Establishment of production methods of rare sugars by Izumoring (Keywords: Izumoring, Rare sugars, Production)

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Outline of technology

Rare sugars are monosaccharides that occur in small amounts as natural products. Among six carbon sugars there are 34 hexoses (8 ketohexoses, 16 aldohexoses, and 10 hexitols). The only carbohydrate monomers that occur in large amounts in nature are D-glucose, D-galactose, D-mannose, D-fructose, D-xylene, L-arabinose, and D-ribose.

Rare sugars can be defined as monosaccharides (the monomer building blocks of carbohydrates) that are present in only small amounts in nature. The concept of Izumoring provides a technology for the preparation of all 34 hexoses from the cheap and common sugars - D-glucose, D-fructose, and D-galactose. All 34 hexoses can be interconverted enzyme-catalyzed reactions. (Details of Izumoring are shown on the next page.)

The right figure shows the amounts of various monosaccharides existing on the earth. D-Glucose, shown in green, exists in the largest quantity. The small red circles represent rare sugars which are numerous but only occur naturally in small amounts. Izumoring is a strategy to produce all rare sugars from inexpensive D-glucose. Practically, this system has been shown to be able to produce all the few monosaccharides abundant in nature.

Because hitherto rare sugars have only been accessible in very small amounts in nature, their properties have not been evaluated. Nearly all natural organic compounds on the earth are produced by living organisms. Rare sugars are expected to be carbohydrates that (1) cannot be produced by biological reactions, (2) are unnecessary for organisms, and (3) therefore, have no physiologic activity. Until recently, research both on methods for the production of substantial quantities of rare monosaccharides and studies of their potential use have been neglected. Izumoring technology has for the first time allowed access to rare sugars which has allowed experiments to evaluate their various physiological activities on many organisms. Research on rare sugars is progressing rapidly, and comprehensive evaluation of the research accomplishments obtained so far suggests that rare sugar science may well develop into a novel and important sugar life science which have enormous chemotherapeutic and other potential.

Sales points

- Rare sugars can be produced systematically from inexpensive glucose.
- Monosaccharides obtained from any source - including wastes - can be used as raw materials for the production of rare sugars.
- 14 rare carbohydrates have now been produced by the technology based on Izumoring and marketed as reagents.

Expected application fields and products

(1) Food materials, foods and beverages, sweeteners, seasonings
(2) Foods for specified health uses, healthy foods and beverages
(3) Agricultural chemicals that induce resistance against diseases, control of plant growth
(4) Pharmaceuticals, organ conservation solutions
(5) Use as high value building block for the preparation of pharmaceutical products

Comparison with existing products

No comparable product

References, patents, etc.

- References:


Other matters to note

(Developer’s comment)

The basis for the production methods of monosaccharides was laid by extensive research on organic chemistry by E. Fisher in the later half of the 1800s. The structures of monosaccharides were determined in this era, mostly with the establishment of their production methods. For this reason, no systematic research was conducted on the synthesis of monosaccharides, which was regarded as having been completed. It was also hampered by the great
difficulty in the synthesis of monosaccharides by techniques of organic chemistry because of their complex chiral structures. In recognition of the central role that carbohydrates play in many biological processes, there has been enormous effort by organic chemists to make unnatural and rare sugars; none of this work has allowed the preparation of substantial quantities of material and involve the use of many steps by environmentally unfriendly procedures. The strategy of Izumoring provides access to all monosaccharides by green biotechnological procedures on which the chemistry is all conducted in water. This has laid the foundation for the determination of physical [such as conformation, solution structure and solubility] and chemical and biological properties of all rare sugars.

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**Izumoring : A strategy for bioproduction of rare sugars**

This figure shows the interconversion of all 6 carbon monosaccharides by Izumoring. The red circles are aldohexoses, blue circles are ketohexoses, and yellow circles are hexitols. Hexoses are connected to one another with a line, which represents enzyme reactions. The red lines are aldose isomerase (catabolic reaction between aldose and ketose), blue lines are polyol ketose oxidoreductase (enzymes that oxidize or reduce carbon 2 to transform polyols to ketoses), yellow lines are D-tagatose-3-epimerase (an enzyme that epimerizes position 3 of all free ketohexoses), and white lines are aldose reductase (enzymes that reduce aldoses to the corresponding polyols).

Characteristics and usefulness of Izumoring are summarized below.

1. This figure, which contains all 34 hexoses, indicates that all hexoses could be interconverted.
2. All D-type sugars are shown in the blue region in the right, all L-type sugars in the red region in the left, and hexitols and meso-hexitols in the yellow region in the middle. All these hexoses are arranged symmetrically around the red star in the center.
3. As shown by the red arrows, there are only 4 routes for the synthesis of L-type sugars from D-type sugars.
4. Using this figure, the production plan of a target rare sugar can be laid easily.
5. The figure clearly shows the relationship of each sugar to other to be seen and allows an optimal route for each transformation to be established.