocellulose in society.

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