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# Preparation Method of Sorbitol and Its Prospects for High-value Applications

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**Abstract:** As a multifunctional polyol with excellent biocompatibility, low calorific value, and high stability, sorbitol has evolved from traditional applications in food (as a low-GI sweetener) and cosmetics (as a humectant) to high-value fields like advanced pharmaceuticals, bio-based materials and new energy electronics. This article systematically introduced its mainstream preparation methods. The first one was catalytic hydrogenation, which were the dominant industrial process with high conversion and mature purification systems. The second one was biological fermentation, which was an environmentally friendly route with promising green potential. The high-value applications tailored to different purity grades (industrial, food, pharmaceutical and electronic grades) were discussed and the synergistic development mechanism between preparation techniques, purification processes, purity levels and application values were analyzed. Finally, future trends were prospected, including green catalysis upgrading, deep functional modification and intelligent continuous production. This review provides crucial technical support and strategic reference for the sorbitol industry to shift from scale expansion to value enhancement.

**Keywords:** Sorbitol; Preparation technology; High-value application; Different levels of purity

## 1. Introduction

People's health is the core of the "Healthy China 2030" planning outline, emphasizing comprehensive and continuous protection of people's health. The "14th Five-Year Plan" of China also clearly proposes to comprehensively promote the construction of a healthy China and advocate healthy lifestyles. With the improvement of people's living standards, health problems caused by high-sugar diets have become increasingly prominent. As a high-value product from starch processing, sorbitol is widely used in food [1], medicine [2], cosmetics [3] and other important fields closely related to people's health. As a low-calorie sweetener, sorbitol has a sweetness similar to that of sucrose but with lower calories, which can meet people's demand for sweetness while reducing calorie intake and help to prevent diseases related to high-sugar diets such as obesity, diabetes, and cardiovascular diseases [4]. Moreover, sorbitol cannot be utilized by oral bacteria to produce acid, and it can also inhibit the growth of streptococcus and the production of acid, thereby reducing the chance of tooth corrosion by acid and lowering the risk of oral diseases.

Sorbitol ($C_6H_{14}O_6$) is a six-carbon alcohol widely present in nature (Figure 1). It is produced through the reduction reaction of glucose and has physicochemical properties such as mild sweetness

(60%-70% of sucrose), low calories, strong hygroscopicity and good chemical stability [5]. Its application has covered traditional fields such as food, medicine and cosmetics. With the deepening of technological upgrading and functional modification research, it has also demonstrated significant application value in high-end fields such as bio-based materials and medical products. Purity is the core indicator determining the application value of sorbitol. Industrial grade (purity $\geqslant$ 95%) is mainly used for cosmetic raw materials and ordinary plastic plasticizers; food grade (purity $\geqslant$ 98%) is used as a low GI sweetener and moisturizer; pharmaceutical grade (purity $\geqslant$ 99.5%) is used in injections and drug excipients [6]; electronic grade (purity $\geqslant$ 99.9%) is applied in the new energy industry. Currently, the industrial production is dominated by catalytic hydrogenation method, but the strict requirements for purity and impurity control in high-value applications drive the preparation technology to transform towards greenness, precision, and functionality. This paper reviews the optimization achievements of preparation processes and high-value application cases in recent years, builds a technical and application compatibility development framework, and provides support for the upgrading of sorbitol preparation processes and its high-value applications.

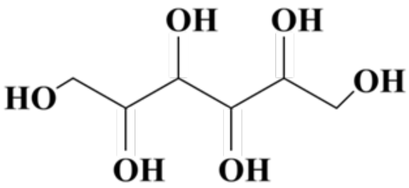

**Figure 1:** The Structural Formula of Sorbitol.

## 2. Preparation Method of Sorbitol

### *2.1 Catalytic Hydrogenation Method*

The catalytic hydrogenation method typically involves hydrolyzing starch into glucose, and then reducing the glucose through a hydrogenation reaction under the action of a catalyst to obtain [7]. The process flow for preparing sorbitol from starch was shown in Figure 2. The commonly used raw material for this method is starch. Due to wide availability and stable prices, corn starch becomes the preferred raw material for industrial production, enhancing the stability and economy of raw material supply. This process has notable advantages, including readily available raw material, high glucose conversion rate and relatively reduced by-products. After decades of industrial iteration, the process has reached a very high level of maturity, and has formed a standardized production system from raw material pretreatment to hydrogenation reaction, purification and refinement. Therefore, catalytic hydrogenation method is the absolute mainstream preparation method in the global commercial market.

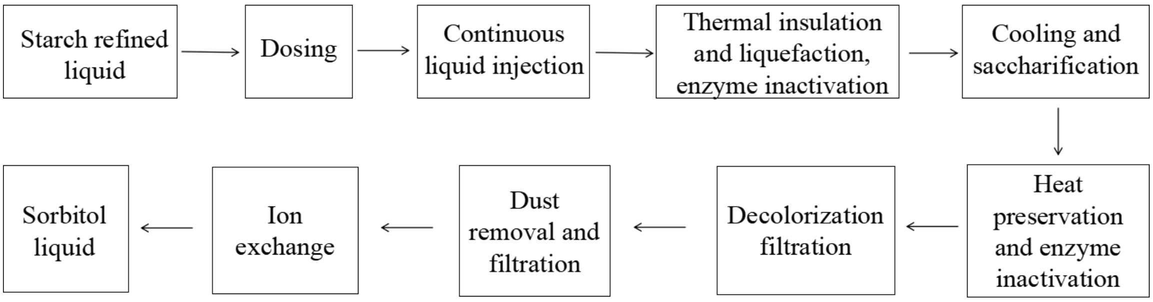

**Figure 2:** The Process Flow for Preparing Sorbitol from Starch.

### *2.2 Bioprocessing of Sugar Fermentation*

Sugar fermentation is a crucial process in the biosynthesis of sorbitol. In industrial production, the core form mainly involves the fermentation of Bacillus subtilis. Glucose and fructose are commonly used as the reaction substrate in the mixture. This technology relies on the catalytic mechanism of the specific oxidoreductase system of the microorganism. Through redox reactions, glucose and fructose are simultaneously converted into gluconolactone and sorbitol[8]. The gluconolactone in the system can further be generated through lactone hydrolysis and become gluconic acid. This preparation method has the advantages of excellent conversion efficiency, low production cost and low raw material loss. It has now been widely applied in the industrial production of sorbitol.

## 3. High-value application of Sorbitol

### *3.1 Pharmaceutical Field*

Sorbitol is the most widely used polyol excipient and therapeutic agent in the pharmaceutical industry due to its non-toxicity, non-participation in glucose metabolism, excellent biocompatibility and high stability. The purity requirements for sorbitol used in the pharmaceutical field are relatively high, usually above 99%. The core applications mainly include injection administration, solid dosage forms, biopharmaceuticals, gastrointestinal administration and topical preparations [9]. In injections, sorbitol is mainly used as an osmotic regulator, which is widely used in amino acid infusions, antibiotic injections, vitamin preparations. Its aim is to regulate the osmotic pressure of the drug solution and achieve isosmoticity with human plasma. Thus, it can reduce vascular irritation and is an important substitute raw material for mannitol. Injection with 10% sorbitol is used as a diuretic in clinical treatment of cerebral edema, intracranial hypertension and glaucoma. Compared with mannitol, sorbitol has mild onset, mild rebound effect and superior safety [10]. In solid dosage forms, due to the moderate sweetness and no hygroscopicity, sorbitol is used as a filler, binder and flavoring agent for tablets and capsules. In tablets and capsules, the use of sorbitol can improve the molding properties of the preparation, and is suitable for diabetes patients' special sugar-free drugs [2]. As a freeze-drying protective agent, high-purity sorbitol can inhibit protein denaturation and is widely used in antibody drugs, recombinant proteins, vaccines and insulin preparations, significantly improving the stability and storage period of biological drugs [11]. In addition, sorbitol is also used as a permeability laxative, oral preparation moisturizer, and is an indispensable pharmaceutical excipient in modern drug preparations [12].

### *3.2 The field of Bio-based Materials*

Sorbitol with low toxicity and multiple hydroxyl groups can be easily modified, making it a core monomer, plasticizer, crosslinking agent and functional additive in the field of bio-based materials. It is applied in bio-based engineering plastics, degradable packaging, functional hydrogels, etc.

#### *3.2.1 Bio-based Engineering Plastics and High-performance Resins*

Sorbitol undergoes acid-catalyzed dehydration cyclization to form isosorbide, which is used as a bio-based diol to replace petroleum-based bisphenol A and is used to synthesize bio-based polycarbonates [13]. It has been scaled up for use in automotive interiors, optical lenses, food contact containers and electronic casings. Additionally, as a bio-based crosslinking agent, isosorbide dimethacrylate is used in UV-curable resins, 3D printing (SLA) and bio-based coatings, enhancing material hardness and glass transition temperature [14].

### 3.2.2 Degradable Bio-plastics and Packaging Materials

Sorbitol serves as an efficient bio-based plasticizer and is used in thermoplastic starch (TPS), polylactic acid (PLA), polycaprolactone (PCL) and alginate-based biobased films. Its multiple hydroxyl groups break hydrogen bonds in starch, enhancing material flexibility and thermal processability. An addition of 5%–7% can balance tensile strength and elongation at break. At a 10% concentration, it achieved complete composting within 30 days, suitable for food packaging, disposable tableware and eco-friendly films [15]. Simultaneously, sorbitol and citric acid condensation formed a fully bio-based hydrophilic resin (SAP), with a main chain containing hydrolysable ester bonds, which rapidly degraded in activated sludge and was used for agricultural and forestry water retention and hygiene materials.

### 3.2.3 Green Composite Materials and Functional Additives

Sorbitol and choline chloride can form a natural low-melting-point solvent to replace traditional silane coupling agents [16], achieving efficient dispersion of silica, reducing VOC emissions, and enhancing the low rolling resistance and wear resistance of green tires. In epoxy encapsulation materials, sorbitol serves as a toughening agent and crosslinking aid, improving the flexibility, melt flowability and interfacial bonding strength of the encapsulation material, which can solve the cracking and delamination problems in advanced packaging, and meet the requirements of green semiconductor packaging.

### 3.2.4 Bio-based Functional Hydrogels and Flexible Electronics

Sorbitol is widely used as a plasticizer, crosslinking aid and functional doping component in hydrogels due to its strong hydrophilicity, excellent biocompatibility and toughening modification properties. The introduction of sorbitol can help to solve the problems of high mechanical brittleness, unstable water content and poor conductivity of traditional hydrogels, and enhance the tensile properties, moisture retention and structural stability. In the field of flexible electronics, sorbitol-based conductive hydrogels have high toughness, ion conductivity and biological compatibility [17]. They can be used in flexible strain sensors, wearable electronic devices and implantable electrode materials, enabling precise monitoring of human movement and physiological signals, while also giving devices green degradability and low biological toxicity characteristics [18].

### 3.2.5 Functional Food

The sweetness of sorbitol is approximately 60% to 70% of that of sucrose, and its calorie content is only 50% of that of sucrose [19]. It has the functional characteristics of a low glycemic index (GI $\approx$ 9), no caries-causing effect, no participation in insulin metabolism, stable moisturizing properties, etc. It is a core non-sugar sweetener and quality improver in the field of functional foods, and is widely used in sugar-free foods, low-sugar baking, healthy beverages, oral care foods and special dietary foods [20]. It is metabolized slowly in the body and does not cause sharp fluctuations in blood sugar, making it suitable as a sweetener for diabetic patients [6]. At the same time, it can inhibit the acid production of oral Streptococcus mutans, reduce tooth enamel erosion, and has a significant anti-caries function. It is commonly used in sugar-free candies, chewing gum and children’s health foods. In addition, the good moisturizing property of sorbitol can maintain the softness and freshness of baked foods, meat products and dried fruits, which can extend their shelf life. In probiotic foods, it can be used as a preservative to increase the survival rate of probiotics in the gastrointestinal environment and exert a probiotic synergistic effect, making it an important functional ingredient in the upgrade of modern healthy foods.

## 4. Conclusions

As a biogenic platform compound with both health attributes and multi-functionalities, sorbitol has achieved a value upgrade from a traditional basic raw material to a core auxiliary material in the high-end industry under the dual drive of the "Healthy China" and "Carbon Neutrality" strategies. This article systematically reviews the technical characteristics and optimization progress of the two preparation methods: catalytic hydrogenation and biological fermentation. The dominant position of catalytic hydrogenation in large-scale production and the green potential of biological fermentation is clarified. The high-value application of sorbitol has formed three core sections: pharmaceuticals - bio-based materials - functional Foods. In the pharmaceutical field, its biocompatibility and stability promote the upgrade of formulation performance. In the biogenic materials field, it replaces petrochemical raw materials such as bisphenol A, helping the development of degradable plastics, flexible electronics, etc. In the functional food field, its low-calorie and anti-cavity characteristics align with the trend of healthy diet, becoming the core ingredient of sugar-free foods. The expansion of these application scenarios not only enhances the industrial added value of sorbitol, but also builds a cross-border integration bond between starch deep processing and high-end manufacturing.

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