Making Yogurt Even Healthier

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Cholesterol is an important component in human cell membranes. Although cholesterol is necessary for normal biochemical functions, current research also indicates that it plays a causal role in the development of vascular atherosclerosis—fatty buildup of plaque in artery walls, which blocks the blood flow. Plant sterols, also called phytosterols, decrease the level of cholesterol in human blood. Phytosterols are an active ingredient of cholesterol-reducing functional foods, like yogurts or spreads. With its partner Resitec of Brasil, Sulzer Chemtech has developed a novel method of manufacturing high-purity phytosterol at lower production cost and with less environmental impact.

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Blood cholesterol is made up of two kinds of cholesterol. Low-density lipoprotein (LDL) is often referred to as "bad" cholesterol, because it can slowly build up on the walls of the arteries. High-density lipoprotein (HDL)—the "good" cholesterol—helps to remove LDL from arteries and to prevent blockage.

Recent developments in functional foods include the enrichment of fat-containing foods with phytosterol, a substance naturally occurring in plants, in order to provide traditional foods with a cholesterol-lowering ability (Fig. 1).

Growing Market

Today, the main phytosterol users are the food and the pharmaceutical industries. The market for functional food products containing phytosterol in a suitable form, such as margarine, yogurt, spreads, salad dressings, or beverages, is growing fast. This rise in popularity increases the demand for food-grade phytosterol. Relevant regulations specify a total sterol concentration of over 99.0% and set stringent limits on various trace impurities, like polyaromatic hydrocarbons.

1 The cholesterol-lowering effect of phytosterol has been known since the 1950s. Today, it is a main ingredient of functional food, like this yogurt drink. Sulzer Chemtech has developed a patent-worthy method of extracting highly pure phytosterol from plant feedstock.

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The raw material for the production of phytosterol comes mainly from two sources. The first one is the distillate obtained by steam refining soybean oil. The other source is crude tall oil (CTO) taken from the soap skimming of black liquor in cellulose production, mainly from pinewood. Black liquor is a by-product formed during the pulping of wood in the pulp and paper industry. Because of its high phytosterol content and its easy availability, CTO is of great interest as raw material. It is usually distilled to produce rosin, fatty acids, and pitch. The latter contains all the unsaponifiable substances including sterol and a wide range of impurities. Today, CTO pitch is rarely used except as fuel, which causes technical problems due to the corrosive flue gas.

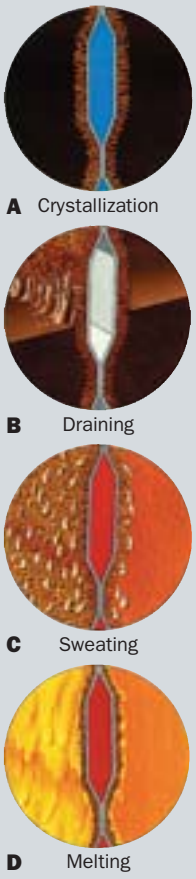
New Technology

The Resitec group company Resitol LTDA in Palmeira (Brazil) has a long tradition of distilling CTO collected from about a dozen pulp mills in the area. Since 2003, Resitol LTDA produces crude phytosterol of over 50% purity from the CTO pitch, using a new process developed and patented by Resitec. Currently, the usual process for separating and concentrating sterol from raw materials of plant origin involves suspension crystallization from solvents followed by phase separation by filter press. The process requires the use of large quantities of solvent mixture, which is also difficult to recover after use.

To meet the market demand for a high-purity product and in order to be able to sell directly to user industries, in 2002, Resitec decided to study means of purifying their crude phytosterol to the required level of 85%.

The Road to High-Purity Phytosterol

The Sulzer static crystallizer relies on a system of vertical plates—which serve as a heat-transfer surface—immersed into the material to be crystallized. The heat-transfer medium flows through the plates and maintains optimal conditions for crystal growth. At the beginning, the crystallizer is filled with the mixture to be crystallized. The mixture is cooled under controlled conditions, and a predetermined part freezes onto the heat-transfer surface (A). After the crystallization is completed, the mother liquor, which contains concentrated impurities, is drained off, leaving a film over the whole crystal mass held back in the crystallizer (B). By carefully increasing the temperature to just below the melting point of the solid phase, the purer melt is released to flow over the crystal mass, and it removes the film containing impurities as the process is prolonged. In this way, the impurities melt away preferentially, wash the crystal layer, and rinse the equipment. This partial melting is also called sweating (C). After the sweating is completed, the temperature of the heat-transfer medium is increased to melt the product (D). Instead of discharging the molten crystals, they are recrystallized, with impurities passing into the residue and sweat fractions.

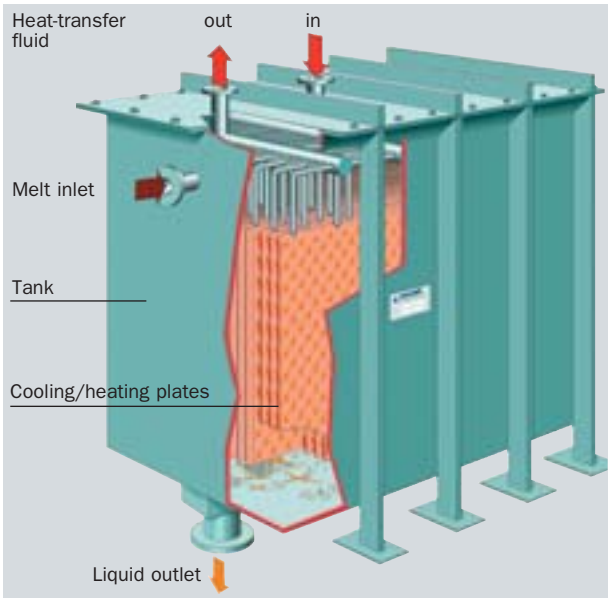


Successful Pilot Plant Operation

Being aware of all of the problems associated with existing processes, the specialists of Resitol were looking for an alternative technology. After having evaluated various possibilities, the static crystallization process developed by Sulzer Chemtech emerged as the most promising option (Fig. 2). A first small-scale test at the Sulzer laboratory in Switzerland showed very promising results, which led the two companies to enter into close cooperation in the year 2003 with the aim of jointly developing a process for the final purification of phytosterol.

The fractional crystallization group of Sulzer Chemtech, in collaboration with Resitec, has developed an entirely new purification process using Sulzer's modified static crystallization process. The improved process allows the production of high-purity sterol at high yield and under mediation of only one solvent (see box).

2 Using Sulzer's static crystallization process, crude phytosterol obtained from soybean oils or tall oil pitch can be used to produce high-quality phytosterol of a purity higher than 99%.



Process Applicable to Industrial Plant

During the development of the process, Sulzer Chemtech engineers performed extensive tests in a custom-built pilot plant. The test results have prompted Resitec to order the first plant using this unique process (Fig. 3). The new process ensures simple and reliable plant operation of this plant because:

- Fully automated control of the mass balance guarantees constant product quality
- Phase separation by only gravity flow eliminates the need for filter press or centrifuge
- A minimum of mechanical moving parts (only standard pumps and valves) reduces maintenance
- Extremely flexible operation allows reliable process modifications to handle changes in feed quality or product requirement
- The use of a single solvent makes recovery easier
- There is no slurry handling and no solid transport
- There is no wastewater or off-gas; the process is environment-friendly

Sulzer and Resitec made a number of innovative changes to the design and the construction of the static crystallizer as well as to the production process of crude sterol, with the result that the two companies can jointly claim patent rights for the new sterol purification process. This process, which allows the production of a highly pure product at reduced costs, has raised broad interest. Therefore, Sulzer engineers expect orders for further plants in the near future. ◀

3 The 1:1 correlation of the pilot plant with the industrial plant avoids scale-up uncertainty and therefore makes the process in the first commercial plant highly predictable.

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