Секция «Химия»

Chemical structure and functional applications of natural polysaccharides in biomass conversion and biotechnology

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Natural polysaccharides represent a major component of biological biomass and play an essential role in biochemical processes, renewable energy production, and modern biotechnology. From a chemical perspective, polymers such as cellulose, chitin, lignin-associated carbohydrates, and marine polysaccharides exhibit complex molecular structures that determine their physicochemica properties and biological functions [1]. Polysaccharides in biomass conversion also serve as key substrates to produce a variety of value-added biochemicals, including organic acids, bio-based polymers, and platform molecules used in green chemistry [2]. Advances in enzymatic hydrolysis, metabolic engineering, and catalytic processing are significantly improving the efficiency of polysaccharide depolymerization and the sustainable utilization of lignocellulosic biomass. Cellulose, the most abundant biopolymer on Earth, forms the structural framework of plant cell walls and constitutes a large fraction of photosynthetic biomass. Due to its high carbohydrate content, cellulose-rich biomass is considered a promising raw material for the fermentation of sugars into ethanol, which can be used as a renewable biofuel and gasoline additive. However, the presence of lignin, a complex aromatic polymer derived from phenylalanine and glucose, forms covalent cross-links with cellulose and significantly limits enzymatic degradation by cellulases [3]. Therefore, the chemical understanding of lignocellulosic structures is crucial for improving biomass conversion technologies.

Another important structural polysaccharide is chitin, a linear homopolysaccharide composed of β (1$\rightarrow$4)-linked N-acetylglucosamine units. Structurally similar to cellulose, chitin differs by the presence of an acetylated amino group at the C-2 position, which contributes to its mechanical strength and biological functions in fungal cell walls and arthropod exoskeletons. In contrast, marine polysaccharides such as agar and its purified component agarose, derived from red algae, possess unique gel-forming properties due to their sulfated galactose-based backbone structures. Agarose forms stable three-dimensional gel matrices through double-helix formation, enabling its widespread use in biochemical laboratories as a support medium for electrophoretic separation of nucleic acids [1].

Overall, the chemistry of natural polysaccharides provides critical insights into biomass utilization, structural biology, and biotechnological applications. Understanding their molecular architecture and physicochemical behavior is essential for advancing renewable bioenergy production, biomaterials development, and analytical techniques in modern chemical and biochemical research.

Источники и литература

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