PALL

Food and Beverage

Application Bulletin

# Fermentation Broth Clarification Systems for Food and Feed Ingredients Manufacturing

## Overview

Producers of bulk food and feed ingredients such as amino acids, organic acids, and vitamins use fermentation as the basis of their production. Today's modern industrial biotechnology processes use carefully selected and purified microbial cell cultures to produce an ever-increasing variety of ingredients and increase productivity.

During fermentation, the microorganisms multiply in industrial bioreactors, utilizing a carbohydrate source for energy. The course of microbial growth progresses under well-controlled conditions of aeration, agitation rate, temperature, pH and other parameters. Fermentation can last from a few hours to several days. The metabolic end products produced by the microorganisms are the basis for many ingredients used today.

After fermentation, important steps of extracting and purifying the metabolites of interest from the cell mass follow. The first step is primary broth clarification, to remove the spent cells and other suspended solids from the fermenter contents. Primary broth clarification is carried out by a variety of methods ranging from centrifugation to filtration. Today's ingredient manufacturers are looking for the most cost-effective clarification solutions that will provide the highest product quality and maximum yield, while ensuring process safety and minimizing waste volumes.

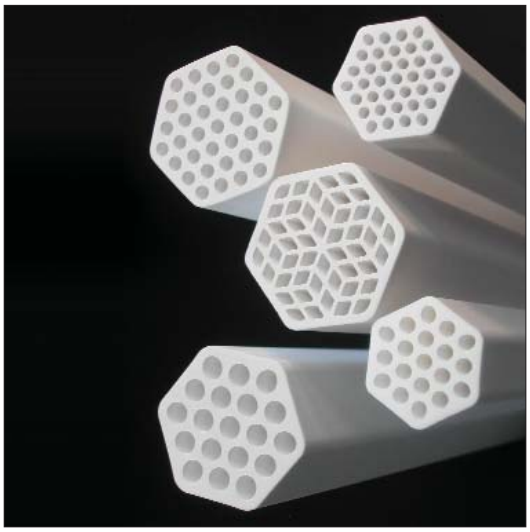
## The Challenge

A large producer of feed additives and vitamins needed technology to manufacture a variety of products in an enclosed system. Due to changing market conditions, this producer desired a degree of flexibility in operation matched to the particular product type being manufactured.

The fermentation broth ranged, on average, from 20 to 25 % spin solids, a relatively high solids load. Varying feed stream characteristics and throughput conditions required additional system flexibility.

Maximum separation efficiency of the desirable components of the fermenter broth was required to achieve very high and constant downstream fluid quality.

The chosen clarification technology needed to achieve very high Volumetric Concentration Factors (VCF) in order to maximize yield. The system of choice needed to be automated, reliable, simple to operate, and as robust as possible against power failures and process upsets.



## The Solution

Membralox® ceramic crossflow technology was chosen for this new, state of the art facility for its ability to reliably deliver the highest filtrate quality regardless of broth characteristics. Unlike centrifugation, where cell size and density as well as fluid viscosity influence the separation efficiency, membrane separation offers an absolute physical barrier that will always provide the optimum separation.

Additionally, ceramic technology provided a solution which could operate without incurring the storage, handling and waste typical of filter aid-based precoat technology. An additional advantage of this solution is the ability to further use the product retentate stream, for example by drying it for use as animal feed.

Large diameter membrane channels were selected to handle the high feed spin solids. This resulted in the highest possible VCF and a retentate concentration in excess of 45 %. To further maximize recovery, diafiltration was used and resulted in an additional increase in the final yield of over 25 %.

Initial pilot testing done on a small scale system determined the proper membrane pore size and process parameters for scale-up. During this first phase Pall® Scientific Laboratory Services (SLS) personnel collaborated with the customer to optimize the process parameters and provide in-depth technical support. Even after system commissioning, the pilot unit continues to be used for testing new bacteria strains and new fermentation techniques, which has allowed continuous new product development and improvement.

Based on successful piloting results, Pall offered over 2,200 $m^2$ of ultrafiltration membrane area in HCB module design. The **Membralox** HCB module range, with its unique hexagonal membrane shape, is able to obtain an extremely high membrane packing density up to 285 $m^2$ / $m^3$, thus significantly reducing filtration system costs.

Three systems were ordered over three distinct phases to suit the continuously increasing production capacity requirements of this plant. The systems were engineered to provide maximum flexibility, high yield and simple process control. The process is based on a fed batch concept with batch diafiltration at constant volume. This concept allows high average flux, low membrane surface area and high efficiency diafiltration. Operators are able to modify setpoints, such as VCF, flux, and diafiltration ratio to accommodate variable feed quality and periodically varying volumetric throughputs. Single loops can also be operated independently of each other, in case of mechanical upsets, such that production can still proceed on a limited basis.

**Membralox** ceramic filtration modules consist of porous ceramic membrane elements, sealed in stainless steel housings with polymeric gaskets. Key features include:

- 3, 4 and 6 mm ID feed channel sizes available in various module configurations for handling a wide range of feed streams, and allowing optimum system configuration
- Extremely robust elements using an ultra-pure underlying alpha alumina support structure, with 12 µm pore size and 30 % porosity, leading to wide chemical compatibility, high flux and suitability for continuous high temperature operation
- Various membrane pore sizes for microfiltration and ultrafiltration

In crossflow filtration, the feed stream moves parallel to the membrane filtration surface and purified liquid passes through the membrane. The parallel flow of the feed stream, combined with the boundary layer turbulence created by the crossflow velocity, continuously sweeps away particles and other substances which would otherwise build up on the membrane surface. As a result, crossflow filters routinely maintain higher permeate rates longer than conventional dead-end filters. Crossflow technology offers the ideal solution for handling high solids load applications.

## The Benefits

This manufacturer required a cost-effective and flexible system capable of achieving high permeate quality and reliable system operation. The **Membralox** system offered the following:

- Process flexibility due to batch system configuration
- High product recovery due to high solids handling capability and use of diafiltration
- Reduced cost and increased efficiency of downstream processes due to high filtrate quality, as compared to centrifuge and precoat technologies
- Reduced process maintenance and waste due to absence of filter aids
- Extremely long life due to ceramic element construction
- Reduced operator exposure and maximum product protection due to a fully enclosed design
- Process simplicity, reliability and safety due to system automation
- Space savings due to compact system footprint

## About Pall Corporation

Pall Corporation is the largest and most diverse filtration, separation, and purification company in the world. Pall serves the food and beverage industries with advanced membrane filtration technology and systems engineered for reliability and cost-effectiveness. Our systems are easy to install, simple to use, and satisfy a wide range of filtration requirements. Our Total Fluid Management$_{SM}$ approach offers customers solutions to address the needs of an entire process, encompassing filtration products, systems, services, and training.

Pall Corporation

**Pall Food and Beverage**

25 Harbor Park Drive
Port Washington, NY 11050 USA
+1 516 484 3600 telephone
+1 866 905 7255 toll free

foodandbeverage@pall.com

**Visit us on the Web at www.pall.com**

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