Quarterly Report on
DOE Contract No. DE-AS02-87C540071

DIRECT ENZYMATIC EXTRACTION OF STARCH FROM CORN AS AN ENERGY-SAVING ALTERNATIVE TO PRODUCTION OF HIGH-FRUCTOSE SYRUP

prepared by
Laboratory of Renewable Resources Engineering
Purdue University
West Lafayette, Indiana 47907

For the Quarter
July 1, 1981 - September 30, 1981

submitted to
Agricultural and Food Processes Branch
Division of Industrial Energy Conservation
U.S. Department of Energy

Attention: Dr. L. R. Kelso

DISCLAIMER
This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED
DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.
DISCLAIMER

 Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
1. An industrial meeting took place here at Purdue on May 18, 1981. A list of future work and suggestions from the industrial advisory group is attached as Appendix.

2. Impurity in the glucose syrup could be reduced from 0.51 gm/ml level (here sedimental method is used) down to 0.23 mg/ml by filtering the syrup through diatome earth filter. The industrial products contain about 0.37 mg/ml (industrial product also filtered through diatomic earth filter).
REMOVAL OF ORGANIC IMPURITY FROM CORN SYRUP

The corn syrup samples from Purdue corn project pilot plant were analyzed for impurity content; these results were then used for the evaluation of the pilot plant operation. The uv scan of the samples (Fig. 1) implies that the light absorbance at 280 nm may serve as an indication of the impurity level. The impurity level of Purdue syrup was considerably higher than that of commercial syrup; however, it diminished to comparable to commercial syrup in the subsequent runs as our technique improved. Factors which influence the impurity content of syrup include: pH of syrup, addition of filter aid, and mechanical separation. Investigation is progressing on the process optimization.

The adsorption of the impurity on activated carbon was carried out in the same apparatuses mentioned in prior reports. Experimental results in batch configuration indicate that it takes 4 hours to reach the equilibrium state when the syrup is treated with carbon powder <325 mesh (Fig. 2). Generally, the higher temperature at which the system is operated, the greater the extent of adsorption can be achieved (Fig. 3). The adsorption isotherm can be best fit with the Langmuir model compared to Freundlich and linear models.

The bed-depth-service-time relationship was applied in the design of the adsorption column. This relationship may be expressed with a simplified equation

\[ t = ar + b \]

where \( t \) is the breakthrough time, \( r \) is the retention time, and both \( a \) and \( b \) are constants (Fig. 4). At a flow rate of 2.5 gpm/ft\(^2\), the adsorption column can treat more than 40 times bed volume of dirty syrup.
UV Spectra of (Top) Dirty Syrup and (Bottom) Clean Syrup Samples are from Purdue Process
COLOR DEPLETION (CORN SYRUP/ CARBON)

FIGURE 2.
ADSORPTION ISOTHERMS
CORN SYRUP/CARBON LANGMUIR MODEL

FIGURE 3.
Bed depth-service time (BDST) relationship

\[ T = \frac{N_0 X}{Co U} - \frac{1}{KCo} \ln \left( \frac{Co}{C} - 1 \right) \]
APPENDIX

Future developmental work and suggestions by industrial advisory groups include:

A. PROTEIN EXTRACTION
   1. Utilize leaching or stage extraction to improve protein extraction efficiency.
   2. Measure ethanol recovery from spent solvent.
   3. Improve protein recovery procedure to reduce starch entrainment.

B. GELATINIZATION AND LIQUEFACTION
   1. Increase steam pressure (or temperature) in jet cooker.
   2. Reduce α-amylase addition level.

C. SACCHARIFICATION
   1. Improve refinery mud separation from syrup.
   2. Improve DE to consistent 96.
   3. Process syrup rapidly to avoid color development.

D. ISOMERIZATION
   1. Add syrup evaporation to improve GI column sterility.
   2. Measure GI half-life.

E. OVERALL
   Complete mass balance enabling estimation of energy requirement for processing corn grits to HFCS.