Bioconversion of Cheese Waste (Whey)

Federal Manufacturing & Technologies

George Bohnert

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Final Report/Project Accomplishments Summary

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AlliedSignal Inc.

Federal Manufacturing
& Technologies

P. O. Box 419159

Kansas City, Missouri

A prime contractor with the United States

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Date: 9-30-97

Revision: 0

A. Parties

The project is a relationship between

AlliedSignal FM&T

Ab Initio

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Kansas City, MO 64641-6159

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B. Background

The US dairy industry produces 67 billion pounds of cheese whey annually. A waste by-product of cheese production, whey consists of water, milk sugar (lactose), casein (protein), and salts amounting to about 7% total solids. Ultrafiltration is used to concentrate cheese whey into a protein-rich foodstuff; however, it too produces a waste stream, known as "whey permeate," (rejected water, lactose, and salts from the membrane). Whey permeate contains about 4.5% lactose and requires treatment to reduce the high BOD (biological oxygen demand) before disposal. Ab Initio, a small business with strong chemistry and dairy processing background, desired help in developing methods for bioconversion of whey permeate lactose into lactic acid.

Lactic acid is an organic acid primarily used as an acidulant in the food industry. More recently it has been used to produce polylactic acid, a biodegradable polymer and as a new method to treat meat carcasses to combat E. coli bacteria. Conversion of whey permeate to lactic acid is environmentally sound because it produces a valued product from an otherwise waste stream.

FM&T has expertise in bioconversion processes and analytical techniques necessary to characterize biomass functions. The necessary engineering and analytical services for pilot biomass monitoring, process development, and purification of crude lactic acid were available at this facility.

C. Description

Bioconversion of lactose into lactic acid using bacteria such as *Lactobacillus bulgaricus* was investigated. A pilot scale 18-liter vessel was equipped with external heater, agitator, and continuous pH control to study biomass growth and lactic acid formation. Lactic acid production was monitored by using both ion chromatography and the amount of base (ammonium hydroxide) added to maintain the desired pH. An ultrafiltration membrane connected to the bioreactor served to concentrate biomass and provide separation of product.

Crude lactic acid was purified using ion exchange resin, carbon treatment, and vacuum distillation.

The purpose of the project was to develop operating methods and define parameters

which would optimize the process by minimizing costs and maximizing the product yield and quality. FM&T provided laboratory facilities, equipment, and engineering expertise to conduct the various experiments and process design. Ab Initio's role was to acquire the various bacteria cultures, growth and nutrient media, whey feedstock, ion exchange resins, and miscellaneous items needed to complete the experiments. In addition, Ab Initio conducted the day-to-day care and monitoring of biomass. The parameters which influenced biomass growth and concentration were determined. Optimum conditions for lactic acid production were identified. Various seed colonies were initiated using different nutrient packages and were monitored for cell growth. Methods were developed to improve seed colony initiation and growth. Separation and concentration techniques such as ultrafiltration and reverse osmosis were practiced to increase biomass and lactic acid concentration. A computer program was acquired to simulate production scale biomass processes. All of the generated data is useful in sizing equipment for a production scale lactic acid plant with whey as its feedstock.

Teaming both members of this CRADA produced a synergistic effect which enhanced the project.

D. Expected Economic Impact

Work at FM&T has assisted Ab Initio in attracting investors. Design and process flow data has enabled calculations associated with capital and operating cost to be estimated.

A 10,000-pound per day lactic acid production plant would be expected to employ several people. Food grade lactic acid is valued at \$0.80 per pound. Conversion of a whey permeate into a lactic acid benefits the environment through waste conversion. Consumer prices paid for cheese could be lowered because of reduced waste treatment costs.

E. Benefits to DOE

Expertise in ultrafiltration and ion exchange was gained. Ultrafiltration is being investigated for volume reduction of spent cutting fluids at the FM&T facility. Ion exchange is used extensively for water purification in precision cleaning applications. A low-cost measurement technique was developed for density determination during vacuum distillation. Polycarbonate pellets sink in dilute aqueous solutions of lactic acid but become buoyant as the desired lactic acid concentration (88%) is achieved. By selection of the appropriate polymer pellets, this technique is applicable for a wide range of solution densities. This work complements FM&T's Quality Policy goals of respecting the environment and process improvement through reduced waste.

F. Industry Area

Dairy, food, and municipal wastewater treatment.

G. Project Status

Completed as scheduled.

H. Point of Contact for Project Information

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I. Company Size and Point of Contact

Steve Dzuro
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J. Project Examples

Lactic acid samples

K. Technology Commercialization

Unknown to date