XPURE
innovative continuous chromatography

July 2, 2020 CASE STUDY

#Application Note: Fractionating Chromatography for Sweeteners

Sugar is produced in many countries all over the world. The term “sugar production” relates to various products, primarily mono- and disaccharides.

There are two widely applied large-scale chromatographic carbohydrate (sugar) separations: the isolation of the disaccharide sucrose from molasses and the separation of the two monosaccharides fructose and glucose **(Figure 1)**.

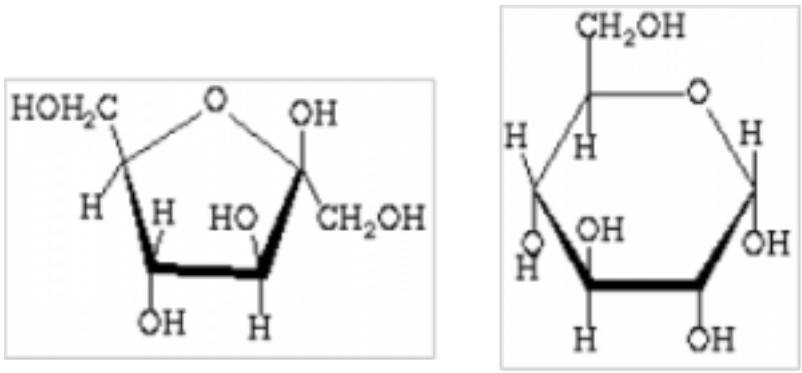

Figure 1. The structure of fructose (left) and of glucose (right)

Sugar Refining

Monosaccharides like fructose and glucose are produced mainly from beet, cane, or corn. After several refinery steps, including milling, filtration, and hydrolysis, a mixture containing glucose is obtained. Glucose is isomerized using immobilized enzymes to the much sweeter component fructose. The composition of this equilibrium mixture ranges from 50/50 to 45/55 (fructose/glucose), and often contains up to about 8% of oligosaccharides.

This mixture is separated by chromatographic separation into a fructose-rich and a glucose-rich component. The dry matter content of the feed flow varies up to 60%w/w.

The resin material used in fructose/glucose fractionation is a gel-type sulfonated

polystyrene-DVB strong acid exchange resin in the calcium form. The separation is based on the preferential adsorption of fructose, which forms a complex with the calcium ions. This chromatographic method is called Ligand Exchange Chromatography (LEC). There are several commercially available resins for this application.

A secondary phenomenon is that larger molecules, i.e. higher oligosaccharides, are not able to physically fit into the resin pores. The mechanism of separating large molecules from small molecules by preventing some of the large molecules from getting inside the stationary packing is called size exclusion chromatography. Size exclusion chromatography takes place simultaneously with ligand exchange chromatography in the purification of fructose. This results in larger oligosaccharide concentration to leave in the raffinate phase. Size exclusion can also be exploited in the separation of higher saccharides from monosaccharides.

Both components are recovered for over 90% and the purity of the product flows is above 90% as well. Glucose is recycled and re-isomerized; fructose is sold as a pure product or mixed with the equilibrium mixture mentioned above to yield high-fructose syrup. The fractionation process takes place at 60°C, to reduce microbial contamination and to reduce the pressure drop by lowering the dynamic viscosity of the liquid.

SMB Chromatography

The chromatographic separation of fructose and glucose can be efficiently done in a simulated moving bed (SMB). **Figure 2** shows experimental data from a glucose-fructose fractionation in an SMB system. It also shows the predicted performance from our process design software.

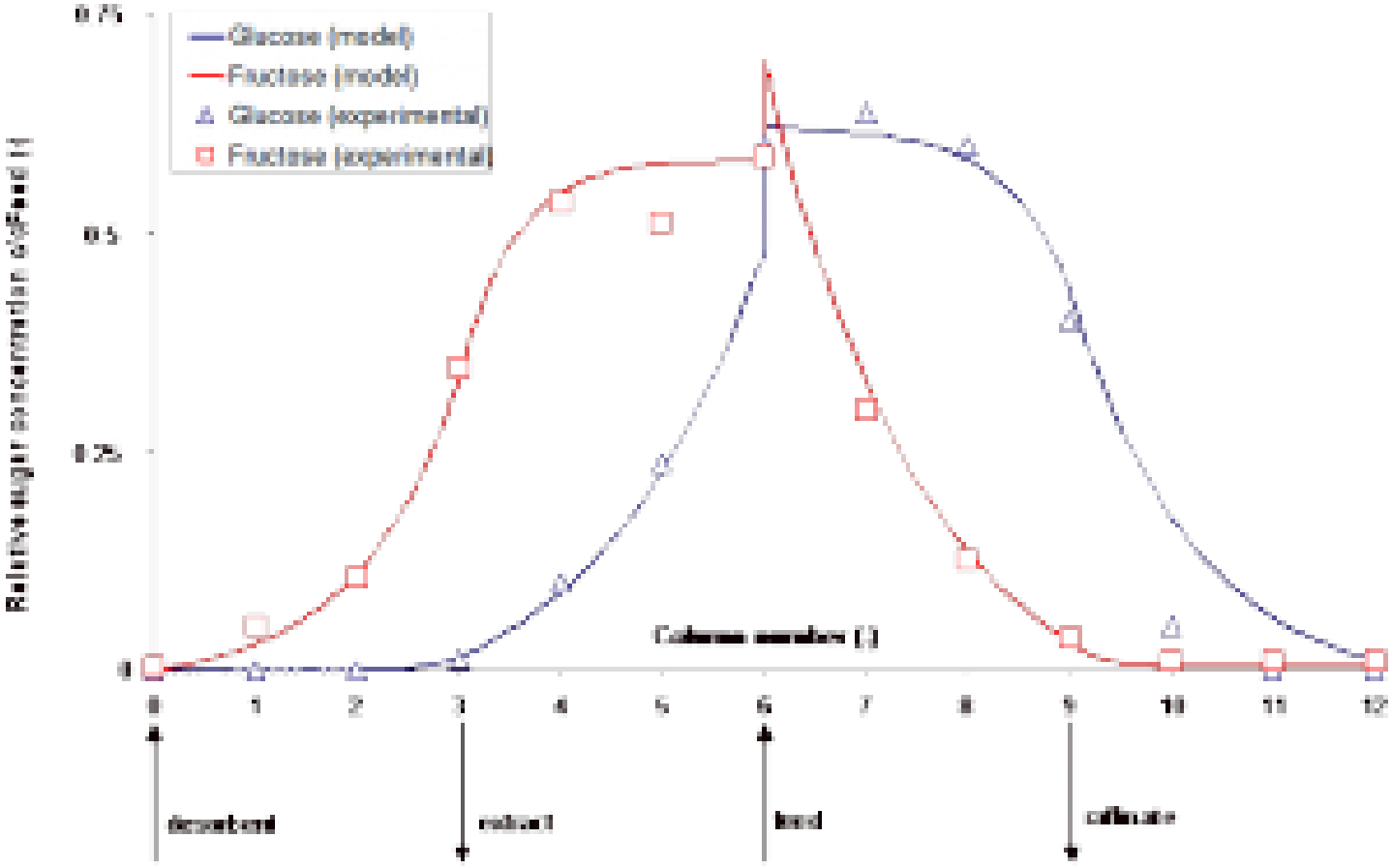

Figure 2. Comparison of production data of fructose/glucose fractionation on a 12-column system with calculations according to our process design model

The same fractionation mechanism applies for lots of other applications,

- often directly related to sugar processes where C5/C6 sugars are involved,
- or indirect sugar processes where sugar lies at the basis of a fermentative route to produce biomaterials like organic acids, (residual) saccharides, and amino-acids.

Figure 3 conveys a generic projection of a 4 zone / 8 column fractionating SMB system. It is stereotype for any binary fractionation system.

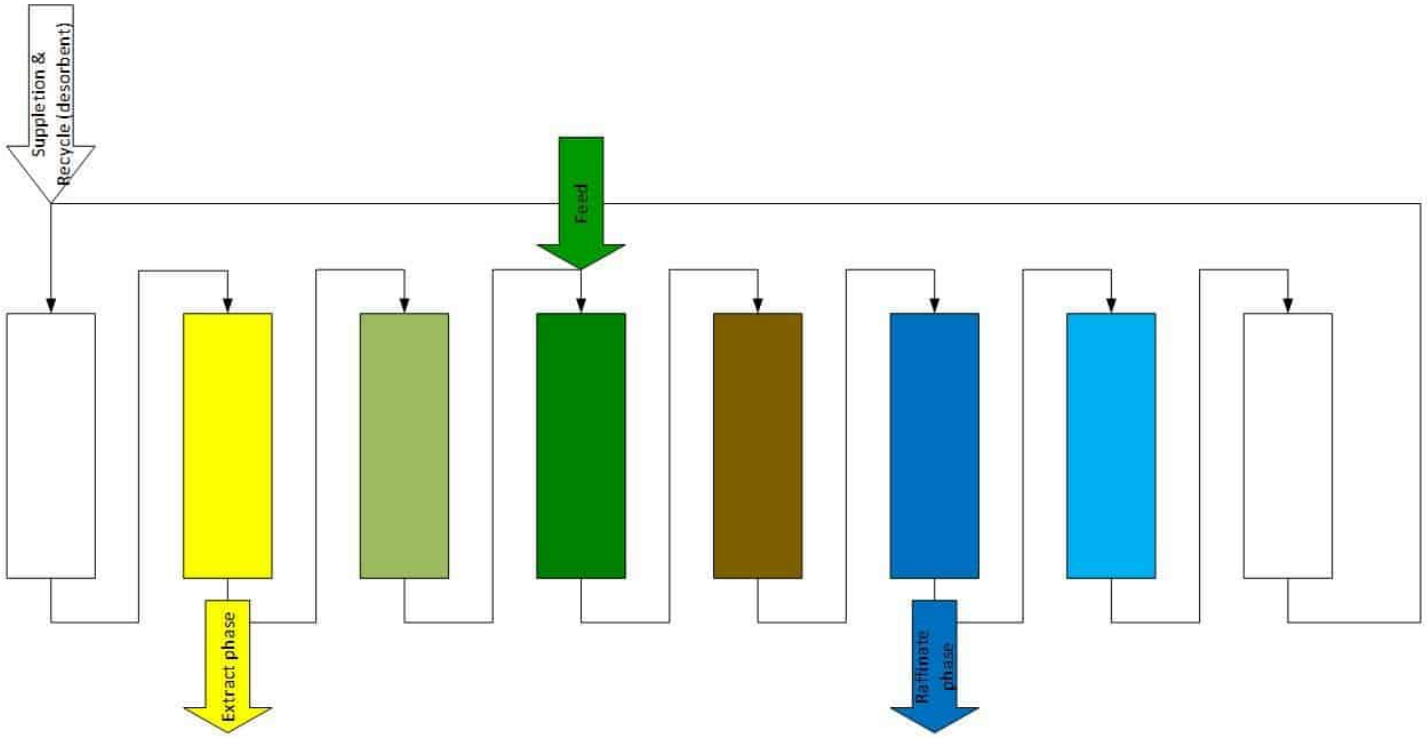

Figure 3. Representation of a 4-zone SMB system to separate Fructose (strongest chelating) in Extract Phase (yellow exit) from Glucose (weakest chelating) in Raffinate Phase (blue exit). Green input flow represents the feed mixture. The white influent represents the desorbant buffer, often water.

Application Areas

The fractionating principle evidently can be applied in a large field of applications.

- Fractionate out undesirable side-components from natural sweetener, for example, steviol glycoside
- Separation of betaine from cell culture supernatant
- Separation of organic acids from inorganic solution
- Upgrading C5- and C6 from cellulose hydrolysates, idem for organic acids

In conclusion, fractionating chromatography is a strong separation tool that perfectly suits continuous SMB operation.