World Academy of Science, Engineering and Technology
International Journal of Biotechnology and Bioengineering
Vol:18, No:07, 2024

Dinoflagellate Thecal Plates as a Green Cellulose Source

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Abstract : Cellulose, the most abundant biopolymer, is the major constituent of plant and dinoflagellate cell walls. Thecate dinoflagellates, in particular, are renowned for their remarkable capacity to synthesize intricate cellulosic thecal plates (CTPs). Unlike the extracellular two-dimensional structure of plant cell walls, these CTPs are three-dimensional and reside within the cellular structure itself. The deposition of CTPs occurs with remarkable precision, and their arrangement serves as crucial taxonomic markers. It is noteworthy that these plates possess the hardness of wood, despite the absence of lignin. Partial and prolonged hydrolysis of CTPs results in the formation of uniform long bundles and lowdimensional, modular crystalline whiskers. This observation aligns with the consistent nanomechanical properties, suggesting a CTPboard structure. The unique composition and structural characteristics of CTPs distinguish them from other cellulose-based materials in the natural world. Spectroscopic studies using Raman and FTIR methods indicate a clear low crystallinity index, with the OH shift becoming more distinct following SDS treatment. Birefringence imaging confirms the highly organized structure of CTPs, demonstrating varying degrees of anisotropy in different regions, including both seaward and cytosolic passages. The knockdown of a cellulose synthase enzyme in dinoflagellates resulted in severe malformation of CTPs and hindered the life-cycle transition. Unlike certain other microalgal groups, these unique circum-spherical depositions of CTPs were not pre-fabricated and transported "to site," but synthesized within alveolar sacs at the specific site. Our research is particularly focused on unraveling the mechanisms underlying the biodeposition of CTPs and exploring their potential biotechnological applications. Understanding the processes involved in CTP formation can pave the way for harnessing their unique properties for various practical applications. Dinoflagellates play a crucial role as major agents of algal blooms and are also known for producing anti-greenhouse sulfur compounds such as DMS/DMSP, highlighting the significance of CTPs as a carbon-neutral source of cellulose. Grant acknowledgement: Research in the laboratory are supported by GRF16104523 from Research Grant Council to JTYW.

Keywords : cellulosic thecal plates, dinoflagellates, cellulose, cell wall
Conference Title : ICABA 2024 : International Conference on Algal Biotechnology and Applications
Conference Location : Vienna, Austria
Conference Dates : July 29-30, 2024