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A commentary on microbial cellulose

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Cellulose is the basic component of all plants and the most abundant biopolymer in the world. It can also be generated from other sources such as microorganisms, and this type of cellulose is called Microbial cellulose (MC)[1]. MC is a linear glucose polymer with hydrogen bonding between hydroxyl groups of neighboring parallel chains and is organized in fibers in close association with lignin and hemicellulose [2]. MC can be extracellularly synthesized into nanoscale fibrils from some strains of bacterial genera such as Acetobacter, Agrobacterium, Gluconacetobacter, Rhizobium, and Sarcina. The unique structure of MC confers upon it physical and chemical advantages such as a high water holding capacity (more than 700 times its dry weight), crystallinity, mechanical stability, and hydrophilicity [1, 3]. In comparison to plant cellulose (PC), microbial material is of a higher purity and has better mechanical properties. In light of these attractive characteristics, MC is considered to be one of the most promising biomaterials in the field of industrial and applied materials science. Based on a review of the literature, it is found that the MC has already been used in many fields, such as those of medicine, food processing, textiles, and paper [1, 4]. Cellulose can be generated from four sources: from plants, enzymes, chemicals, and microorganisms. MC is generated by many microorganisms, such as algae (Phaeophyta, Rhodophyta, and Chrysophyta), fungi (Saprolegnia), and bacteiara (Acetobacter, Agrobacterium, Achromobacter, Aerobacter, Sarcina, Azotobacter, Rhizobium, Pseudomonas, Salmonella, and Alcaligenes) in varying amounts (low or high). Among the bacterial sources, the most effective producers of cellulose are reported to be A. xylinum, A. hansenii, and A. pasteurianus [5]. Generally, to produce MC fibrils, the Acetobacter xylinum is cultured in Hestrin–Schramm medium (Fig. 1). This medium includes (%, w/v); glucose, peptone, yeast extract, disodium phosphate, and citric acid. To remove any impurities, the harvested cellulose fibrils are boiled in 2% sodium dodecyl sulfate and 4% NaOH solutions. Then, to neutralize the pH, the MC is rinsed in distilled water [2]. Due to the expensive material needed for the production of MC, some authors have proposed that this could be replaced with waste material such as agricultural residues. For example, Moosavi-Nasab et al. have reported the production of bacterial cellulose using *Gluconacetobacter xylinus* and low quality date syrup [3]. The MC has a wide variety of applications in various areas and industrial fields, including the medical, biomedical devices, cosmetics, environmental, food processing, textile and paper, acoustics, electronics, pharmaceutical, waste treatment, broadcasting, mining, and refinery sectors [1, 4].

Nata de coco, a sweet candy dessert from the Philippines, was the first use of MC in the food industry. Monascus-nata complex was also used. In Japan, MC was introduced into diet fermented tea drinks in 1992. Kombucha, also known as Manchurian tea, was the other dessert that was produced from MC. In the treatment of chronic wounds, the application of special materials which have desirable properties, such as hydrocolloids, hydrogels, and biological or synthetic membranes has been common. In this context, MC has been successfully used as a wound dressing. MC was recommended especially in burn cases, and with chronic wounds like venous leg ulcers, bedsores, and diabetic ulcers. Its unique characteristics, such as light weight, durability, high water holding capacity, porosity, good shape retention, and high surface area rendered MC a suitable alternative to conventional wound dressings. These properties also allow the potential transfer of antibiotics or other medicines into the wound, while at the same time serving as an efficient physical barrier against external infection [5, 6].

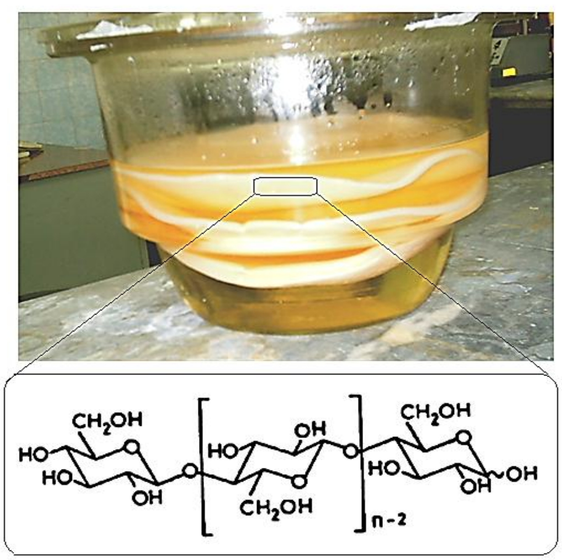

Figure1. Prepared Microbial cellulose

As seen in Fig. 2, the application of MCs for wound dressings is illustrated (images courtesy of the Center of Burn Healing, Siemianowice Slaskie, Poland and Professor Stanislaw Bielecki of the Institute of Technical Biochemistry, Technical University of Lodz, Poland).

Recent important applications of MC include those in tissue engineering (bone grafts), relief of the cardiovascular system, the digestive tract, the urinary tract, the trachea, and applications as synthetic blood vessels and stents [7, 8]. MC also has applications in environmental engineering as a new adsorbent material in remediation processes. Rezaee et al. used bacterial cellulose produced by *Acetobacter xylinum* to successfully remove mercury ions from synthetic and chlor-alkali wastewater [9]. They reported that an adsorption capacity of approximately 65 mg/g was obtained for cellulose under dynamic conditions. In other work, to treat nitrate, Rezaee et al. were able to immobilize denitrifying bacteria

Figure 2. A never-dried microbial cellulose membrane shows remarkable conformability to the various body contours, maintains a moist environment, and significantly reduces pain [8].

on porous MC membranes. They demonstrated that the immobilization of the denitrifying bacteria onto MC increased the adsorption capacity, decreased washout of the cells, and conferred higher activity and better operational control [10]. Godini et al. investigated the feasibility of using a microbial biopolymer produced by Acetobacter xylinum as a carbon source for heterotrophic biological denitrification. They believed that MC would be a suitable carbon source for nitrate removal in a heterotrophic biological denitrification process [2]. Using bacterial cellulose, Shen et al. synthesized diethylenetriamine-bacterial cellulose (EABC) and investigated its adsorption properties for Cu(II) and Pb(II) from aqueous solutions [11]. Using a similar method, carboxymethylated-bacterial cellulose (CMBC) were obtained by Chen et al. [12], and they were able to remove 12.63 mg of copper and 60.42 mg of lead per 1 g of CM-BC. Hossini et al. reported that they were able to simultaneously achieve nitrification and denitrification using a polypyrrole/microbial cellulose (PPy/MC) composite electrode [5]. They reported that they were able to remove approximately 97.42% and 62.47% of ammonium and TN under optimal conditions.

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