" Recent advances in the microbiology of cellulose biosynthesis and degradation in bacteria "

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Abstract

Bacterial cellulose and plant cellulose possess the same molecular formula $(C_6H_{10}O_5)n$, but have very diverse physical and chemical properties. Bacterial cellulose has significant advantages over plant cellulose in terms of purity, degree of polymerization, crystalline index, tensile strength and water holding capacity. This review primarily focuses on biosynthesis and bio-degradation/bio-conversion of cellulose in bacteria, to ensure better understanding of cellulose production and its fate.

Keywords: Bacterial cellulose, Properties, biosynthesis, degradation, Bacteria

Introduction

Cellulose $(C_6H_{10}O_5)n$, a homo-polysaccharide, can be structurally described as having a linear chain of numerous β(1→4) inter-linked D-glucose units (). It is a polymer available biologically [1]. It finds use in various industries like pulp and paper industry, bio-energy industry and textile industry [2]. Cellulose is found plentiful in nature as it is the most abundant macromolecular bio-polymer in the world. Simple chemical structure of cellulose contradicts the complicated process of its biosynthesis and the further structural assembly of the polysaccharide.

Brown in 1886 first noticed the un-branched pellicle growth, which had same chemical structure as plant cellulose, thus identifying it as bacterial cellulose. He observed the formation of cellulose in the presence of oxygen and glucose, by the resting cells of *Acetobacter xylinum*. Henceforth, *A. xylinum* has served as a model microorganism for the detailed studies of cellulose.

Acetobacter xylinum, an aerobic gram-negative bacterium that it's inter-woven extracellular cellulose ribbons are synthesized as a part of its primary metabolite. This bacterium is used as a model for cellulose biosynthesis studies since it can grow and produce cellulose in various substrates.

Bacterial cellulose has unique physiochemical characteristics versus the plant cellulose. Bacterial cellulose is highly pure, and is free from hemi-cellulose or lignin. The main focus is concentrated on biosynthetic production of cellulose, targeting cost effective as well as large quantities of cellulose production. Bacterial cellulose finds application as a biomaterial for electrical instruments, food ingredients [3] and also is used in the medical field [4]. Using a bacterial system for cellulose production is advantageous in many ways. The bacterium can be grown quickly under specific conditions to produce cellulose from a wide range of carbon sources like glucose, ethanol, sucrose, glycerol etc.

Properties of Cellulose:

- Cellulose has extremely high stability because it produces very high levels of polymer from a broad range of carbon and nitrogen sources [3].
- It has unique nanostructure [5].
- It has good water holding capacity [6].
- Its degree of polymerization is very high[7].
- It has very high mechanical strength
- It has high crystallinity [8].
- It is light weight and sturdy at the same time.
- It is a sustainable raw material for industrial us [9].

Various bacterial species which synthesize microbial cellulose are belong to the genus of *Gluconacetobacter (*formerly*Acetobacter), Agrobacterium, Aerobacter, Achromobacter, Azotobacter, Rhizobium, Sarcina and Salmonella*.[10] Cellulose biosynthesis has also been witnessed in the *Burkholderia spp., Pseudomonas putida, Dickeya dadantii, Erwinia chrysanthemi*, and also in the popular model organism *Escherichia coli*. [2, 11]. This review will give insights underlying into the fundamentals of utilization of cellulose, biosynthesis,bio-degradation and bio-conversion of cellulose aiming to facilitate the research and application of cellulose.