

# AGRICULTURE

## Project Fact Sheet



## INDUSTRIAL MEMBRANE FILTRATION AND FRACTAL SEPARATION SYSTEMS

### BENEFITS

- Creates energy-efficient separation and purification processes
- Increases the overall capacity of separation and purification systems
- Provides low-capital alternatives to conventional crop-based purification/separation processes
- Produces an inexpensive sugar feedstock that can be used in a variety of industrial applications
- Significant energy savings for general use in the new biobased products industry

### APPLICATIONS

The new separation and purification systems have multiple applications in the industrial sector. The proposed system will result in capital and operational cost savings. The system will also eliminate or reduce the flow of waste streams and thus favorably impact environmental problems.

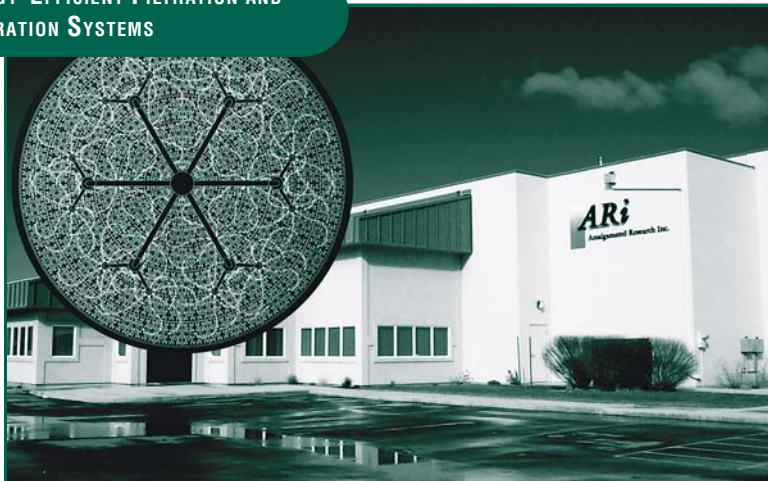
The fractal separation system has potential uses in waste treatment, and chemical and food processing applications. Improved operational efficiencies, potential capital savings, and reduced environmental waste loads will make the system attractive for many industries.

## SEPARATION AND PURIFICATION PROCESSES WILL MAKE BIOMASS CONVERSION MORE ECONOMICALLY FEASIBLE

Purification and separation represent a major operational barrier in the conversion of crop-based renewable resources (e.g., cellulosic biomass such as straw, corn stover, wood, etc.) into chemicals and fuels. Biomass feedstocks often contain materials including fiber, particulates, and suspended solids (e.g., soil) that can erode, corrode, or plug separation and purification systems such as membrane filters, ion exchangers, and chromatography units. The large, initial capital investment along with high operating costs for the replacement of membrane filters and ion exchanger/chromatographic resins contribute to high costs for the overall process. As a result, biobased products from lignocellulose are not cost-competitive with conventional, fossil-based products.

Amalgamated Research Inc., its industry partners, and the Idaho National Engineering and Environmental Laboratory (INEEL) are collaborating to develop new, highly-efficient purification and separation technologies that will substantially reduce capital costs while dramatically improving operational efficiencies of the industrial processing plants. A pretreatment stage will be incorporated into a membrane purification system to remove large solids such as soil and fiber. The membrane unit will use membranes that are more durable and less susceptible to fouling, thereby reducing the frequency and cost of maintenance. Overall process efficiency of chromatographic separators and ion exchangers will be increased and the unit sizes reduced with the use of fractal distributors and new, more effective resins.

### ENERGY-EFFICIENT FILTRATION AND SEPARATION SYSTEMS



The fractal distribution pattern (see inset) will enable more efficient separation of chemical products.



## Project Description

**Goal:** To develop and scale-up a membrane filtration system, and chromatography and ion exchange separation systems that will lower capital investment costs while providing improved separation/purification efficiency in biobased products processing.

The membrane filtration system consists of three parts: 1) a pretreatment clarification system that removes over 80% of the suspended solids from the liquid stream; 2) a screening unit that removes fibrous material; and 3) the hybrid membrane filtration system using spiral and tubular membranes. The first two parts have already been developed and only require optimization. Membranes capable of withstanding a combination of high temperature, corrosive conditions, and abrasive materials will be tested.

Using computer software and the expertise of the Idaho National Engineering and Environmental Laboratory, a fractal distributor for the chromatography and ion exchange separation systems will be analyzed to determine the optimal flow patterns. These fractal columns will be as much as ten times smaller without reduction in the throughput. In addition, new resins based on silica rather than polymers will be developed to provide a higher throughput, better durability, and increased operational energy savings. The net result should be smaller, lower capital and operating cost chromatography and ion exchange systems.

Amalgamated Sugar LLC, a member of the Sugar Company Consortium, will supply a nonhazardous "raw sugar beet juice" stream which contains abrasive material and membrane foulants similar to those in cellulose acid hydrolysis streams for initial prototype testing. The filtration and separation systems will be tested on the raw beet juice.

## Progress and Milestones

- Test and optimize screening equipment as a pretreatment method for membrane filtration.
- Conduct long-term testing with the hybrid membrane system using commercial-size membrane modules. Test the new experimental, high-temperature spiral modules manufactured by Koch Membrane Systems. Optimize control strategy and regimes of operation. Develop reliable cleaning strategies.
- Build a corrosion resistant, fully-automated pilot fractal installation for evaluation of the chromatography system. Test it on several model solutions and investigate the effect of bed configurations on system performance. Determine the best modes of operation.
- Test industrial prototypes of ion-exchange equipment using high-density fractal distributors.
- Optimize the geometry of channels and outlets in the fractal distributors using INEEL's computational fluid dynamics software to reduce the pressure drop and improve efficiency of fluid distribution. Modeling will include novel distributor arrangements as well as fluid outlet points.
- Manufacture and test prototypes of improved fractal distributors.



### PROJECT PARTNERS

Amalgamated Research Inc.  
Twin Falls, ID

Arkenol, Inc.  
Mission Viejo, CA

Idaho National Engineering and  
Environmental Laboratory  
Idaho Falls, ID

Koch Membrane Systems, Inc.  
Wilmington, MA

Sugar Company Consortium

### FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

Mark Paster  
Office of Industrial Technologies  
Phone: (202) 586-2821  
Fax: (202) 586-3237  
mark.paster@ee.doe.gov

Please send any comments, questions,  
or suggestions to  
webmaster.oit@ee.doe.gov

Visit the OIT Web site at  
www.oit.doe.gov

Office of Industrial Technologies  
Energy Efficiency  
and Renewable Energy  
U.S. Department of Energy  
Washington, D.C. 20585



DOE/GO-102001-1456  
September 2001