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Ion exchange resins for sugar decolorisation

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Pure-white crystals and clear syrup

A multi-stage process is applied to produce white granulated sugar or clear sugar solutions from sugar cane or sugar beet. Ion exchange resins play a particularly important role in the decolorisation of raw solutions that range in colour from yellow-brown to brown. Customised resins and specially adjusted decolorisation processes make it possible to satisfy the tough quality requirements set by the food industry.

Sugar from sugar cane and sugar beet

Sugar cane (Saccharum officinarum) and sugar beet (Beta vulgaris) are key ingredients in industrial sugar production. Sugar cane, particularly from Brazil, India and China, accounts for around 55 per cent of global sugar production, which amounted to more than 160 million metric tonne in the 2006/2007 crop year. The European Union produces almost exclusively sugar beet. In 2006/2007, around 17 million metric tonne of sugar were produced from around 110 million metric tonne of sugar beet. Other leading sugar beet producers include the United States, Russia and Ukraine.

Raw sugar solutions, made by extracting sugar beet pulp, and, to an ever greater extent, the juice extracted from sugar cane, are naturally yellow-brown/brown. This coloration increases during processing as a result of the enzyme-catalysed and heat-induced procedures involved. These include the Maillard reaction between sugar and amino acids, enzymatic browning and caramelisation. Coloured products are also produced through the alkaline decomposition of sugars. Colour intensity is determined

photometrically in accordance with the ICUMSA [1]. It is specified in ICU (International Color Units) and serves as an important quality criterion. Ion exchange resins are used for a number of purposes during the process of creating pure-white granulated sugar or clear sugar solutions for industrial use, e.g. in the beverage industry.

In traditional ion exchange processes (*Fig.* 1), gel-like ion exchange resins in particular enable the selective removal of mineral salts from solutions. These salts would otherwise spoil the taste of the sugar and the products it is used to create.

In addition, macroporous ion exchange resins in particular can also act as absorbers to efficiently bind colour impurities, thus removing them from the solutions. Ionic interaction with impurities and hydrophobic interaction between non-polar areas of the chromophoric molecules and the resin matrix play a role here. Single- or multi-stage purification processes and/or combinations of different resins are used, depending on the level of impurity or colour intensity of the solutions.

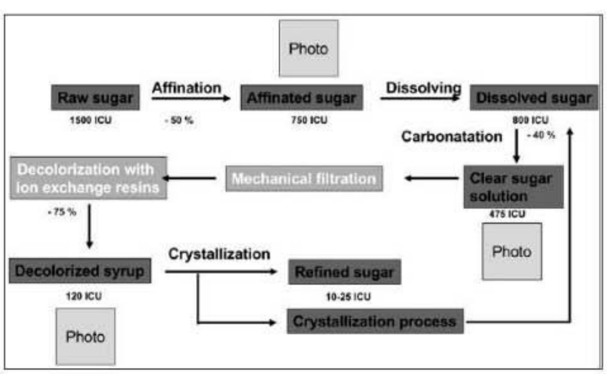

Fig. 1 Schematic diagram of the purification and decolorisation process for raw sugar solutions (approximate color intensity [ICU], decolorisation per process step [blue, %])

Decolorisation with ion exchange resins complements traditional purification methods, the most important of which is crystallisation. Other methods used for purification include clarification through carbonatation and phosphatation, in which impurities are filtered off, and the affination of impurities from the crystal pulp (magma).

Absorber resins are superior to traditional activated carbon filters, particularly for solutions with only moderate colouring (< 1,000 ICU). Not only is it far more time-consuming to regenerate these carbon filters, the regeneration process usually cannot be performed on-site, which generates extra costs and reduces the system's productivity. In contrast, ion exchange resins charged with colouring molecules can quickly be readied for operation again by simply washing them with a saline solution on-site – and this procedure can be performed several times.

Macroporous decolorisation resins in action

Special macroporous ion exchange resins – based primarily on styrene polymers and crosslinked via divinylbenzene units [2] – have been developed specifically for use in the foodstuffs industry. These ion exchange resins comply fully with food law requirements in many countries of the world.

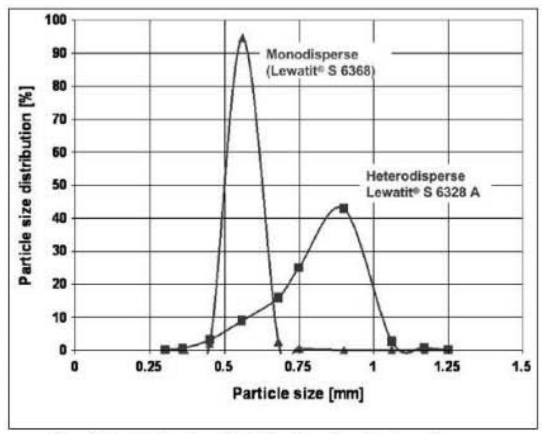

Fig. 2 Particle size distribution for heterodisperse and monodisperse ion exchange resins for the decolorisation of sugar solutions

They are used for the decolorisation of sugar solutions, typically in cylindrical filter units. These filter units measure between 50 and 400 cm in diameter and between 100 and 400 cm in height. The filling level of the resin bed is between 100 and 200 cm. Typical flow rates during operation are of the order of 2.0 - 2.5 bed volumes/hour (bv/h).

Both mono and special heterodisperse resins (*Fig.* 2) are used in the sugar decolori-

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Extending process portfolio for production

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sation process. If the latter exhibit a low proportion of fine grain, they are also suitable for filtering concentrated and, therefore, high-viscosity solutions, e.g. syrups. This property is present per se with monodisperse resins.

At a given flow rate of the sugar solution across the resin column, the pressure drop is always lower with monodisperse ion exchange resins than with heterodisperse ones (*Fig. 3*). What's more, the maximum permitted pressure drop for monodisperse resin is 300 kPa, which is 50 kPa higher than for heterodisperse ion exchange resins. Both effects complement each other perfectly during the filtration of raw sugar solutions with high clouding when the pressure drop in the filter must be limited in order to avoid damaging the resin.

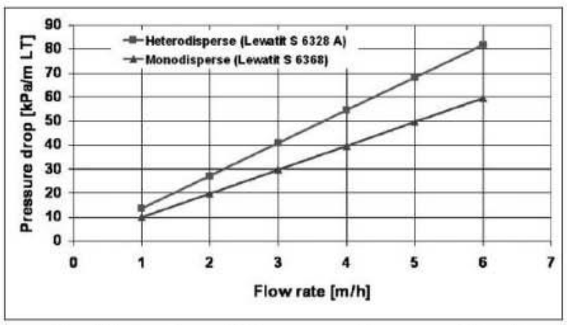

Fig. 3 Comparison of the pressure drop per meter of layer thickness for heterodisperse and monodisperse, macroporous exchange ion resins for different flow rates (70 °C, 65 % dry substance in solution)

Monodisperse resins also offer advantages for regeneration, which is reflected in both the amount of time and water required by this process step. Thanks to the standardised length of diffusion paths, monodisperse resins require around 30 per cent less cleaning water after the actual regeneration process – despite their high porosity.

The colour slip, i.e. the residual colour in the purified sugar solution, is predominantly a function of the initial colouring content and the amount of solution previously filtered via the ion exchange resin (*Fig. 4*). Solutions with up to 500 ICU exhibit only a very gradual increase in residual colour during treatment, whereas the absorber resin quickly loses efficiency when there are far higher colour concentrations in the starting solution. In these cases, it is a good idea to carry out preliminary purification using other methods.

Ion exchange resins in sugar production

Ion exchange resins complement and extend the process portfolio for industrial sugar production. They help realise higher sugar yields, cut waste and meet the increasingly strict quality requirements. For instance, often only residual colours of 25-50 ICU are tolerated. The long service life of the resins and their simple and cost-effective regeneration enables their profitable application in the process.

In addition to the desalination and decolorisation of sugar solutions, ion exchange resins are also used for the inversion (hydrolysis) of disaccharides, particularly saccharose, and for the treatment of diluted sugary solutions. For example, they can be used to desalinate whey, grape must and fruit juices or to remove unwanted, excess acid and bitterness from orange juice.

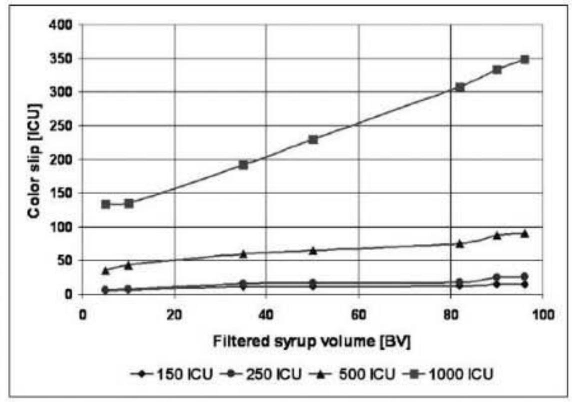

Fig. 4 Color slip of sugar solutions (65 % dry substance) depending on the starting color and overall filtration quantity (75 °C, spec. load 2 bv/h, cycle duration 48 h) for a heterodisperse, macroporous ion exchange resin

Bibliography

[1] International Commission for Uniform Methods of Sugar Analysis (ICUMSA), ICUMSA Methods Book, Verlag Dr Albert Bartens KG, Berlin 2007

[2 Ion exchange resins from the Lewatit S range of Lanxess Deutschland GmbH, specifically Lewatit S 6328 A (heterodisperse) or Lewatit S 6368 (monodisperse) ❍

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