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DOWEX OPTIPORE SD-2 Adsorbent as an Alternative to Activated Carbon in the Processing of Corn Syrups and High Fructose Corn Syrups

1994 Scientific Conference
Sponsored by Corn Refiners Association, Inc.
September 19-21, 1994
Oak Brook, Illinois

By: Alan Greenberg
Senior Development Specialist
The Dow Chemical Company

Introduction

The Dow Chemical Company is a leading supplier to the corn sweetener industry. Products available to assist in the processing of corn into corn syrup and high fructose corn syrup include DOWEX* ion exchange resins, DOWEX MONOSPHERE* 99 chromatographic resins for saccharide separations, and a full line of membranes including FILMTEC reverse osmosis elements. One of the newest products for the corn sweetener industry is DOWEX OPTIPORE* SD-2 adsorbent for the decolorization of corn syrup and high-fructose corn syrup streams.

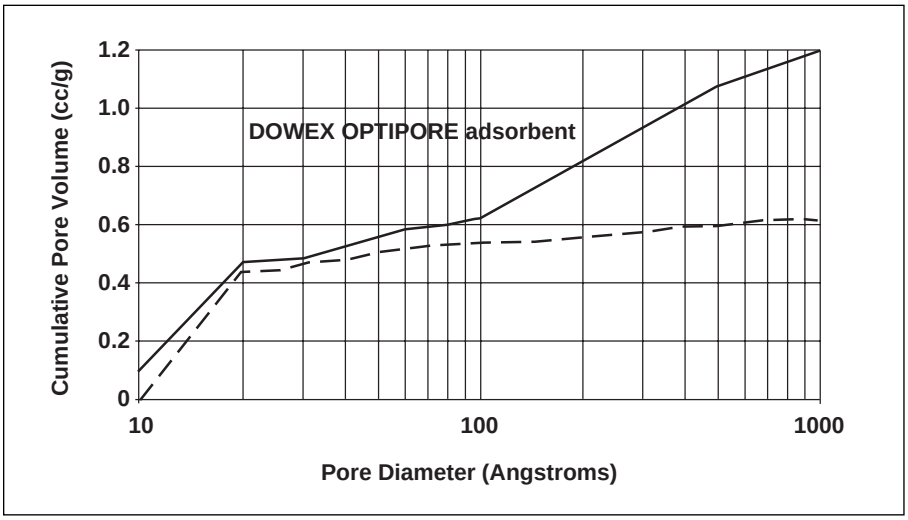
DOWEX OPTIPORE SD-2 adsorbent has been designed to have many of the same properties as activated carbon without many of the difficulties in handling. The first commercial installation of the adsorbent was in 1990 and systems have been running continuously since then. Currently there are commercial installations in North America, South America and Europe.

This paper will focus on the product properties of DOWEX OPTIPORE SD-2 adsorbent and present several examples of the adsorbent's performance on corn syrup and high fructose corn syrup streams.

Product Properties

Using the expertise developed in decades of producing high quality ion exchange resins, The Dow Chemical Company has designed a special adsorbent for use in the decolorization of corn syrup and high fructose corn syrup streams. The adsorbent is built upon a styrene/divinylbenzene copolymer backbone. This macroporous copolymer is then reacted to provide an adsorbent with a very small amount of weak base character. Unlike traditional ion exchange resins, the adsorbent has a minimal amount of ion exchange capacity and instead depends upon adsorption for the removal of color bodies. DOWEX OPTIPORE SD-2 adsorbent was specially designed to mimic the porosity found in activated carbon in the range of pore sizes critical for color component adsorption (Figure 1). The large amount of porosity greater than 100 Å allows for fast kinetics.

Figure 1. Comparison of DOWEX OPTIPORE Adsorbent and Activated Carbon - Porosity



DOWEX OPTIPORE SD-2 adsorbent was also designed to be easy to work with. It has low swell, less than 5% expansion, allowing for easy vessel design. The adsorbent also has a low pressure drop, allowing the DOWEX OPTIPORE SD-2 columns to be run at normal plant flow velocities. The product is able to be configured as either a single pass or double pass system. Double pass systems using the adsorbent provide a higher quality effluent.

DOWEX OPTIPORE SD-2 adsorbent is chemically regenerable. Counter-current regeneration is preferred to obtain the best performance and best product quality. The standard regeneration of DOWEX OPTIPORE SD-2 includes the use of dilute sodium hydroxide for desorption of the color compounds, a hot water rinse to further desorb the materials and cleanse the pores, and a dilute acid neutralization to bring the pH of the adsorbent back into the range best tolerated by your syrup stream. Unlike activated carbon, DOWEX OPTIPORE SD-2 does not require furnace regeneration. The adsorbent shows consistent removal of both color and after-heat color components from cycle to cycle.

With DOWEX OPTIPORE SD-2 adsorbent you can expect to see color removal and after-heat color removal capabilities similar to that of activated carbon (Figures 2 and 3). As a general rule, color reductions of 70-75% and after-heat color reductions of approximately 50% can be achieved with a single pass through the adsorbent. Configuring the adsorbent in a double-pass mode improves both the color and after-heat color removal capabilities of the system. Double pass systems typically generate streams with 90% less color and 75% less after-heat color values than measured in the influent stream.

Figure 2. Comparison of DOWEX OPTIPORE Adsorbent and Activated Carbon - Color

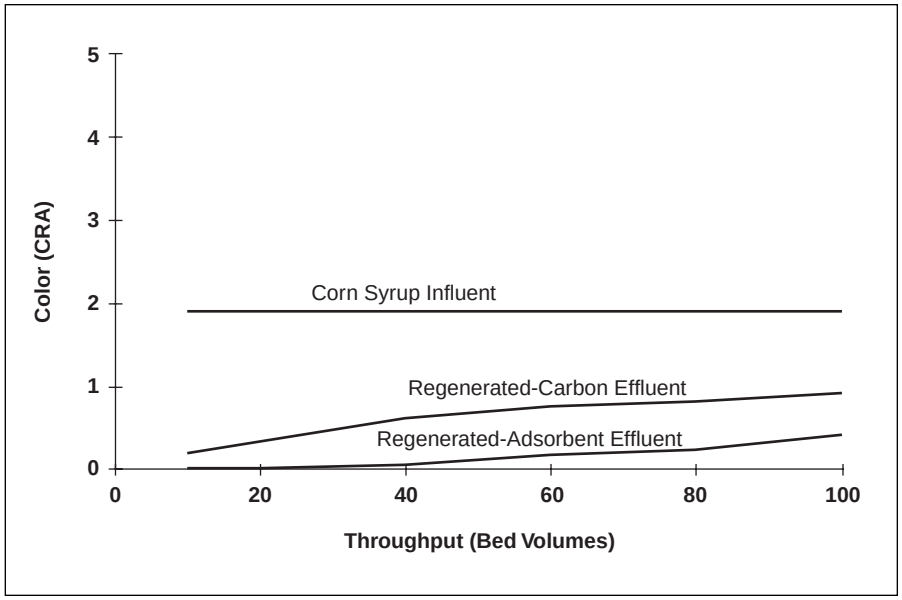


Figure 3. Comparison of DOWEX OPTIPORE Adsorbent and Activated Carbon - After-Heat Color

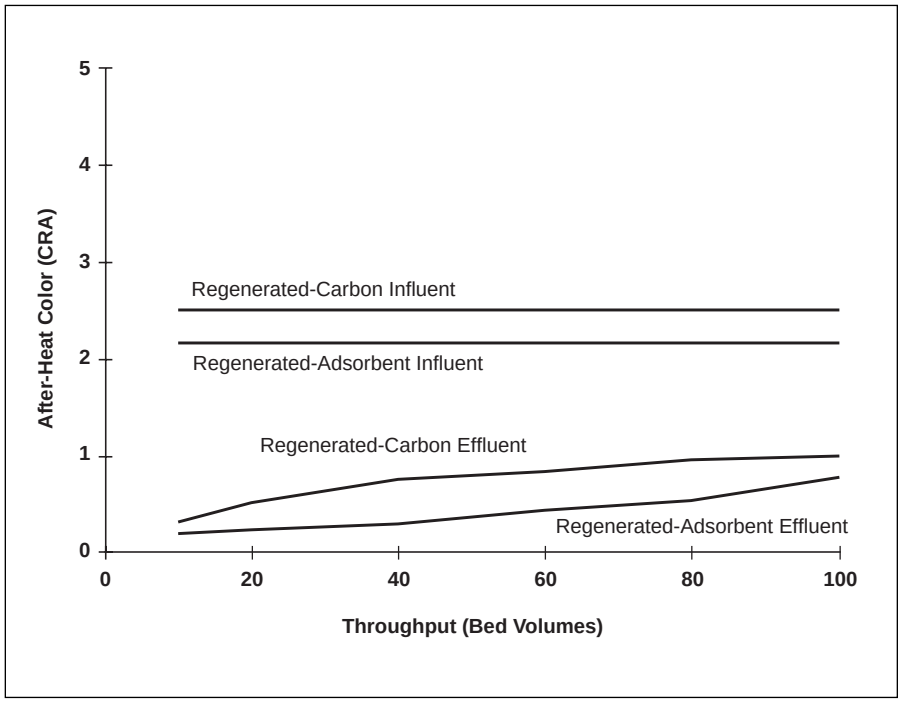


Figure 4. Removal of Color From Corn Syrup Single-Pass

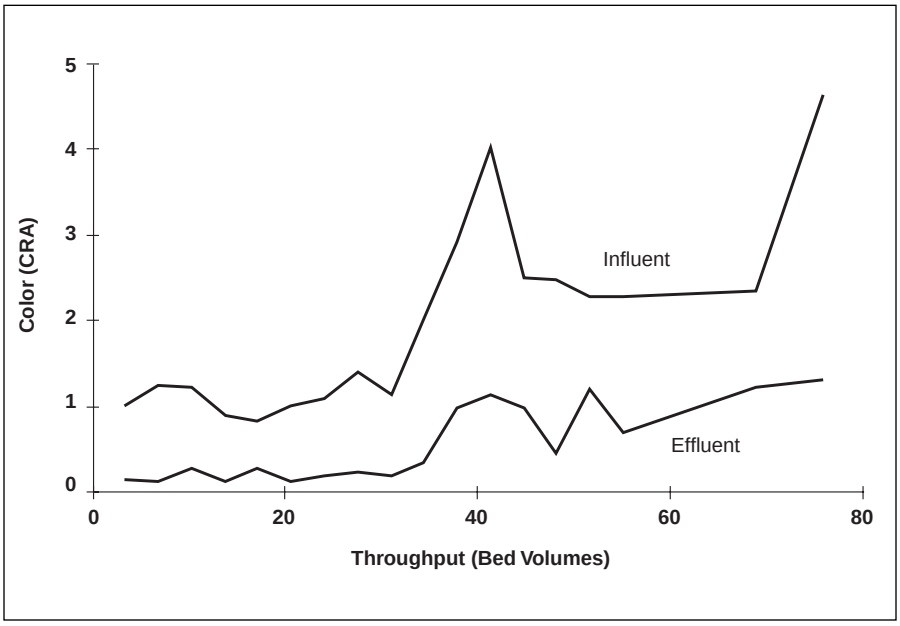
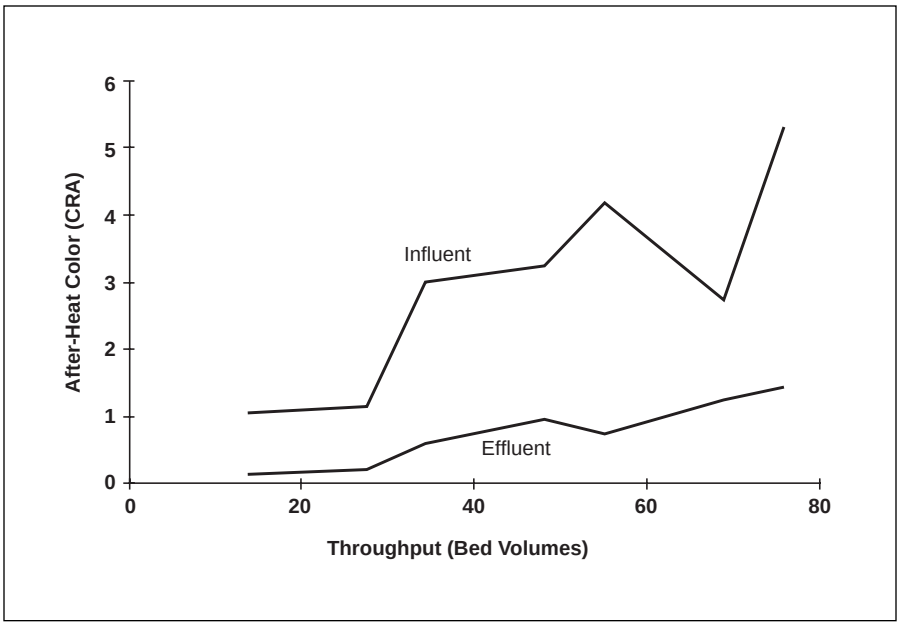


Figure 5. Removal of After-Heat Color from Corn Syrup Single-Pass



Applications of DOWEX OPTIPORE SD-2 Adsorbent

DOWEX OPTIPORE SD-2 adsorbent has been successfully used in a wide variety of corn syrup and high fructose corn syrup applications. In corn syrup streams ranging from 35 to 63 DE, the adsorbent has been successfully evaluated for decolorization and taste/odor polishing. In 42% high fructose corn syrup use, the product has been shown to be successful in the reduction of color and after-heat color on both the dextrose side and fructose side of the process. In addition, DOWEX OPTIPORE SD-2 adsorbent is useful in reducing 5-hydroxymethylfurfural (HMF) levels by up to 50%. The product also has been used for taste/odor polishing of HFCS.

In single pass service, at 3 bed volumes per hour, DOWEX OPTIPORE SD-2 adsorbent provides the expected 70-75% color removal and 50% after-heat color removal (Figures 4 and 5). In addition to a simple reduction in color, the adsorbent also acts to reduce the variability of the final product quality, even during swings in color induced by the process. Effluent colors and after-heat colors of less than 1 (based on the CRA scale) are maintained, in this example, for over 20 hours.

Figure 6. Removal of Color from Corn Syrup Double-Pass

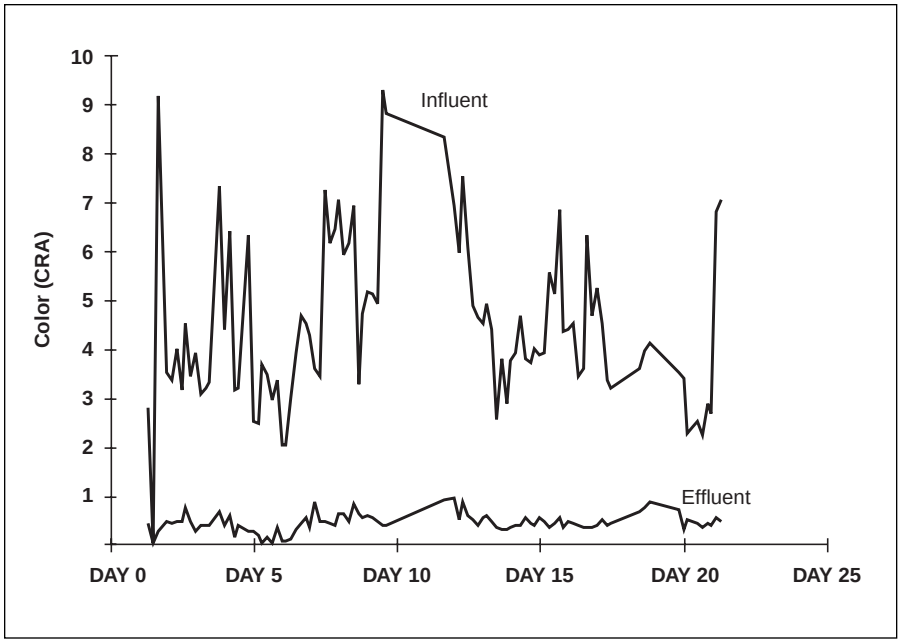
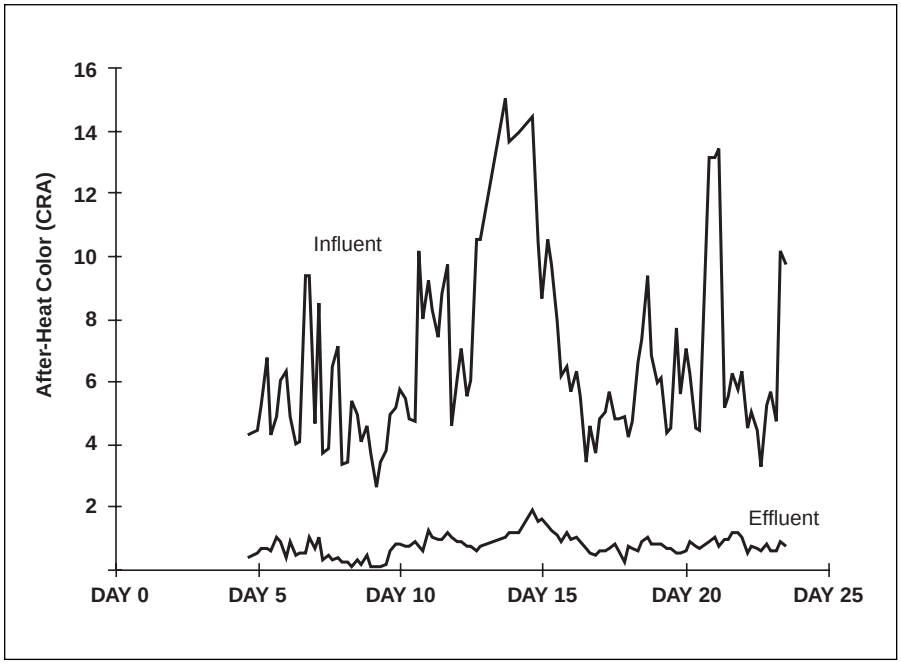


Figure 7. Removal of After-Heat Color from Corn Syrup Double-Pass



The double pass results are even more dramatic (Figures 6 and 7). Despite large swings in influent color and after-heat color components, the DOWEX OPTIPORE SD-2 maintained color and after-heat color levels of the effluent at less than 1 CRA unit. The sole excursion, above 1 CRA unit, in effluent after-heat color is due to a sustained, very high level of after-heat color components being introduced to the adsorbent. This excursion produced a color level less than 1.5 CRA units. These figures also demonstrate the consistency of product quality obtained over several regeneration cycles of the adsorbent.

Commercial installations of DOWEX OPTIPORE adsorbents on the dextrose side of high-fructose corn-syrup have duplicated the results obtained in corn syrup service.

Figure 8. Removal of Color from Fructose

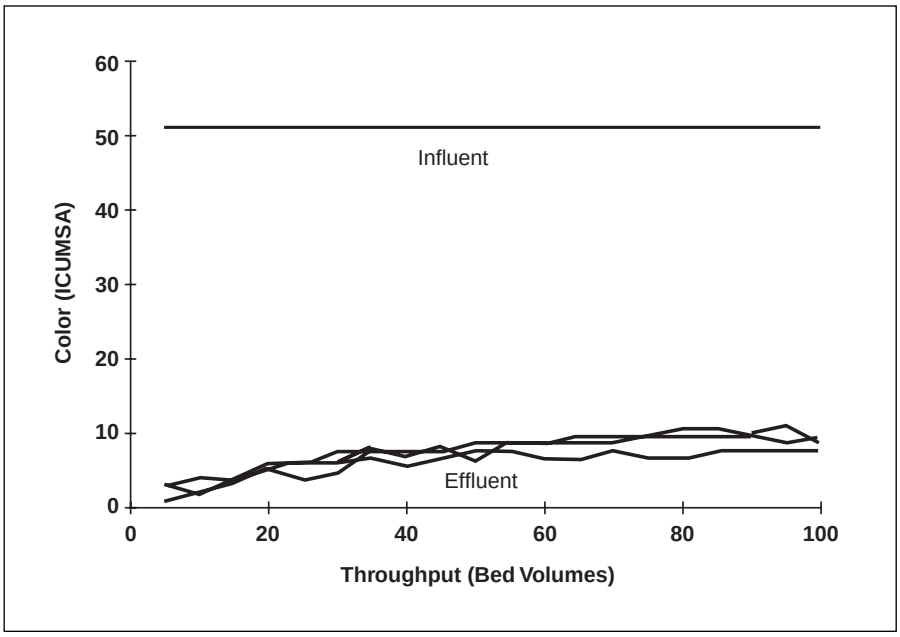
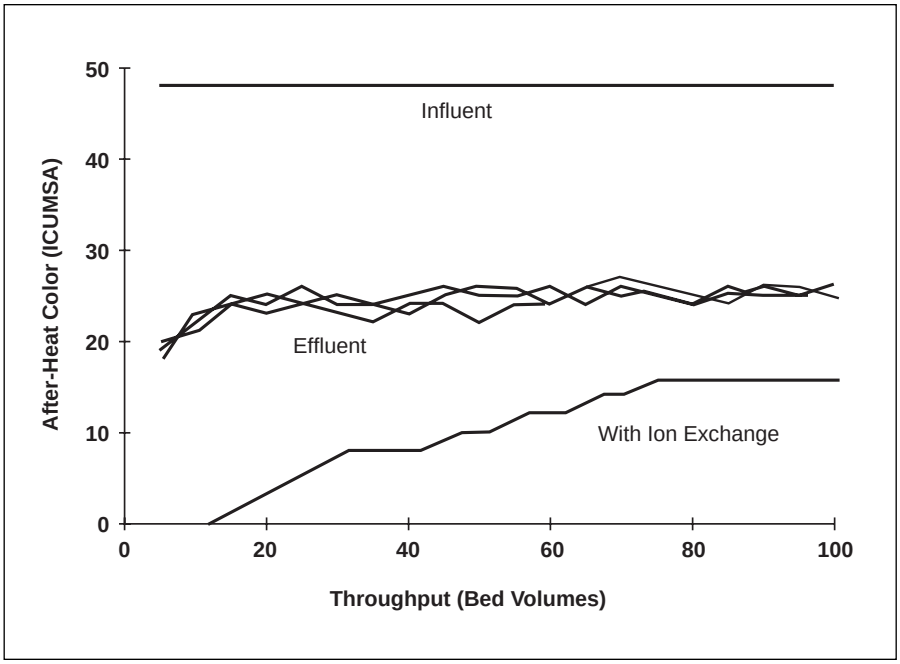


Figure 9. Removal of After-Heat Color from Fructose

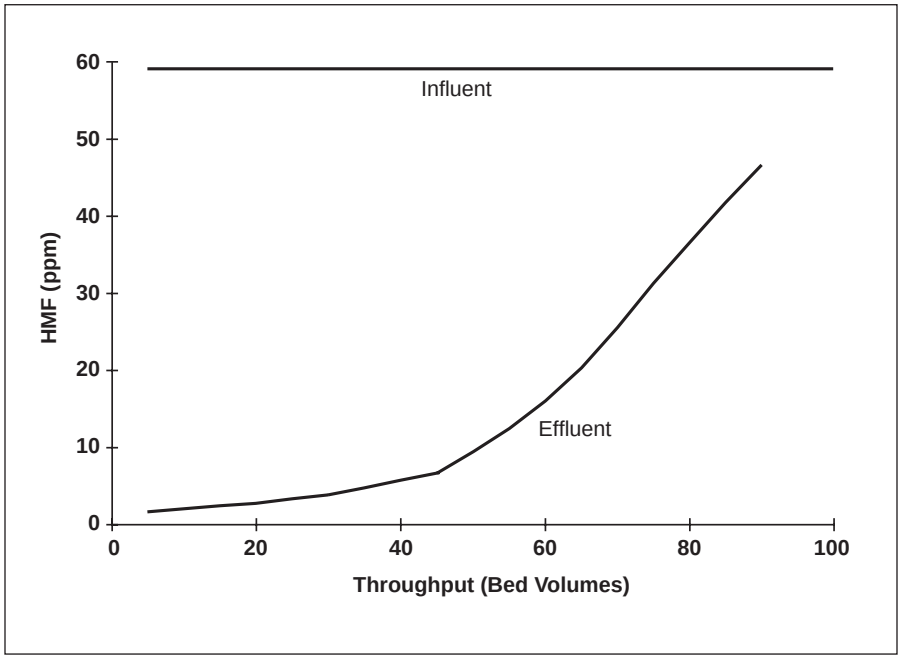


Color and heat-color removal capabilities are again comparable to those obtained with activated carbon, when the resin is used on the fructose side of the HFCS process.
An approximately 70-75% reduction in color is obtained as well as a 50% reduction in after-heat color (Figures 8 and 9). The synergistic effect of DOWEX OPTIPORE SD-2 adsorbent with ion exchange resin on the reduction of after-heat color has also been demonstrated.

An added benefit of using DOWEX OPTIPORE SD-2 adsorbent in fructose service is the removal of HMF. DOWEX OPTIPORE SD-2 is very effective at removing HMF from HFCS during the early portion of its cycles. At 65 bed volumes of throughput, or approximately 22 hours of cycle time, the adsorbent has removed at least 50% of the HMF in the syrup stream (Figure 10).

As expected from any product being introduced into a corn syrup plant, the product meets FDA 21 CFR 173.25. No significant changes in organic acid or carbohydrate profiles have been detected.

Figure 10. Removal of HMF from Fructose



Summary

DOWEX OPTIPORE SD-2 adsorbent is one of the newest products in Dow's catalogue of products for use in corn sweetener applications. The decolorization performance of the adsorbent can be compared to that of activated carbon (in current processes). Systems using DOWEX OPTIPORE SD-2 provide a 75% reduction in syrup color and a 50% reduction in after-heat color. Color reductions of 90% and heat-color reductions of 75% are achievable by configuring the resin in a double pass mode. In addition, a 50% reduction in HMF can be seen during the first 65 bed volumes of service. Improved taste and odor characteristics of the syrups are an extra benefit.

In short, DOWEX OPTIPORE SD-2 adsorbent provides the corn processor with the color removal capabilities of activated carbon, coupled with an improvement in plant appearance, reduced handling requirements, and the elimination of furnace regeneration.

Dow Liquid Separations Offices.
For more information call Dow Liquid Separations:

Dow Europe
Dow Information Centre
Liquid Separations
Schurenbergweg 5
1105 AP Amsterdam Zuidoost
P.O. Box 12121
1100 AC Amsterdam
The Netherlands
Tel. +31 20 691 6268
Fax +31 20 691 6418

Dow Pacific
Dow Chemical Japan Ltd.
Liquid Separations
Tennoz Central Tower
2-24, Higashikanagawa 2-chome
Shinagawa-ku, Tokyo 140
Japan
Tel. (813) 5460 2100
Fax (813) 5460 6246

Dow Pacific
Dow Chemical Australia Ltd.
Liquid Separations
26 Rodborough Road
French's Forest
New South Wales 2086
Australia
Tel. 61-2-9776-3226
Fax 61-2-9776-3299

Dow Latin America
Dow Quimica S.A.
Liquid Separations
Rua Alexandre Dumas, 1671
Sao Paulo - SP - Brazil
CEP 04717-903
Tel. 55-11-5188 9345
Fax 55-11-5188 9919

Dow North America
The Dow Chemical Company
Liquid Separations
Customer Information Group
P.O. Box 1206
Midland, MI 48641-1206
USA
Tel. 1-800-447-4369
Fax (517) 832-1465

Internet
http://www.dow.com/liquidseps

Warning: Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

Published July 1998.

Form No. 177-01525-798QRP
171-329-E-798