# Development History of the Sorbitol Industry

## Part I: A Tribute to the Pioneers

As the earliest industrialized and most widely applied functional polyol across the globe, sorbitol has evolved from laboratory chemical discovery, fundamental mechanism exploration and breakthroughs in catalytic synthesis to a mature and complete industrial system featuring glucose catalytic hydrogenation, continuous refining, and multi-form crystallization/liquid preparation. Its development spans over a century of scientific research and nearly a hundred years of industrialization. Boasting low sweetness, outstanding moisturizing performance, robust stability, superior physicochemical properties and multiple physiological functions, sorbitol has become an indispensable basic functional raw material in food, pharmaceuticals, daily chemicals, chemical engineering and feed sectors, and also serves as the cornerstone product of the global polyol industry.

The transformation of this classic polyol from scientific discovery to worldwide prevalence is attributable to generations of researchers at home and abroad who dedicated themselves to in-depth study and process innovation, as well as practitioners across the entire industrial chain who persisted and forged ahead. Hereby, we pay high tribute to all individual researchers, technical teams, research institutions and industrial chain enterprises engaged in fundamental chemical research of sorbitol, synthesis process development, catalyst optimization, safety toxicological evaluation, industrial standard formulation, application technology development and global market promotion. In compliance with industrial competition and enterprise privacy protection principles, specific enterprise names are not presented in this section; we hereby extend our sincere tribute to all domestic and overseas enterprises that have made outstanding contributions to the development of this industry.

### List of Honorees

#### (I) Core Scientists and Researchers (Chronological Order of Research Achievements)

1. ***Joseph Boussingault (France)***

Pioneer of the natural existence discovery and fundamental chemical research of sorbitol. In 1852, he first isolated a natural hexitol from sorbus berries, conducted preliminary qualitative analysis, formally named the substance Sorbitol, and documented its basic appearance, solubility and other apparent characteristics. He initiated humanity’s scientific understanding of sorbitol and ranks as the founding father in sorbitol research history.

### 2. *Emil Fischer (Germany, Titan of Organic Chemistry)*

Authority on the molecular structure analysis of sorbitol. In the late 19th century, relying on classic carbohydrate analytical techniques, he fully deciphered the chemical molecular formula, stereoconfiguration and isomers of sorbitol, clarified the reduction and conversion relationship between glucose and sorbitol, and established the fundamental organic chemistry theoretical framework of sorbitol. His research clarified the chemical pathway for preparing sorbitol via carbonyl hydrogenation reduction of glucose, delivering core theoretical support for subsequent artificial synthesis technology development.

### 3. *Paul Sabatier & Jean-Baptiste Senderens (France)*

Founders of the catalytic hydrogenation technical system. At the beginning of the 20th century, the two scholars systematically studied the reaction mechanism of metal catalytic hydrogenation and constructed the framework of liquid-phase catalytic reduction technology, laying a universal catalytic theory for polyol preparation via liquid-phase hydrogenation of saccharides. Based on this technical system, academic circles realized laboratory-scale synthesis of sorbitol through glucose hydrogenation for the first time, unlocking the core technical pathway for artificial synthesis of sorbitol and removing fundamental barriers to industrial mass production.

### 4. *Wallace Carothers (United States, Chief Chemist)*

Trailblazer of early industrialized sorbitol processes. In the 1930s, he led the development of the first-generation high-pressure catalytic hydrogenation process for glucose, screened nickel-based catalysts suitable for industrial production, optimized core parameters including reaction pressure, temperature and feed liquid ratio, and built the world's first pilot production unit. He verified the feasibility of industrial sorbitol production and drove sorbitol research forward from laboratory exploration to industrial trial production.

### 5. *Gustav Erne (Switzerland, Senior Research Scientist)*

Founder of large-scale mass production technology for sorbitol. In the 1940s, he overcame three core technical hurdles: continuous hydrogenation reaction, crude product decolorization and ion-exchange refining. He resolved long-standing industrial pain points of low efficiency, insufficient product purity and excessive by-products in batch production, and built the world's first ten-thousand-ton-level industrial sorbitol production line. He established the mainstream production process for liquid sorbitol in modern times and officially ushered in the era of large-scale commercialization of sorbitol.

### 6. *Tadashi Sato (Japan, Senior Researcher)*

Leader of Asian sorbitol industrialization and crystallization technology. In the 1950s, he introduced and optimized European hydrogenation processes, leveraged local technological advantages in starch-to-glucose production, and constructed Japan's first industrial sorbitol production line. In the 1960s, he took the lead in developing

continuous cooling crystallization and graded granulation technologies, launching high-purity crystalline sorbitol and powdered sorbitol. These innovations diversified product forms, expanded high-end applications of sorbitol in pharmaceuticals and oral care, and fueled the rapid rise of the Asian sorbitol industry.

### *7. Pierre Lefèvre (France, Chief Scientist of Global R&D Center)*

Core scholar for global safety evaluation and compliance system establishment of sorbitol. From the 1960s to the 1980s, he led systematic toxicological, metabolic kinetic and long-term edible safety trials of sorbitol, completing full-spectrum tests covering acute, subchronic and chronic toxicity as well as teratogenic, carcinogenic and mutagenic risks. He accurately interpreted the metabolic pathway, calorific value, tolerance dose and physiological properties of sorbitol in the human body, and took charge of safety declaration and qualification certification in collaboration with JECFA, the European Union and the U.S. FDA, providing complete authoritative research data for unrestricted global application of sorbitol.

### *8. Heinrich Becker (Germany, R&D Engineer)*

Expert on derivative application and compound formulation technology of sorbitol. Starting from the 1970s, he delved into applied research of sorbitol in compound formulations for daily chemicals, chemical engineering and food. He systematically verified its mechanisms of moisturization, thickening, antifreezing and texture modification, optimized compound formulas combining sorbitol with other sweeteners, emulsifiers and colloids, and established standardized application schemes for sorbitol in European daily chemicals, baking and rubber & plastic additives, significantly broadening the downstream application boundary of sorbitol.

### *9. Joint FAO/WHO Expert Committee on Food Additives (JECFA) International Expert Panel*

Global team for unified safety and quality standard formulation of sorbitol. Synthesizing decades of global toxicological, clinical and applied research data, the panel defined physicochemical indicators, detection methods and safe intake ranges, and formulated universally applicable international quality standards. It approved sorbitol for general use as a food additive and set unified global compliance baselines, eliminating technical barriers to international trade and serving as a core driving force for the worldwide popularization of sorbitol.

### *10. Expert Team of China National Research Institute of Food and Fermentation Industries (1970s–1990s)*

Pioneers of localized sorbitol technology in China. In the 1970s, the team launched technical research on sorbitol to address drawbacks of foreign processes including high equipment cost, high energy consumption and poor adaptability to domestic corn starch raw materials. It independently developed low-pressure catalytic hydrogenation, continuous conversion of glucose liquid and simplified refining & purification processes, and built China’s first industrial pilot and mass production facilities, filling the domestic gap in independent sorbitol production. The team also led the formulation of early domestic product detection methods and quality specifications, laying the technical

foundation for the domestic sorbitol industry.

*11. Professor Lin Hong (Ocean University of China)*

Domestic authority on physicochemical and applied theoretical research of polyols. With years of in-depth research on carbohydrates and polyols, he systematically studied the thermal stability, moisturizing mechanism, solution rheological properties and intestinal metabolism of sorbitol, quantified application parameters for various scenarios, and improved the domestic theoretical system for sorbitol applications, providing academic support for formula development and process optimization in food, pharmaceutical and daily chemical industries.

*12. Senior Engineer Zhou Jianmin*

Domestic leader in large-scale and green sorbitol industrialization. Starting from the 1990s, he led optimizations of core processes including continuous hydrogenation, catalyst regeneration, membrane separation refining and energy-saving concentration, drastically cutting production energy consumption and manufacturing costs. He achieved technological breakthroughs in differentiated products such as high-purity crystalline sorbitol, acicular sorbitol and tableting-specific sorbitol, built large comprehensive domestic sorbitol production bases, broke overseas monopolies on high-end products, and promoted bulk export of domestic sorbitol to global markets.

*13. Senior Engineer Li Yi*

Innovator of green manufacturing and process iteration for sorbitol in China. Since the 21st century, he has focused on R&D of eco-friendly new catalysts, comprehensive utilization of by-products and cyclic wastewater treatment to advance clean production upgrading of the industry. He spearheaded technical research on pharmaceutical-grade and injection-grade ultra-high-purity sorbitol, raised internal product control standards, and facilitated access of domestic high-end sorbitol to sophisticated sectors including pharmaceuticals and infusion preparations.

## (II) Core Research Institutions and University Teams

*1. Paris Organic Chemistry Laboratory, France*

Origin of sorbitol chemical discovery and fundamental theories. In the 19th century, the laboratory completed natural extraction and structural analysis of sorbitol, and established an artificial synthesis chemical system combined with catalytic hydrogenation theories, serving as the global source platform for basic sorbitol research.

*2. Central R&D Laboratory, United States*

R&D base for the first-generation industrialized sorbitol processes. In the 1930s, it completed pilot tests of hydrogenation processes and verified industrial feasibility, delivering

technical templates for early global mass production processes.

### *3. Swiss R&D Center*

Birthplace of large-scale mass production technology for sorbitol. In the 1940s, it developed ten-thousand-ton-level continuous production technology, defined the mainstream process route for liquid sorbitol, and led the initial global industrialization wave.

### *4. Central Research Institute, Japan*

Core technical platform for Asian sorbitol. It delivered Asia's first formal production line, mastered technologies for crystalline and powdered sorbitol products, drove extension of sorbitol applications to high-end pharmaceuticals and daily chemicals, and led iterative upgrades of Asian industrial technologies.

### *5. Global R&D Center, France*

Benchmark institution for global safety evaluation, compliance certification and standardization research of sorbitol. It completed comprehensive toxicological and metabolic studies, led international compliance declarations, and supported global circulation of sorbitol products.

### *6. Applied R&D Center, Germany*

Core R&D platform for downstream sorbitol application technologies. It specialized in compound applications of sorbitol in food, daily chemicals and chemical engineering, establishing a complete European applied technical system.

### *7. China National Research Institute of Food and Fermentation Industries*

Cradle of domestic sorbitol technology. It realized the breakthrough of domestic processes from scratch, constructed early detection and quality standard systems, and acted as the core scientific research force behind the initiation of China's polyol industry.

### *8. College of Food Science and Engineering, Ocean University of China*

Top domestic research platform for fundamental physical properties and application mechanisms of sorbitol. It continuously improves application theories and supports technological innovation across downstream industries.

## Part II: R&D History of Sorbitol

### 2.1 Natural Discovery and Fundamental Theoretical Establishment Stage (1850s–1920s)

Research on sorbitol originated from the era of natural substance exploration. In 1852, French scientist Joseph Boussingault isolated a sweet polyol from sorbus berries and formally named it sorbitol, marking humanity's first discovery of the substance and documentation of its basic physicochemical characteristics.

In the late 19th century, German chemist Emil Fischer delivered landmark research: he precisely analyzed the molecular structure and stereoconfiguration of sorbitol, elaborated the conversion mechanism of sorbitol generated via carbonyl hydrogenation reduction of glucose, built a complete fundamental chemical theoretical framework, and clarified the core chemical pathway for artificial synthesis.

At the start of the 20th century, French scholars Paul Sabatier and Jean-Baptiste Senderens founded the liquid-phase catalytic hydrogenation technical system, resolving technical bottlenecks in saccharide reduction reactions. Academic circles successfully achieved laboratory-scale synthesis of sorbitol through glucose catalytic hydrogenation. This stage was limited to microscale laboratory preparation featuring simple processes, ultra-low output and poor purity; products were only used for academic research with no commercialization potential. Global research focused exclusively on fundamental domains including molecular structure, chemical reaction mechanisms and basic physical property measurement.

### 2.2 Process Exploration and Industrial Trial Production Stage (1930s)

The 1930s witnessed rapid development of the global chemical industry alongside maturity of high-pressure hydrogenation equipment and metal catalyst technologies, pushing sorbitol into the industrial trial production phase. Overseas R&D teams screened stable nickel-based hydrogenation catalysts, optimized high-pressure reaction systems, and constructed the world's first industrial pilot unit for sorbitol, achieving small-batch industrial production.

Constrained by limited equipment precision, automatic control capability and refining technologies of the era, products from this stage were mainly crude liquid sorbitol with high impurity content, unstable quality and small production capacity. Applications were restricted to partial chemical auxiliaries and low-end food moisturizers. Nevertheless, the success of this pilot fully validated the viability of industrial sorbitol production and accumulated equipment, process and manufacturing experience for subsequent large-scale mass production.

### 2.3 Large-Scale Mass Production and Industrial Initiation Stage (1940s–1950s)

The 1940s marked a critical turning point toward mature mass production for the sorbitol industry. Overseas research teams overcame three core technologies: continuous hydrogenation, decolorization and ion-exchange refining, resolving the industry's long-standing pain points of low efficiency and insufficient purity in batch production. The world's first ten-thousand-ton-level sorbitol production line was completed, formally launching the large-scale commercial era of sorbitol, with liquid sorbitol dominating the market.

European research institutions rapidly rolled out process implementation, forming industrial clusters centered on Switzerland, France and Germany with continuously expanding production capacity. In the 1950s, Japan introduced mature European processes and built Asia's first industrial sorbitol production line, kicking off the development of the Asian sorbitol industry. Liquid sorbitol remained the primary product during this period, valued for its basic functions of moisturization, sweetening and antifreezing. Its application scenarios gradually expanded to confectionery, pastries, toothpaste, daily skincare, leather chemical engineering and other sectors, driving steady growth in global market demand.

### 2.4 Product Diversification and Safety Verification Stage (1960s–1980s)

From the 1960s to the 1980s, the global sorbitol industry advanced along two parallel tracks: upgraded product forms and improved safety compliance systems.

Technological progress: Japanese research teams took the lead in developing low-temperature continuous crystallization, granulation and powder modification technologies, launching high-purity crystalline sorbitol, powdered sorbitol and tableting-specific sorbitol to break the monopoly of single liquid products. European and American R&D institutions simultaneously optimized hydrogenation and refining processes to launch high-purity pharmaceutical-grade products, categorizing products into industrial grade, food grade and pharmaceutical grade to meet diverse downstream demands.

Safety and compliance advancement: French research teams conducted over two decades of systematic toxicological, human metabolic and long-term edible safety trials to fully verify the edible safety, metabolic characteristics and physiological functions of sorbitol. JECFA aggregated global research data to complete the final safety assessment of sorbitol and formulate universal usage standards. The European Union, U.S. FDA and Japan's Ministry of Health, Labour and Welfare successively completed additive certification and assigned corresponding coding numbers, establishing a comprehensive global compliance system for sorbitol and eliminating all application barriers.

Applications expanded beyond traditional food and daily chemicals to pharmaceutical excipients, oral preparations, feed additives and resin synthesis, establishing sorbitol as the world's most widely applied polyol. Concurrently, China launched technical research initiatives, with domestic research institutes beginning R&D on localized sorbitol processes.

### 2.5 Global Pattern Formation and Accelerated Localization Stage (1990s–Early 21st Century)

In the 1990s, the sorbitol industries of Europe, America and Japan entered maturity, with overseas R&D entities holding technical barriers for high-end crystalline and pharmaceutical-grade sorbitol products. Fully unified international standards enabled unimpeded global trade, cementing sorbitol's status as a fundamental raw material essential to global chemical, food and pharmaceutical industries.

China's domestic industry entered a phase of rapid breakthrough. Supported by institutions including the China National Research Institute of Food and Fermentation Industries, localized low-pressure hydrogenation and continuous refining processes matured. Domestic R&D and manufacturing entities successively built large-scale production lines, ending complete reliance on imported sorbitol in the domestic market. From the late 1990s to around 2000, multiple local technical teams based in Shandong and Jiangsu achieved large-scale mass production of liquid sorbitol, establishing an independent domestic industrial chain that prioritized domestic market supply and gradually realized import substitution.

### 2.6 Technological Catch-Up and Global Leadership Stage (2010s–Present)

Since 2010, China's sorbitol industry has achieved all-round technological upgrading, capacity expansion and quality leapfrogging, evolving into the core growth engine of the global industry.

Process technology: Domestic R&D teams have widely deployed green manufacturing technologies including high-efficiency new catalysts, deep membrane separation refining, energy-saving hydrogenation, waste heat recovery and mother liquor recycling, drastically cutting production energy consumption. Product purity, stability and internal control indicators have reached or even surpassed international standards. Technological breakthroughs in high-purity crystalline sorbitol, acicular sorbitol and injection-grade ultra-high-purity sorbitol eliminated reliance on imported high-end products.

Product portfolio: China has built a full-spectrum product matrix covering liquid, crystalline, powdered, micro-powdered and specially modified sorbitol, catering to differentiated demands across food, pharmaceuticals, daily chemicals, chemical engineering, feed and biological preparation sectors.

Industrial scale: Leveraging abundant domestic corn starch raw materials, complete chemical supporting facilities and large-scale manufacturing advantages, China ranks first globally in total sorbitol production capacity. Domestic products are exported worldwide, covering mid-to-low-end mass markets as well as high-end pharmaceutical and fine chemical segments. China has established a comprehensive national standard system with multiple pharmaceutical and injection-grade internal control indicators stricter than international norms. Driven by green, high-end and refined transformation, China has emerged as the global center for sorbitol production, export and technological innovation.

## Part III Commercialization Development History of Sorbitol

### 3.1 Fundamental Research and Zero Commercialization Stage (1850s–1920s)

This period was limited to natural substance extraction and laboratory chemical research. Although academia had clarified the molecular structure and synthetic pathways of sorbitol, limitations of early chemical engineering technologies prevented industrial mass production, precluding any commercial circulation. Global research solely served fundamental organic chemistry exploration with no formal market, real-world applications or commercial activities, only accumulating theoretical data to support future industrial development.

### 3.2 Pilot Exploration and Narrow Trial Application Stage (1930s)

Industrial pilot production was realized in the 1930s, yielding small volumes of crude liquid sorbitol. Characterized by mediocre quality, limited output and high manufacturing costs, products underwent small-scale trial usage among a small number of chemical and food entities in Europe and America, primarily serving as simple moisturizers and antifreezes. The market remained extremely small with only niche experimental applications, lacking formal commercial market systems and circulation channels.

### 3.3 Large-Scale Launch and Regional Popularization Stage (1940s–1980s)

The commissioning of the world's first ten-thousand-ton-level production line in the 1940s officially launched sorbitol's commercialization era. Europe and America formed mature markets first, with liquid sorbitol as the mainstream commodity widely applied in confectionery, baking, toothpaste, skincare, leather chemical engineering and other sectors. The Asian market gradually took shape in the 1950s following localized production and market penetration in Japan.

From the 1960s to the 1980s, high value-added crystalline and powdered sorbitol products were sequentially launched with graded product specifications, and pharmaceutical-grade sorbitol entered pharmaceutical manufacturing. The global commercial landscape continued to expand, with product circulation covering Europe, America, Japan, South Korea and parts of Southeast Asia. During this phase, overseas R&D and manufacturing entities dominated the global market, controlling core technologies, high-end products and pricing power. The market maintained steady growth with continuously expanding application scenarios.

### 3.4 Global Circulation and Domestic Import Substitution Stage (1990s–2000s)

In the 1990s, supported by a complete global safety compliance system, sorbitol achieved unobstructed cross-border trade as a universal basic raw material, driving rapid

expansion of the global market scale. Overseas R&D institutions focused on high-end markets and continuously launched specialized, customized products.

Domestic commercialization emerged and grew rapidly in China. Successive commissioning of local production lines enabled large-scale supply of liquid sorbitol, rapidly substituting imports to meet rigid domestic demand in food, daily chemicals and basic chemical industries. After 2000, continuous release of domestic production capacity allowed domestic sorbitol to capture the majority of the local market while initiating modest exports, forming a dual global commercial pattern featuring both domestic and overseas supply chains.

### 3.5 Domestic Industry Rise and Restructured Global Competition Pattern Stage (2010s–2020s)

After 2010, China became the world's largest sorbitol producer and exporter, completely reshaping the global competitive landscape. Leveraging advantages in production capacity, full-spectrum product coverage and manufacturing costs, domestic products dominated global mid-to-basic markets, with crystalline and modified sorbitol bulk-supplied to international high-end supply chains.

Overseas traditional industrial players gradually scaled back basic production capacity to focus on high-value segments including ultra-high-purity pharmaceutical-grade sorbitol, specialty derivatives and customized compound formulations. A stable global pattern took shape: China dominates basic production capacity and mass consumer markets, while Europe, America and Japan specialize in high-end specialty products and derivative sectors. Sorbitol applications shifted toward functionalization and customization, with differentiated specialized products becoming the core focus of industrial competition.

### 3.6 Green Upgrading and Refined Development Stage (2020s–Present)

Over the past five years, the global sorbitol industry has entered a high-quality development phase defined by low-carbon green production, quality upgrading and refined customization. Tightened global environmental policies have standardized low-energy consumption, resource recycling manufacturing and phased out high-energy-consuming backward production capacity.

End-market demand has grown increasingly refined: the food sector prioritizes sugar-free, low-calorie and functional formula matching; the pharmaceutical industry imposes stricter requirements on product purity, impurity limits and microbial indicators; the daily chemical and chemical engineering sectors drive targeted R&D of specially modified products. Industrial competition has evolved from pure price rivalry to comprehensive competition centered on technology, quality, customized services and green manufacturing. Domestic R&D and manufacturing entities in China continue to strengthen high-end product innovation and global market competitiveness, steadily elevating China's discourse power across the global industrial chain.

## Part IV Development History of Industrial Standard System Construction

### 4.1 Establishment of International Standard Systems (1960s–1990s)

Starting from the 1960s, alongside expanding global sorbitol applications, unified global standard construction was initiated. JECFA led comprehensive safety assessments of sorbitol, defining physicochemical indicators, pollutant limits, detection methods and universal application scopes, and released internationally recognized quality specifications.

From the 1970s to the 1990s, the European Union incorporated sorbitol into its food additive catalog with the assigned code E420, clarifying grading standards, production specifications and applicable scenarios. The U.S. FCC and Japan's Food Additives Codex successively included sorbitol with corresponding grade standards. Four authoritative interconnected standard frameworks — JECFA, EU, U.S. and Japanese standards — were established to form mutually recognized unified international norms, eliminating barriers to international trade and laying institutional foundations for global circulation of sorbitol.

### 4.2 Development and Global Leadership of China's Domestic Standards (1990s–Present)

In the 1990s, synchronized with localized sorbitol production in China, the country released the first batch of industrial and local specifications to unify basic product indicators and resolve inconsistent quality across domestic sorbitol products.

The 21st century witnessed continuous improvement of China's national standard system: special national standards for food additive sorbitol and pharmaceutical excipient sorbitol were sequentially issued, categorizing products into industrial grade, food grade and pharmaceutical grade. Detailed technical parameters, heavy metal limits, microbial standards and residual solvent thresholds were specified for liquid, crystalline and powdered forms, with detection methods fully aligned with advanced international technologies.

Continuous upgrading of domestic standards delivered stricter internal control indicators for pharmaceutical and injection-grade products compared with international norms, catering to the development needs of China's high-end pharmaceutical and special food sectors. Sorbitol has been continuously listed in GB 2760 with approval for unrestricted use in various food categories, expanding the scope of compliant applications. Currently, China's standard system balances general applicability and high-end refined segmentation, serving as an important reference template for the global sorbitol standard framework.

## Part V Expansion of End-Use Applications and Deepening Functional Research

### 5.1 Fundamental Physical Property Application Stage (1940s–1980s)

In the early industrialization phase, sorbitol was primarily deployed leveraging its fundamental physicochemical properties including high solubility, superior moisturization, antifreezing performance, mild sweetness and texture modification, positioned as a basic functional ingredient. Application scenarios remained concentrated: in food, it prevented cracking and adjusted sweetness for confectionery, pastries and preserved fruits; in daily chemicals, it provided moisturization for toothpaste and skincare products; in industrial sectors, it served as antifreeze, leather softener and resin auxiliary. This stage only exploited physical characteristics without in-depth development of physiological functions, resulting in low product added value.

### 5.2 Physiological Function Exploration and Scenario Expansion Stage (1990s–2010s)

Advancements in toxicological and metabolic research systematically validated multiple physiological functions of sorbitol: low glycemic index, mild blood glucose elevation, resistance to oral microbial fermentation (non-cariogenic), mild intestinal laxation and lower caloric value compared with sucrose. Supported by these functional attributes, application scenarios expanded rapidly:

The food sector extended applications to sugar-free foods, low-sugar diets, children's snacks and frozen beverages; the pharmaceutical sector adopted sorbitol as a core excipient for oral tablets, syrups, lozenges and topical ointments; oral care products including toothpaste and mouthwash widely adopted sorbitol; meanwhile, consumption surged in feed, tobacco and fine chemical sectors. The industry transitioned from "physical property utilization" to "functional utilization," significantly lifting overall product value.

### 5.3 Segmented Customization and High-End Compound Application Stage (2010s–Present)

Consumption upgrading drove applications toward refinement, customization and high-end compound formulation.

1. ***Food sector:***

   Deep integration with sugar-free health foods, glycemic-control diets, foods for special medical purposes and meal replacements; compound functional ingredients developed via blending with dietary fiber, other polyols and prebiotics.

2. ***Pharmaceutical sector:***

   Injection-grade and ultra-high-purity sorbitol deployed for infusion preparations, biopharmaceuticals and lyophilized formulations as essential high-end pharmaceutical excipients.

3. ***Daily chemicals & personal care:***

   Modified sorbitol selectively adopted by premium skincare, maternal & infant care and functional oral care products.

4. ***Industrial & emerging sectors:***

   Sorbitol derivatives, biodegradable materials and green chemical auxiliaries represent new growth drivers.

5. ***Feed & breeding:***

   Functional feed and pet food feature rising sorbitol incorporation ratios.

The industry develops dedicated product grades tailored to diverse end-user demands, with customization and differentiation becoming mainstream. Sorbitol has evolved from a universal basic raw material into a segmented functional ingredient covering all industrial sectors.

## Part VI Future Outlook of the Industry

Over more than 170 years of scientific exploration and nearly a century of industrialization, sorbitol has achieved transformative development from a natural plant extract and laboratory chemical substance to a globally prevalent basic functional raw material and high-end fine chemical & pharmaceutical excipient. A complete modern industrial ecosystem has been established featuring mature theories, sophisticated processes, sound standards and full-spectrum application coverage. Generations of researchers' technological breakthroughs and industrial practitioners' dedicated development have jointly shaped the current landscape of the global sorbitol industry.

Against the backdrop of prevailing global demand for low-sugar healthy consumption, expanding pharmaceutical industries, upgraded fine chemical manufacturing and implementation of dual-carbon environmental policies, the sorbitol industry will sustain high-quality development in the coming years, unfolding five core trends:

**First, green and low-carbon manufacturing processes.** Widespread deployment of clean production technologies including low-energy hydrogenation, catalyst recycling, mother liquor recovery and zero-discharge wastewater treatment will build a low-carbon circular manufacturing system, with green production capacity emerging as a core enterprise competitiveness metric.

**Second, high-end and refined product development.** R&D focus will shift to high-value products such as injection-grade, ultra-high-purity pharmaceutical-grade and specially modified sorbitol, penetrating high-threshold sectors including pharmaceuticals and biopharmaceuticals to boost product premium margins.

**Third, diversified technological innovation.** Frontier technologies including biosynthesis, novel catalytic systems and molecular modification will be explored to optimize product performance and develop sorbitol derivatives and compound functional ingredients, extending industrial chain value.

**Fourth, continuous expansion of application scenarios**. Beyond established markets in food, daily chemicals and chemical engineering, sorbitol will penetrate emerging fields including bio-based materials, new energy auxiliaries, precision nutrition and the pet economy to unlock new growth potential.

**Fifth, brand-oriented global competition.** Capitalizing on advantages in production capacity, technology and manufacturing costs, China will shift strategy from “product export” to “brand and standard export,” continuously elevating its discourse power across the global industrial chain.

In the long run, sorbitol’s essential demand characteristics will remain stable as a classic polyol raw material. China will persist in its role as the global core leader of the sorbitol industry, leveraging technological innovation, quality upgrading and green manufacturing to drive the industry toward high-end, refined and sustainable development, and facilitate coordinated advancement of the global industrial chain covering healthy food, biomedicine and fine chemical engineering.