FLUX ENHANCEMENT IN CROSS FLOW MEMBRANE FILTRATION: FOULING AND IT'S MINIMIZATION BY FLOW REVERSAL

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ABSTRACT

The loss of permeate flux in crossflow membrane filtration, such as reverse osmosis (RO), ultrafiltration (UF) and microfiltration (MF) is inevitable. This is caused by concentration polarization and membrane fouling and is perhaps the single most important reason for relatively slow acceptance of crossflow membrane filtration in many areas of chemical and biological processing. To overcome the losses in permeate flux associated with concentration polarization and fouling, in cross flow membrane filtration, we investigated the concept of flow reversal as a method to enhance membrane flux in ultrafiltration [1,2]. Conceptually, flow reversal prevents the formation of stable hydrodynamic and concentration boundary layers at or near the membrane surface. Furthermore, periodic reversal of the flow direction of the feed stream at the membrane surface results in prevention and mitigation of membrane fouling. Consequently, these advantages are expected to enhance membrane flux significantly.

Laboratory scale tests on a hollow fiber ultrafiltration membrane module using bovine serum albumin (BSA) and Dextran T-70 as model solutes show that the permeate flux is significantly enhanced under flow reversal condition when compared with the conventional unidirectional flow [3-5]. The flux enhancement is dramatic (by an order of magnitude) with increased feed concentration and operating transmembrane pressure. The essential elements of the system include a crossflow hollow fiber membrane module integrated with a three-way valve to direct the feed flow directions. The three-way valve is controlled by a controller-timer for periodic reversal of flow of feed stream. Another important feature of the system is that with changing feed flow direction, the permeate flow direction is also changed to maintain countercurrent feed and permeate flows for enhanced mass transfer driving force (concentration difference).

We also investigated the ultrafiltration of apple juice using flow reversal technology [6, 7]. Traditional methods of fruit juice clarification are both time-and labor consuming and involve the use of large fining tanks as well as large amounts of enzymes and diatomaceous earth. Therefore, it is essential to find more innovative technologies for the clarifying of fruit juices. Of all the components found in apple juice, pectin is most often identified as the major hindrance to membrane performance. The presence of pectin makes the clarification process difficult because of its fiber-like structure, which is believed to cause membrane fouling.

In this study, we investigated ultrafiltration of apple juice in a laboratory scale tubular membrane module. The effect of pectin concentration on membrane flux was studied in a cross-flow UF membrane with and without flow reversal. Over a wide range of pectin concentration in the feed, we collected flux data under various operating conditions in flow reversal and straight through flow conditions. Periodic flow reversal resulted in significant enhancement of flux when compared with operations with the conventional straight through flow.

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List of Published Journal Articles, Completed Presentations and Students Receiving Supports from the Grant:

Journal Articles:

Hargrove, S.C., Parthasarathy, H., **Ilias, S**., "Flux Enhancement in Crossflow Membrane Filtration by Flow Reversal: A Case Study on Ultrafiltration of BSA," *Sep. Sci. Technol*., **38** (12 & 13), pp. 3133-44 (2003).

Conference Proceedings:

Hargrove, S.C., and Ilias, S., "Flux Enhancement in Cross Flow Membrane Filtration by Flow Reversal: A Case Study on Ultrafiltration of BSA," *IIChE CHEMCON 2000*, vol. I, pp. NSP1-4 (2000), Calcutta, India, December 18-21, 2000.

Presentations:

Pryor, E., and **Ilias, S.,** "Flux enhancement in ultrafiltration of apple juice through flow modifications," 2003 AIChE Annual Meeting, November 16-21, 2003, San Francisco, California, Paper No. 73c, p. 111 (2003).

Ilias, S., and Pryor, E., "Flux Enhancement through Flow Modifications: A Study on Ultrafiltration of Apple Juice," Proc, 13th Symposium on separation Science and Technology for Energy Applications, Oct 27-30, 2003, Gatlinburg, Tennessee, Abstract. P. 63 (2003).

Pryor, E., and **Ilias, S.,** "Clarification of Apple Juice Utilizing a Flow Reversal Ultrafiltration Technique," 14th Annual Meeting of the North American Membrane Society (NAMS), Paper No. 401, May 17-21, 2003, Jackson Hole, Wyoming.

Parthasarathy, H., and Ilias, S., "Effect of Flow Reversal on Permeate Flux in Crossflow Membrane Filtration," MRS 2002 Fall Meeting, Paper No. AA15.5, Boston, Massachusetts, December 2-6, 2002.

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M.S. Thesis:

Harikrishnan Parthasarathy (2002): Evaluation of Optimal Flow Reversal Time in Crossflow Membrane Filtration of BSA and Dextran T-70, North Carolina A&T State University.

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