

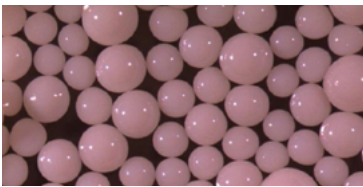
Ion Exchange Resins for Cane Sugar Decolorization

DuPont™ AmberLite™ FP Ion Exchange Resins

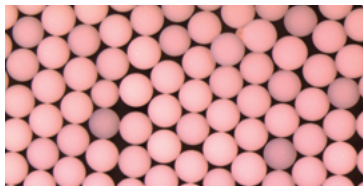


Decolorization – a key step in the production of white sugar from sugarcane.

Initial treatment of sugarcane yields raw sugar syrup that is yellow- or tan-colored, and that color must be removed before crystallization of white sugar. Filtration and precipitation can extract much of the color from the raw syrup, but the remaining color is mostly soluble organic impurities that are difficult to remove. DuPont™ AmberLite™ Ion Exchange Resins are widely used for final decolorization. Their high capacity and physical stability offer industry-leading process reliability and low cost of total operations.



AmberLite™ FPA90 Cl Resin



AmberLite™ FPA900UPS Cl Resin

DuPont consistently offers:

- ▶ **Reliability** – capital investment in worldwide production facilities to supply increasing global demand and offer leading quality, global service, and support.
- ▶ **Value** – products designed for applications that help lower operating costs and increase throughput, yield, and product quality.
- ▶ **Innovation** – R&D focused on delivering innovative products to maximize plant performance.

DuPont Ion Exchange Resins – the reliable and preferred choice for decolorization.

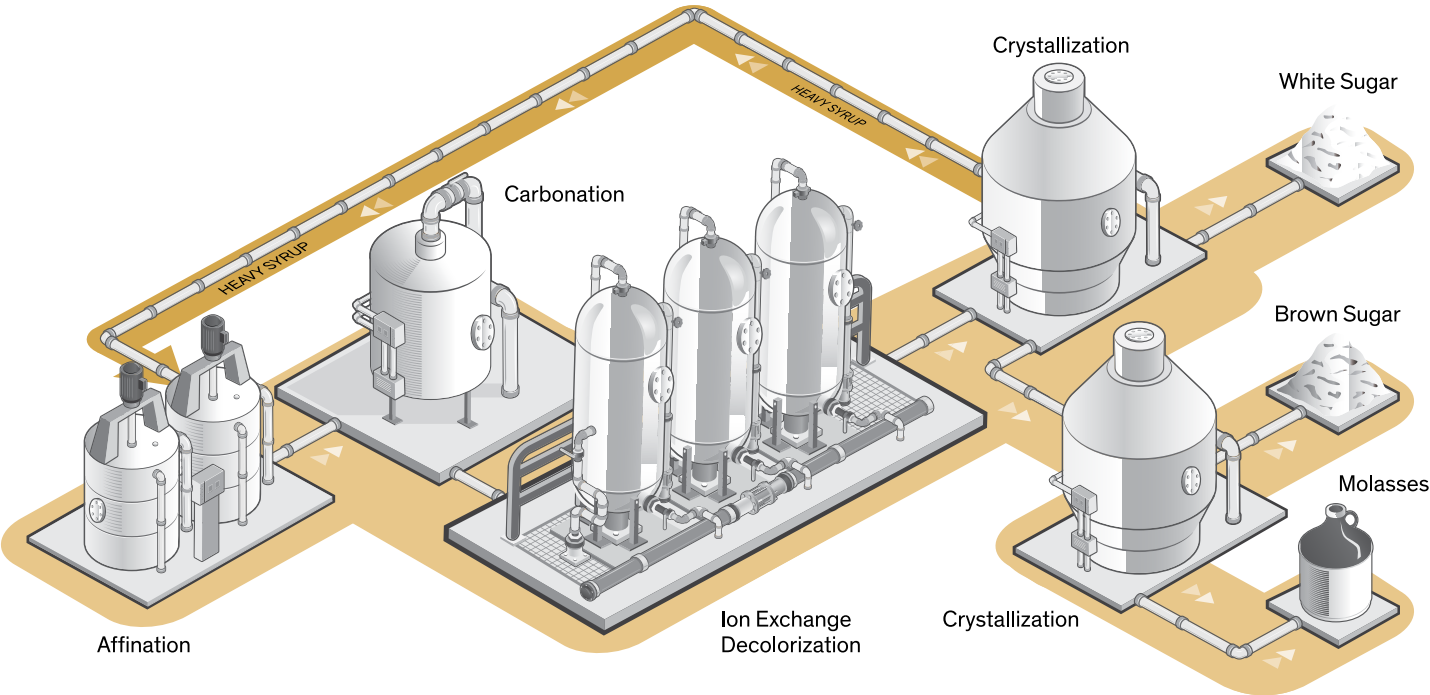
As the world’s largest manufacturer of ion exchange resins, DuPont offers a comprehensive, high-quality product line and industry-leading technical expertise to serve the needs of the cane sugar processing industry.

DuPont™ AmberLite™ Ion Exchange Resins are widely used for the cane sugar decolorization process, for cane syrups up to 2000 ICU in color. These resins have high capacity and internal surface area designed for efficient low- and high-molecular weight color bodies.

AmberLite™ Resins also have excellent physical strength and can withstand harsh operating conditions, offering longer operating lifetimes and few complications such as increased pressure drop due to bead breakage.



Simplified Sucrose Refining Process Schematic



Types of DuPont Ion Exchange Resins used in cane sugar decolorization.

Ion exchange resins are an excellent choice for the final cane sugar decolorization step, offering system flexibility, as well as low cost to operate.

Many of the color bodies remaining after the cane pretreatment steps are hydrophobic and anionic. This makes macroporous strong base anion exchange resins an excellent choice to remove color, as color bodies bind to the beads through both ionic and hydrophobic interactions. Ion exchange resins offer exceptional performance and advantages in process efficiency compared to other options such as activated carbon and bonechar.

Acrylic and Styrenic anion resins offer different advantages.

Acrylic resins – can remove high levels of color from syrup. The acrylic groups are only moderately selective for cane color components, enabling the adsorbed color to be efficiently removed during regeneration, leading to minimal long-term fouling. Because of this moderate selectivity, however, acrylics are typically not used to achieve very low exit color.

Styrenic resins – the best choice for the lowest colored syrup. The styrenic backbone gives high selectivity for cane sugar color components, enabling very efficient color removal and lower final color than can be achieved with acrylic resins. Multiple passes through styrenic resin beds may be needed depending on the color level of the feed sugar and exit color requirements. Styrenic resins are more prone to organic fouling because of their higher selectivity



for color components, so good regeneration is key to maintaining resin performance.

While macroporous ion exchange resins are the most common choice for decolorization, gel resins can be used for decolorization in applications in which very low color syrup is required, such as liquid sugar production. The less porous internal bead structure leads to efficient decolorization but also lower decolorization capacity, so gel resins are best only for polishing of low-color feed syrup.

System Design

The choice of resins and number of beds will depend on the color of the feed syrup and exit color requirements. Depending on the color level of the syrup, single or multiple passes through resin beds may be employed.

Cane Sugar Decolorization Selection Guide

| | AmberLite™ FPA98 CI Resin | AmberLite™ FPA900UPS CI Resin | AmberLite™ FPA90 CI Resin AmberLite™ FPA90RF CI Resin |
|------------------------|---------------------------|--|---|
| Matrix | Acrylic | Styrenic | Styrenic |
| Structure | Macroporous | Macroporous | Macroporous |
| Best For | High Color Syrup | Moderate Color Syrup | Moderate Color Syrup |
| Recommended Feed Color | < 2,000 ICU* | < 800 ICU* | < 800 ICU* |
| Benefits | Efficient Regeneration | High % Decolorization; Uniform-sized for Maximum Efficiency | High % Decolorization; RF is size-graded for Packed Beds |

*ICU = International Color Unit, the standard unit for describing sugar color as defined by ICUMSA (International Commission on the Uniform Methods of Sugar Analysis). The unit itself is sometimes referred to as ICUMSA.

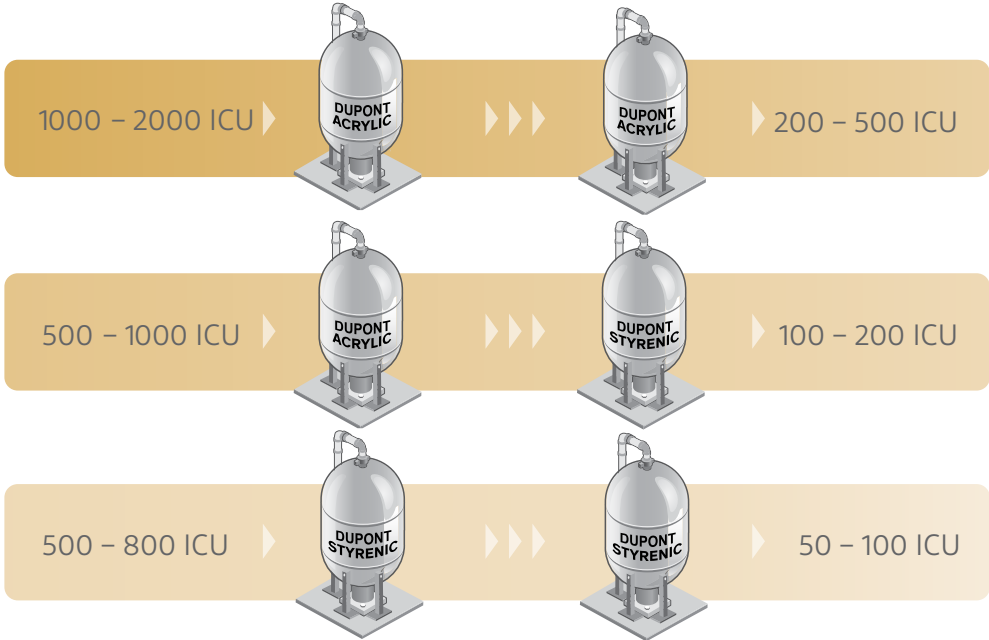


Ion Exchange System Operations.

Three typical resin column arrangements and input/exit color levels are shown below. A common approach for decolorization is to have an initial pass through acrylic resin followed by one or more passes through styrenic resin.

- Acrylic/acrylic is the workhorse decolorizer, giving the greatest efficiency of color removal when higher output color is suitable for downstream processing.
- Acrylic/styrenic configuration offers low color output, utilizing the efficiency of the acrylic resin while helping to prolong the lifetime of the styrenic resin.
- Systems containing only acrylic or acrylic/styrenic resins offer consistent output color levels, helping to minimize the impact of seasonal fluctuations in the color level of the raw sugar.
- Decolorizing with only styrenic resin is feasible if the feed syrup is not very high in color. Styrenic-only systems are an excellent choice for decolorization of low-color syrups.

Suggested Resin Sequences

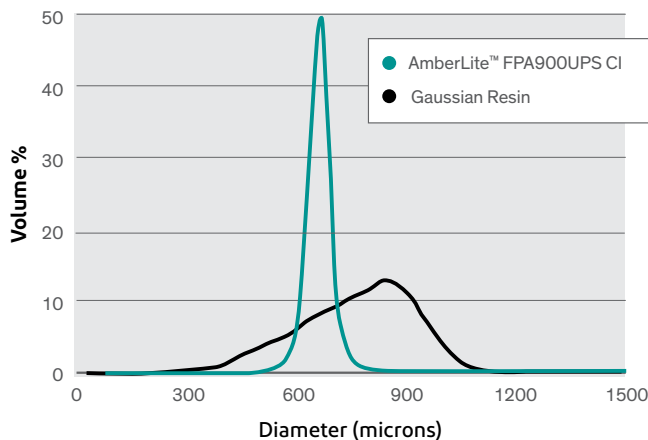


DuPont Products – for process and system flexibility that meet quality and product cost demands.

DuPont offers a comprehensive line of ion exchange resins that are widely used for decolorization and cane sugar processing worldwide. Their physical strength and ability to withstand harsh operating conditions make them an excellent choice for the food and beverage industries—and the resins of choice year after year.

DuPont™ AmberLite™ FPA900UPS Cl Resin

- Maximum decolorization efficiency
- Minimal sweetwater evaporation costs
- Less frequent and more efficient regeneration, and reduced rinsing requirements
- Uniform particle size distribution offers exceptional process efficiency and potential OPEX savings



The narrow particle size distribution of AmberLite™ FPA900UPS Cl leads to consistent decolorization and regeneration operations compared to Gaussian resins.

DuPont™ AmberLite™ FPA98 Cl Resin

- Offers excellent decolorization of high-color feed streams. Its macroporous structure and acrylic backbone provide high color removal capacity and very efficient regeneration.
- Can be placed first in the decolorization cycle to reduce the color load on downstream styrenic resins, which helps extend their lifetime.

DuPont™ AmberLite™ FPA90 Cl and AmberLite™ FPA90RF Cl Resins

- Offer a high degree of color removal because of their high capacity, styrenic backbone, and macroporous structure.
- AmberLite™ FPA90RF Cl is size-graded for exceptional performance in packed beds.

DuPont™ AmberLite™ 14i Resin

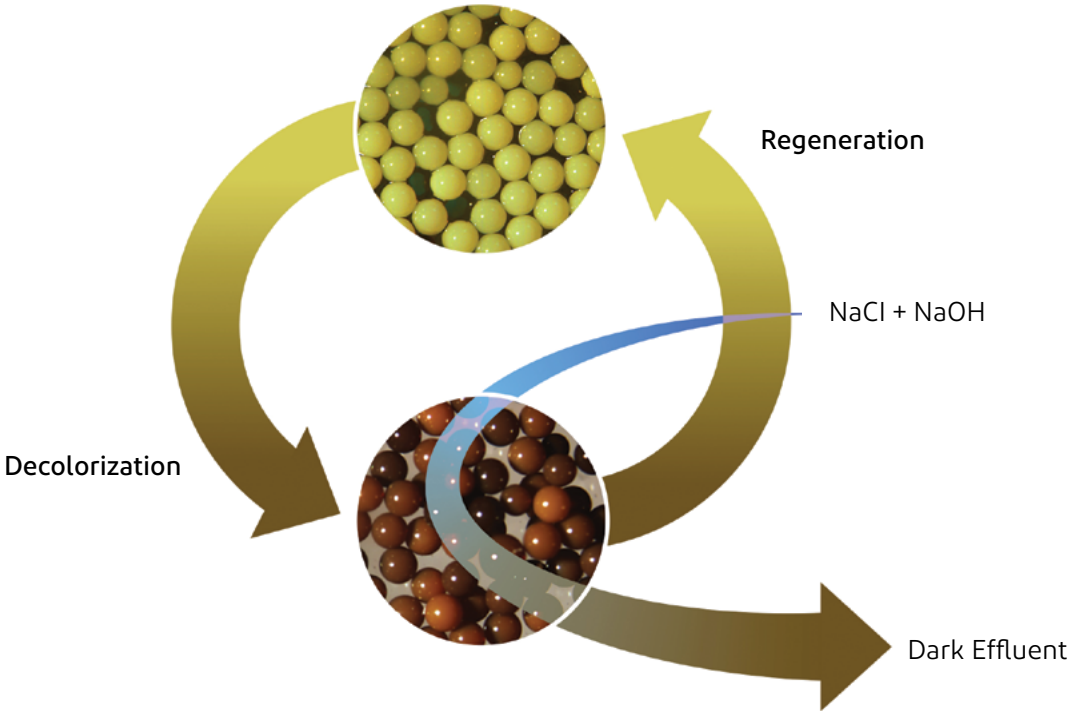
- Inert beads used for minimizing resin losses and filter blockage during upflow operation and helping to improve distribution of feed or regenerant solution above the resin bed.

Recommended resin operating conditions.

Typical conditions for operation and regeneration of DuPont cane sugar decolorizing resins are shown to the right. Regeneration is performed with inexpensive chemicals and it does not require elevated temperatures, so costs are low compared to other decolorization media such as activated carbon. Proper regeneration of decolorizing resins helps maintain their performance and extend their lifetime.

| Operating conditions | |
|-------------------------------|-----------------------------|
| Typical cycle time | 24 – 72 h |
| Maximum operating temperature | 80°C (chloride form) |
| Minimum bed depth | 1000 mm |
| Service flowrate | 2 – 4 BV*/h |
| Regeneration conditions | |
| Regenerant | 10% NaCl + 0.2% NaOH |
| Flowrate | 2 BV/h |
| Chemical use | |
| Co-current | 180 – 200 kg/m ³ |
| Counter-current | 150 kg/m ³ |
| Minimum contact time | ≥ 45 – 60 minutes |
| Temperature | 25 – 70°C |

*BV = Bed volume



Recycling of Regenerant Salt

Regeneration of cane sugar resins involves a salt solution, usually 10% NaCl. Approximately 85% of the salt can be recovered using nanofiltration. Products are HTNF 8040/34 and 4040/34; these products are suitable for continuous use up to 70°C within pH limits. Consult the DuPont™ Membranes for Nutrition Applications brochure for more information

Liquid Sugar Production

Caloric soft drinks are generally formulated with fructose syrups or sucrose crystals. The sucrose cost can be reduced if it is supplied as a liquid from the refiner versus more expensive white crystals. However, additional processing of sucrose syrups is required to reach the high purity and low color required. Typically syrups that have already been through the cane sugar decolorization process still need further processing through a mixed bed and a polishing step to meet final color and organoleptic properties.

A mixed bed of DuPont™ AmberLite™ FP900UPS Strong Base Anion (SBA) with AmberLite™ MAC-3 Weak Acid Cation (WAC) can address these product quality challenges by removing minerals, color and impurities. Mixed bed processing avoids large pH swings seen when separate columns are used, which minimizes sucrose hydrolysis and avoids impurities from degradation reactions that would reduce syrup shelf life. To provide a good balance between cationic and anionic sites, a typical mixed bed polisher consists of 75% (by volume) AmberLite™ FPA900 UPS SBA resin and 25% AmberLite™ MAC-3 WAC resin. After service the resins are separated by backwashing, AmberLite™ MAC-3 is regenerated with hydrochloric acid and AmberLite™ FPA900 UPS is regenerated with sodium hydroxide. The regenerated resins are remixed in place, usually by turbulent air sparging.

Typically after the mixed bed, activated carbon and fine filtration are used to polish the quality of the liquid sugar product and ensure it consistently meets specifications. In certain cases, AmberLite™ SD-2 adsorbent resin can also help with final syrup quality by capturing problematic trace impurities and removing residual color. AmberLite™ SD-2 was designed with a very high surface area and a slight anionic functionality that can provide additional adsorptive chemistries to augment downstream purification schemes.

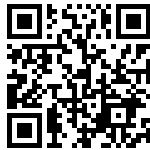
Low GI Glycemic Index Sugar and Polyphenols Extraction

AmberLite™ FPX66 or AmberLite™ XAD™7HP polymeric adsorbents can be used to recover and purify polyphenols from molasses. Recovered polyphenols can then be used to coat sugar crystals, reducing intestinal absorption rates in the digestive tract and lowering the glycemic index of the final sweetener product.

DuPont System Optimization ServicesSM (SOS) – Comprehensive support for the food and beverage processing industries.

At DuPont, we are committed to doing everything possible to support our food and beverage processing customers. That's why, whenever you choose DuPont™ AmberLite™ FP Resins, we offer expert support from our ion exchange technical service and development teams.

DuPont also offers a full range of System Optimization ServicesSM (SOS) to help you achieve optimum performance from your resin, system, and plant operations. SOS ServicesSM place our extensive knowledge and experience at your disposal. These services can complement your R&D innovation team, lighten the burden of your system start-up and staff training, and support the ongoing operation and maintenance of your system.



[Contact DuPont SOS ServicesSM](#)



Request a Sample of DuPont Ion Exchange Products

Small orders of DuPont ion exchange resins, polymeric adsorbents, chelating resins, and copolymers can be ordered online through the Octochem website.



[Request a Sample Online](#)

Regulatory Compliance

The resins featured here may be subject to food contact application restrictions in some countries. For country-specific food contact compliance statements, regulatory datasheets, and information on dietary rules, please contact [DuPont Contact Center](#).

DuPont has a fundamental concern for all who make, distribute, and use our products, and for the environment in which we live. This concern is the basis for our product stewardship philosophy by which we assess the safety, health, and environmental information on our products and then take appropriate steps to protect employee and public health and our environment.

The success of our product stewardship program rests with each and every individual involved with DuPont products—from initial concept and research to manufacturing, selling, using, disposing, and recycling each product.

A closer look at the cane sugar refining process.

Sugar Mills



Sugar mills are located in cane growing areas. Cut cane is processed to dark raw sugar crystals for export to refineries. Typically located near global population centers, these refineries further process the raw sugar to produce white sugar. Raw sugar color comes from components of the cane plant as well as from the processing steps. A key goal of refining is to separate white sugar from color.

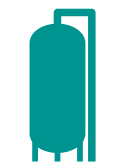
In the Refinery



Affination: In the refinery, raw sugar crystals are centrifuged with hot sugar syrup to remove the outermost layer from the crystals, which contains much of the color. This process is called affination.



Remelting: The crystals are remelted (or dissolved) with hot syrup to produce a dilute thin syrup.



Purification: Precipitation and filtration processes remove solids, some color, and other contaminants.



Evaporation: Multi-step evaporation produces hot, colored, concentrated syrup called thick juice.

Decolorization: The thick juice is processed through ion exchange resins to lower its color. Color must be brought to roughly 50 – 200 ICU, which is low enough to produce white sugar.

Crystallization: Final evaporation of this syrup to super-saturation and the addition of seeding crystals enables crystallization of white sugar. The sugar is recovered from the remaining liquid by centrifugation.

Drying and Packaging: The final sugar still requires drying to prevent later hardening or caking. Hot dry air is passed through the white sugar crystals to accomplish this. The dry sugar is finally packaged into familiar consumer-branded packages.

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