NANOCELLULOSE AND ITS POTENTIAL USE IN BIOMEDICAL

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Introduction

Cellulose is the most widely available organic polymer, representing about 1.5 trillion tons of the total annual biomass production, and is considered as an almost inexhaustible source of raw material for the increasing demand on environmentally friendly and biocompatible products [1]. Cellulose can be extracted from the wood, plants, tunicate, bacteria and algae (Figure 1). Nanocellulose materials can be divided into three broad categories, depending on the cellulose nanofibers origin (Table 1).

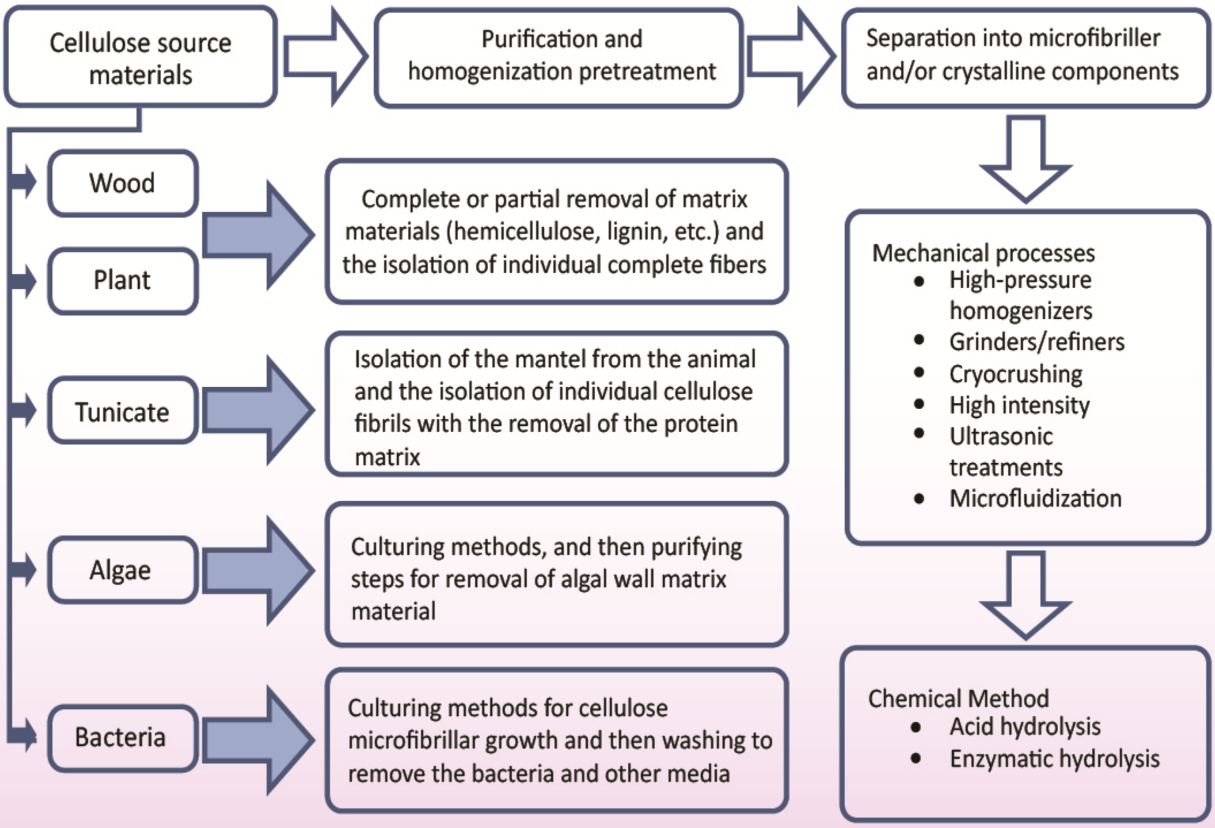

Figure 1. The isolation of cellulose particles from cellulose source [1], [2]

Acronyms	Name	Details	Toxicological experiment
WF PF	Wood fiber Plant fiber	-Hierarchical structure -Low crystallinity (43–65%)	Low toxicity potential Low environmental risk
MCC	Microcrystalline cellulose	-Porous -B10–50 mm in diameter -high cellulose content, -higher crystallinity -aggregate bundles of multi-sized cellulose microfibrils that are strongly hydrogen bonded to each other -Usually the MCC aggregates are broken up into smaller micron-sized rod-like particles (1–10 mm in length) prior to use in composites	Low toxicity potential Low environmental risk
MFC	Microfibrillated cellulose	-Produced via mechanical refining of highly purified WF and PF pulps. -used as a thickening agent in the food and cosmetics industries. multiple elementary fibrils each consisting of 36 cellulose chains arranged in the Ib crystal structure, -high aspect ratio (10–100 nm wide, 0.5–10's mm in length) -B100% cellulose -both amorphous and crystalline regions.	Low toxicity potential Low environmental risk
NFC	Nanofibrillated cellulose	-consists of 36 cellulose chains arranged in crystal structure square cross-section, -high aspect ratio (4–20 nm wide, 500–2000 nm in length), -B100% cellulose -both amorphous and crystalline regions.	Low toxicity potential Low environmental risk
AC	Algae Cellulose	AC particles are the microfibrils extracted from the cell wall of various algae by acid hydrolysis and mechanical refining. The resulting microfibrils are microns in length, have a large aspect ratio (greater than 40) with a morphology depending on algae.	Low toxicity potential Low environmental risk
BC BNC	Bacteria Cellulose Bacteria Nano Cellulose	-large aspect ratio (greater than 50) - morphology depending on the specific bacteria and culturing conditions -Acetobacter microfibrils have a rectangular cross-section (6–10 nm by 30–50 nm), terminating surfaces of (010)t, and (100)t with (100)t being the largest facet,73 and have primarily Ia crystal structure - altering the culture conditions (stirring, temperature, and additives) it is possible to alter the Ia/Ib ratio and alter the width of the micro- fibrils	No evidence of cytotoxicity No evidence of toxicity in vitro and in vivo Non-toxicity and non-immunogenicity
t-CNC	Tunicate cellulose nanocrystals	-produced from the acid hydrolysis of tunicates - ribbon-like shaped t-CNCs have a height of B8 nm, a width of B20 nm, a length of 100–4000 nm (typical aspect ratios 70–100) -B100% cellulose- -highly crystalline (85–100%) -contain a high fraction (76–90%) of Ib crystal structure -highly crystalline and have the largest aspect ratio of any CNC.	Low toxicity potential Low environmental risk

Table 1. The different terminologies used to describe cellulose and cellulose nanoparticles and toxicology experiment results [3]

Bacterial Nano cellulose (BNC)

BNC is a pure cellulose made by bacterial fabrication via biochemical steps and self-assembling of the secreted cellulose fibrils in the medium [2]. The BNC has a fibrillar nanostructure, and its performance including high purity, ultrafine network structure, and high mechanical properties making it suitable for biomedical applications (see Figure 2) [4]. Shaping of the BNC materials in the culture medium can be controlled by the type of cultivation that changes chain sizes, origin of strains that produced different proportion of crystalline phase of BNC, and type of bioreactor[5].

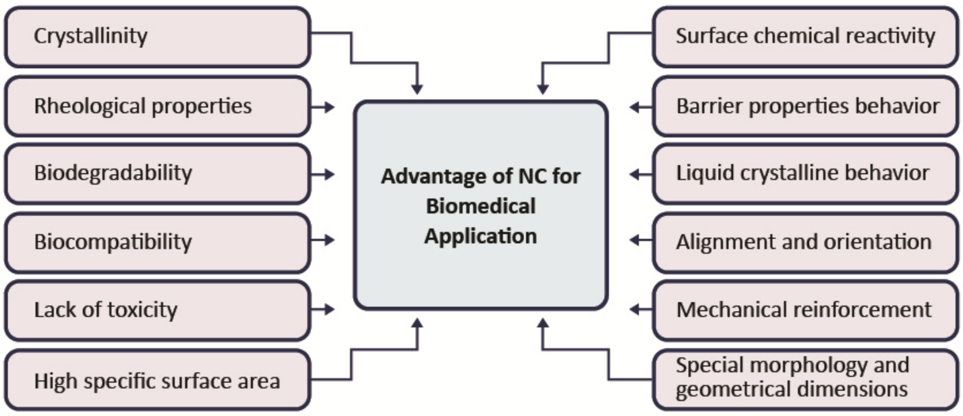

Figure 2. The advantages of NC for biomedical application

Biomedical application of NC

Recently, Nanocellulose has been called as the eyes of biomaterial highly applicable to biomedical industry which includes skins replacements for burnings and wounds; drugs releasing system; blood vessel growth; nerves, gum and duramater reconstruction; scaffolds for tissue engineering; stent covering and bone Figure 3 shows some applications for Nano cellulose within biomedical field[5].

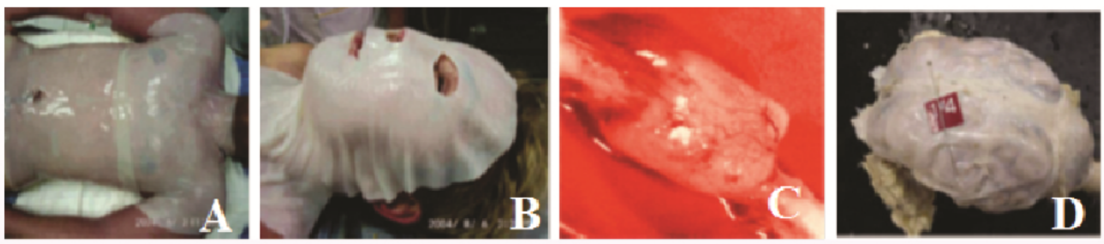

Figure 3: Biomedical applications of nanocellulose (A) and (B) never dried nanocellulose membrane; (C) artificial blood vessels ; (D) dura mater reconstruction[6][7][8][9][10] [11]

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