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Biopaper obtained from microorganisms

Lauro Xavier Filho [a], Pierre Basmaji [b], Carlos Vicente Córdoba [c]

[a] Biotechnology and Natural Products Laboratory, ITP/UNIT, Aracaju-SE, Brazil.
xavierfilho@infonet.com.br

[b] Innovative Technologies of Sao Carlos-Innovatecs, 13560-300-Sao Paulo-Brazil,nanoexpertise@yahoo.com.br

[c] Faculty of Biology, Complutense University, 28040 Madrid, Spain, cvicente@bio.ucm.es

Abstract

We propose to produce biopaper from microorganisms' biosynthesis of cellulose and hemicelluloses. The potential capacity of micro organisms to form bio cellulose and hemicelluloses fibbers was analyzed. Inherent fiber characteristics are largely determined by the ratio and interactions between cellulose and hemicelluloses, by the biosynthesis or biodegradation of specific polysaccharides, and by the interference of cellulose-hemi cellulose interactions using carbohydrate-binding modules. The higher the content of hemicelluloses in the wood, the better the quality of the cellulose, which will become more resistant in the process of manufacturing paper bobbins without, rips. In the final consumption, the paper with these characteristics should guarantee the best quality of printing and also result in material with more resistance and adaptability for the packaging sector. Biocellulose /biohemicellulose is expected to be a new biodegradable biopolymer.

Keywords: Biopolymer, Fermentation, microorganisms, Acetobacter xylinum.

Introduction

Natural fibers have a wide range of industrial applications, such as in paper and textile industries. The new technologies, as transgenic, genomic, proteomic and bioinformatics, have been quickly incorporated. The association of these technologies to the programs of conventional improvement of trees can speed up the process of attainment of products with specific characteristics. In the industry of paper and cellulose, the attainment of trees with reduced content or modified composition of lignin, is one of the examples where these technologies are being applied. Some bacteria produce cellulose/hemicelluloses (celled biocellulose or bacterial cellulose). Plant and bacterial celluloses have identical chemical structure, but different physical and chemical properties. Bacterial cellulose is produced by an acetic acid-producing bacterium, *Acetobacter xylinum*.

Besides the most popular isolation of cellulose from plants, the principal pathways of cellulose production include the biosynthesis by different types of microorganisms, the in vitro enzymatic synthesis, and the chemosynthesis from glucose derivatives[1].

The present paper describes cellulose and hemicelluloses production using microorganisms. Biohemicellulose would be produced from the fermentation developed by a symbiotic association between *Acetobacter xylinum, Saccharomyces cerevisae* and *Schizosaccharomyces pombe,* growing on sugar cane sucrose as carbon source and a solution of mate tea as nitrogen source.

Materials and Methods

Biocellulose can be produced using *Acetobacter xylinum*, also growing on broth of sugar cane or tea. The acetic fermentation process is achieved by using the fine sugar as carbohydrate source. Results of this process would be vinegar and a biomass of biocellulose. Fig. 1 shows, as an example, the schematic process of biocellulose/hemicelluloses production.

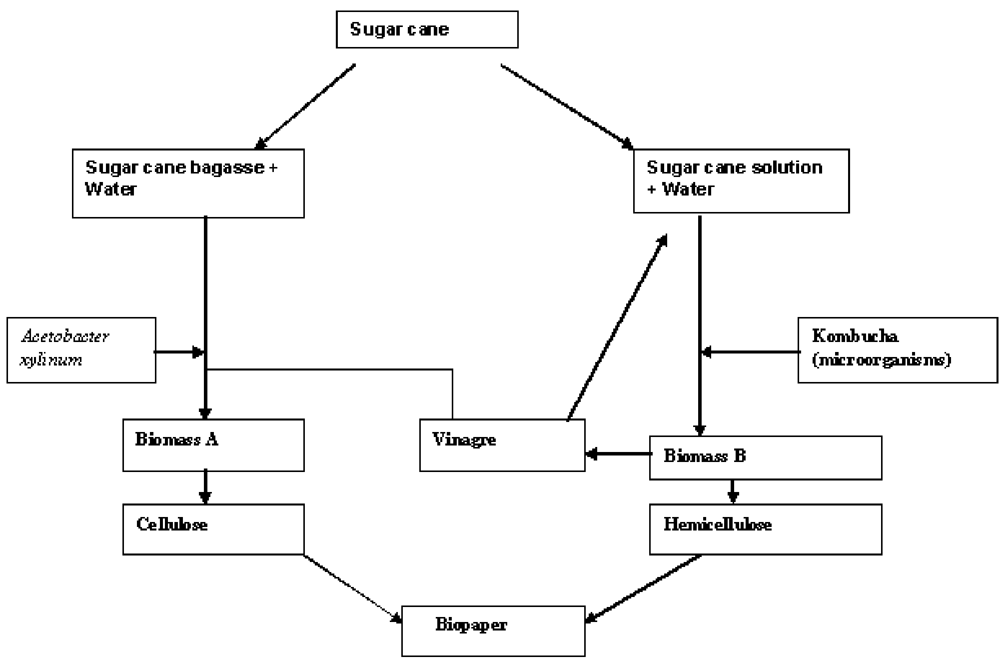

Fig. 1 Schematic process of biocellulose /hemi cellulose production by microorganisms.

Results and Discussion

Production of biocellulose

As noted above, the explanation for cellulose production in microorganisms remains unclear. Several hypotheses have been proposed to explain the synthesis of this biofilm. It has been proposed that cellulose supports aerobic bacteria on the surface of liquids as part of a survival strategy protecting bacterial cells against ultraviolet radiation, as well as against other organisms and heavy metals, and that it facilitates the diffusion of nutrients into the organisms.
Cellulose-producing cells are surrounded by an extra cellular polymeric matrix that supports bacterial population on the surface of liquids. The polymer matrix permits the adhesion of cells to a solid or liquid surface. It also facilitates the access of nutrients due to its absorbent properties and because its concentration in the polymeric network is higher than in the surrounding liquid medium[2].

Laboratory production of cellulose using *A. xylinum* has been conducted primarily with static cultures. Studies seeking to maximize yield have used agitated cultures, a process that can be undertaken in a RDF (rotating disc fermented) reactor or in a continuous flux (airlift) reactor[3,4].

Production of Hemicelluloses

Kombucha is a popular beverage among many traditional fermented foods across the world. It was originated in northeast China (Manchuria) and later spread to Russia and the rest of the world. Kombucha is also frequently called "tea fungus" in the literature, although no fungus is actually involved in the fermentation process [5,6,7,8,9,10].

Kombucha is the product of the symbiotic growth of bacteria (Acetobacter xylinum, Acetobacter xylinoides, Bacterium gluconicum) and some yeast strains (Schizosaccharomyces pombe, Saccharomycodes ludwigii, Saccharomyces cerevisiae, etc.) cultured on sugared tea [6,11,12]. The exact microbiological composition of the product also depends on the source of inoculate and on tea fermentation. Cellulose/hemicelluloses produced during fermentation of substrates by A. xylinum appear as a thin film on the top of the tea to which the cell mass of bacteria and yeasts is attached. This fungus-like mixture of microorganisms and cellulose is likely the reason why Kombucha is also called "tea fungus" (the term indicates such a complex in the text hereafter). Glucose liberated from sucrose is metabolized for the synthesis of cellulose and gluconic acid by Acetobacter strains. Fructose is metabolized to ethanol and carbon dioxide by yeasts. Ethanol is oxidized to acetic acid by Acetobacter strains.

Organic acids produced during fermentation shield the symbiotic colony from contamination with unwanted foreign microorganisms that are not part of the tea fungus[13,14]. An optimum fermentation time is required for the production of a drinkable Kombucha. Longer fermentation often results in the production of too high levels of acids that may pose potential risks when consumed. Recent research on Kombucha has proved that its antimicrobial activity against pathogenic microorganisms is largely attributable to acetic acid [8, 14, 15]. Acetic acid is known to inhibit and destroy a number of Gram-positive and Gram negative microorganisms[16].

Recently, Legaz *et. al*. (2004) [17] produced a new biomaterial, so called Bioskin, using *Acetobacter xylinum, Saccharomyces cerevisiae* and *Schizosaccharomyces pombe* growing on sucrose. At the maximum increase of the biomass in culture, material is mechanically disrupted, filtered through a multi-layered cheese-cloth, pressed and dried. The final dry product is not dissolved in water or organic solvents, but it is rewetted in distilled water, absorbing about 250% of its dry weight.

Ultra structural studies by TEM reveal that Bioskin is an anastomous structure composed by fibers surrounding concrete bodies able to fix osmium tetroxide. After washing with acetone, these bodies disappear, revealing then their lipidic or lipoproteic nature (Fig. 2A). SEM analysis shows that Bioskin is apparently formed by crossed fibers with very large interfibrillar spaces (Fig. 2B). Fibers show a very regular structure without superficial adherences (Fig. 2C). Interfibrillar spaces are undoubtedly the basis of the water-absorbing property of bioskin. Some low molecular weight compounds, such as sucrose, dissolved in water, also enter the void spaces and they crystallize on the surface of fibers to which they remain adhered (Fig. 2D).

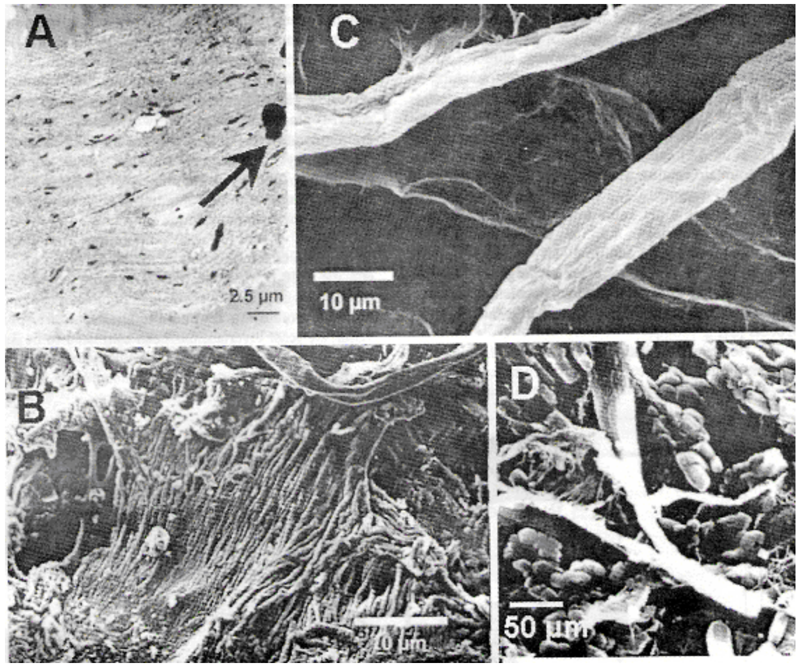

Fig 2 Bioskin ultra structure. A) TEM micrograph of Bioskin showing its fibrillar nature. B) Pressed fibers of Bioskin observed by SEM. C) SEM micrograph of bioskin fibers. D) Crystal of sucrose adhered to bioskin surface.

Conclusion

Biocellulose/biohemicellulose is expected to be a new biodegradable biopolymer. Biopaper can be produced from microorganisms. Biocellulose and biohemicellulose can replace wood cellulose, and reduce consumption of wood for production of paper and fibers in the future. The development of Biocellulose/biohemicellulose in the production of fibers is becoming important in solving ecological problems.

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