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FOUR MEMBRANE CLEANING PROFILES WITH MICRO-90[®] ALKALINE CLEANING SOLUTION, MICRO[®] GREEN CLEAN BIODEGRADABLE CLEANER AND MICRO[®] A07 CITRIC ACID CLEANER

Jennifer Sun, Ph.D. – Research Scientist

jsun@ipcol.com

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SUMMARY

Fouling and cleaning profiles of four types of filter membranes were obtained using MICRO-90[®], MICRO[®] GREEN CLEAN and/or MICRO[®] A07. Simulated fouling processes were performed by using either a synthetic oil emulsion or a combination of the synthetic oil emulsion and a calcium acetate salt bridge mixture. Excellent recovery of permeate flux was obtained with the lowest to be 96.0%. The results prove that MICRO-90[®], MICRO[®] GREEN CLEAN and MICRO[®] A07 are effective at cleaning these types of membranes.

In all four trials, some delamination of the membranes occurred around their perimeters, probably due to the seeding of the membranes in the filtration unit.

Some flux variation occurred during the trials because the optimal pressure of each membrane was controlled manually. This can be seen in instances where the flux rate exceeds 100%.

PURPOSE

To evaluate the cleaning efficiency of MICRO-90[®], MICRO[®] GREEN CLEAN and MICRO[®] A07 on four GE flat sheet membranes in the GE Osmonics SEPA CF II filtration unit. The four membranes include a Cellulosic NF polymer, a proprietary thin film, a polyethersulfone, and an Ultrafillic UF membrane.

INTRODUCTION

Simulated cleaning profiles are valued by potential customers as providing assurance that candidate cleaners will perform as anticipated in their filtration processes. Laboratory-based performance data, along with technical support and sufficient samples for on-site cleaning trials, ensure a quick and successful transition to a more effective cleaning regimen.

In this project, a GE Osmonics SEPA CF II filtration unit was used for the simulated fouling-cleaning experiments on four types of filter membranes using MICRO-90[®], MICRO[®] GREEN CLEAN and/or MICRO[®] A07 as the cleaners. Because of the pH constraints of the Cellulosic NF and the Ultrafillic membranes, only MICRO[®] A07 was evaluated in these trials.

Properties of the four GE membrane polymers are listed in Table 1 below.

TABLE 1 – PROPERTIES OF GE MEMBRANES EVALUATED

POLYMER	GE PART #	MWCO (Daltons)	MAX PRESSURE (Bar)	pH Range	CLEANER(S)
Cellulosic NF	1156755	2,000	15	2 – 8	MICRO A07
Thin Film	3002314	1,000	40	1 – 11	MICRO-90, MICRO GREEN CLEAN& MICRO A07
PES / PS	1221929	10,000	10	1 – 11	MICRO-90, MICRO GREEN CLEAN& MICRO A07
Ultrafillic	1221962	50,000 proteins	7	2 – 9	MICRO A07

EXPERIMENTAL

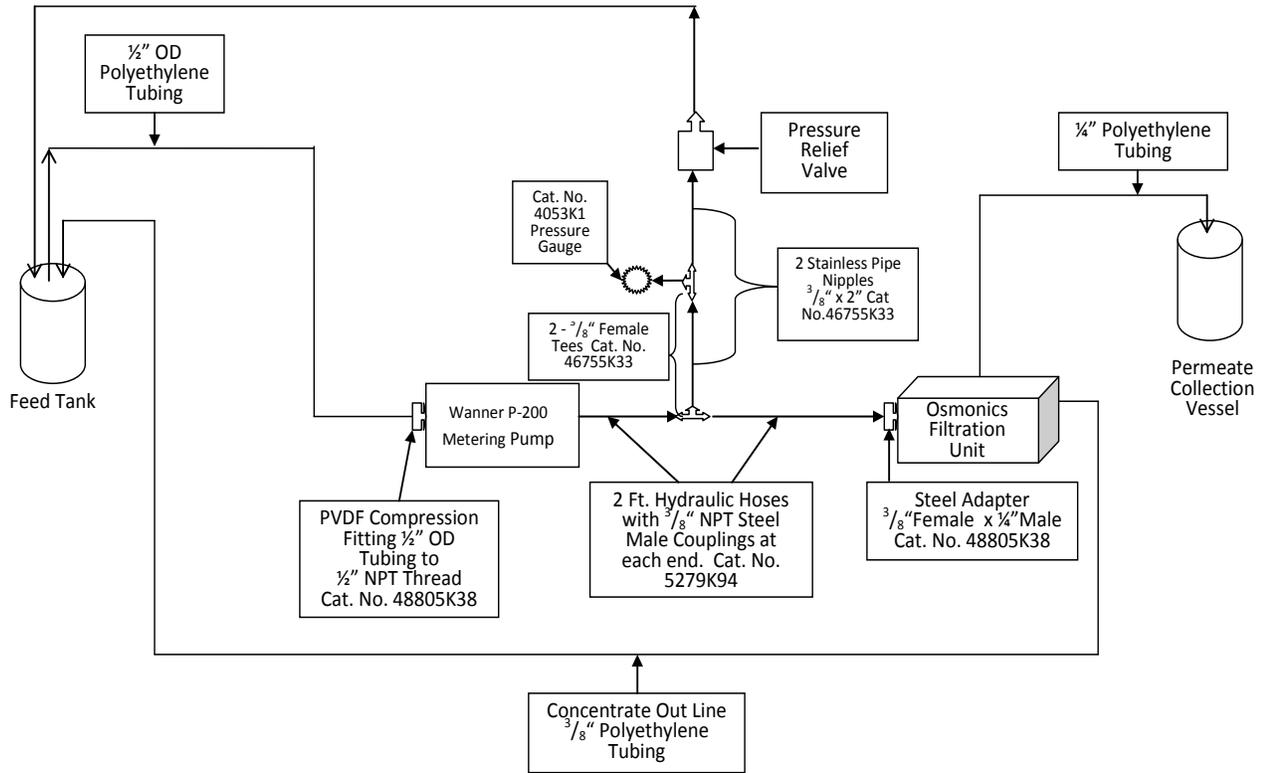
1. Materials and reagents

- a. GE Osmonics SEPA CF II filtration unit (GE Water & Process Technologies);
- b. Wanner Engineering Back Pressure Relief Valve (Wanner Engineering, Inc.; Part No. 111-706);
- c. Power Team SPX Hydraulic Hand Pump (SPX Corporation, Model A, 1000 psi);
- d. Wanner Engineering Hydra-Cell P200 Metering Pump (Wanner Engineering, Inc.);
- e. SEPA CF TF (Thin Film) NF membrane (GE's Water & Process Technologies, Part No. 3002314);
- f. SEPA PES UF membrane (GE's Water & Process Technologies, Type: PW, Part No. 1221929);
- g. SEPA CF Ultrafillic UF membrane (GE's Water & Process Technologies, Type: MW, Part No. 1221962);
- h. SEPA TF (Thin Film) NF membrane (GE's Water & Process Technologies, Type: CK, part No.1156755);
- i. Synthetic oil emulsion: P-80[®] Rubber Lubricant Emulsion (International Products Corp., Lot#130808);
- j. MICRO-90[®] Concentrated Cleaning Solution (International Products Corp., Lot# 140303);
- k. MICRO[®] A07 Citric Acid Cleaner (International Products Corp., Lot# 130205);
- l. MICRO[®] GREEN CLEAN (International Products Corp., Lot# 130326);
- m. Anhydrous calcium acetate (Lot# J18Q096, Alfa Aesar - a Johnson Matthey Company);
- n. Graduated cylinders (100 mL and 10 mL);
- o. Distilled water (Eagles peak Spring Water, Inc.);

2. Set-up

- a. Set-up of the GE Osmonics SEPA CF II filtration unit system is shown in Figure 1.

Schematic 1



Catalog numbers coincide with McMaster-Carr Catalog 114

Figure 1. Set-up of the GE Osmonics SEPA CF II filtration unit System (Cited from a report done by Al Gabbianelli, Chemist; International Products Corporation).



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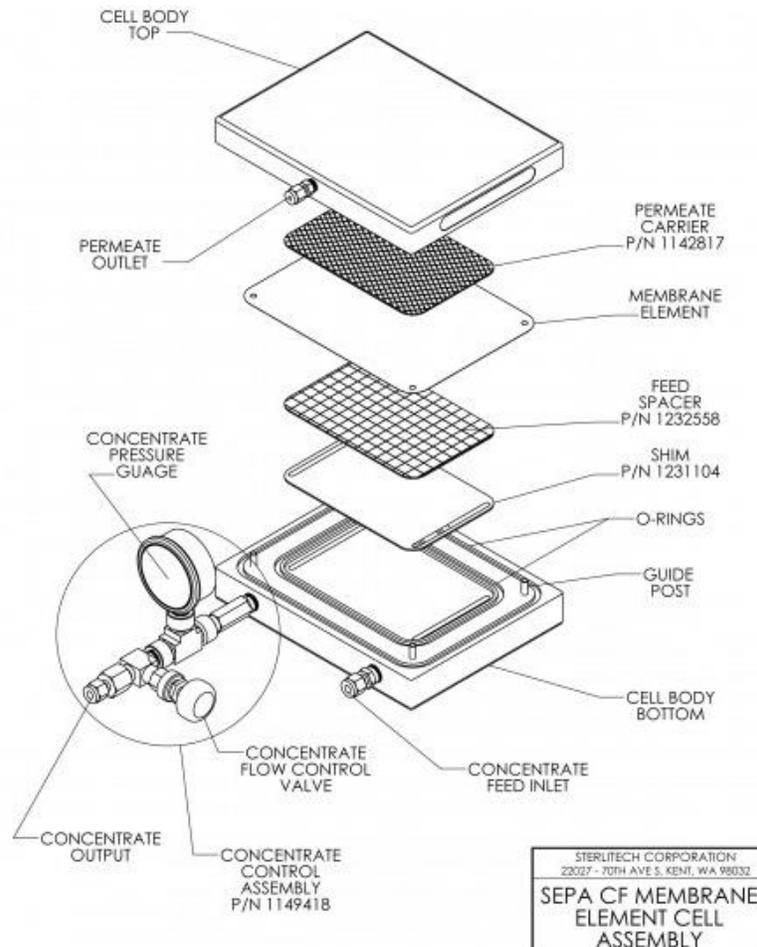


Figure 2. Detailed Assembly of the Filter Cell (cited from the INSTRUCTION MANUAL FOR STERLITECH SEPA CF CELL MEMBRANE ELEMENT CELL).

Within the filter cell is a 75 mil (2 mm) cavity. Two stainless steel shims of 5 mil and 2 mil were placed in the bottom half of the cell cavity. A 65 mil foulant spacer was placed on top of the two steel shims. The filter membrane with its shiny side downwards was placed over the high foulant spacer by using the four guide posts protruding from the bottom half of the cell for proper positioning. A permeate carrier was then placed on the top half and then rinsed with distilled water. The top half of the cell was mounted to the bottom half using the guide posts for proper alignment. The designated pressure for each respective membrane was obtained using the hydraulic hand pump. The pressure seals the filtration cell and holds it in place.

The hydraulic pressure and concentrate pressure used for different membranes are summarized in Table 2 as well as the foulant type and fouling time. The recommended pressure ranges of each membrane were followed. The foulant types and the fouling time were selected on the basis of the needed degree of fouling.



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TABLE 2 - OPERATION CONDITIONS FOR DIFFERENT TYPES OF MEMBRANES

Membrane	Hydraulic pressure (psi)	Concentrate pressure (psi)	Foulant	Fouling time (min.)
Thin Film	200	100	4000 ppm P-80®+10 mM Calcium acetate in 1 liter distilled	10
PES	200	40	10 ppm P-80 in 1 liter distilled water	5
Ultrafillic	200	40	4000 ppm P-80+10 mM Calcium acetate in 1 liter distilled water	15
Cellulosic NF	200	100	750 ppm P-80 in 1 liter distilled water	30

The foulants and fouling time varied according to the different membranes. The general procedure for all the tests was:

1. Circulate with 2 liters distilled water for 15 min to remove any preservatives.
2. Record the filling time to a pre-established volume (used for calculating J_0).
3. Foul and record the filling time.
4. Rinse with 12 liters of distilled water and record the filling time.
 5. Clean with 2% of MICRO-90®, MICRO® GREEN CLEAN and/or MICRO® A07 (40 grams of a cleaner in 2 liter of distilled water)*.
6. Rinse with 16 liters of distilled water and record the filling time.

*Repeated this whole process if three cleaners were used. The Cellulosic NF and Ultrafillic membranes were only cleaned with MICRO® A07 because of their narrower pH range. (MICRO-90® and MICRO® GREEN CLEAN have a maximum pH value of 9.9 and 10.0, respectively.)

RESULTS AND DISCUSSION

The flux of a membrane was calculated using the following equations:

$$\text{Flow (ml/min)} = \text{Permeate volume in mL} / (\text{Drain time in seconds} / 60 \text{ seconds} / \text{min})$$

$$\text{Flux (Gallons/Ft}^2\text{/Day)} = \text{Flow (ml / min)} \times 1440 (\text{Minutes} / \text{Day}) / 0.1514 \text{ Ft}^2 \text{ Filtration Area}^* / 3785 (\text{ml/Gallon})$$

Recovery of flux (J/J_0)*100 = the ratio of a flux after a treatment to the original flux

*The effective filtration area of the GE Osmonics SEPA CF II unit is 5.71" x 3.82" or 0.1514 ft².



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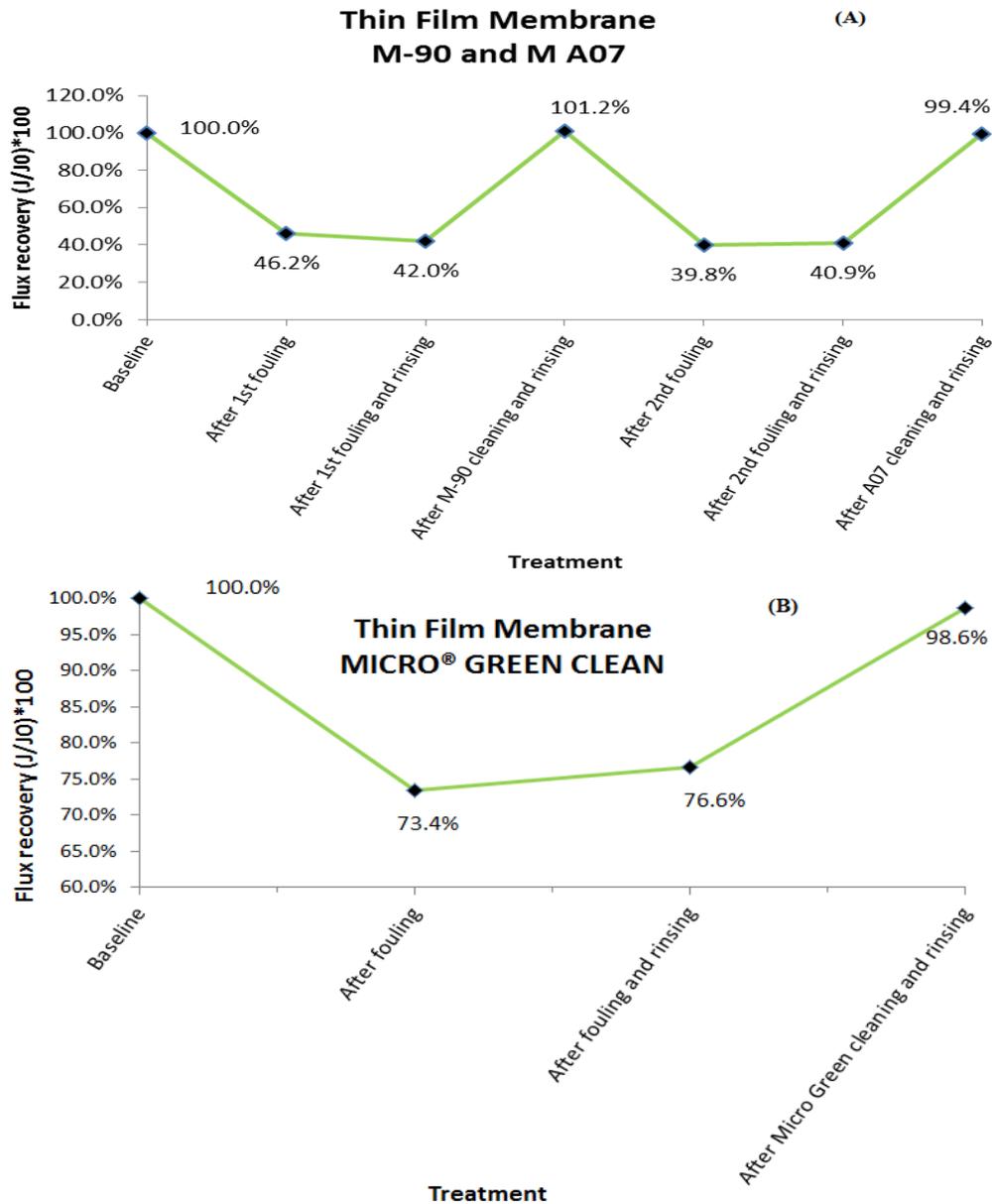


Figure 3. Fouling and cleaning profile of SEPA CF TF (Thin Film) NF membrane with all three cleaners. A: MICRO-90® and MICRO® A07; B: MICRO® GREEN CLEAN

In Figure 3, a profile of the fouling and cleaning process of the proprietary thin film membrane is displayed. The synthetic oil emulsion and calcium acetate mixture was recirculated for ten minutes in order to sufficiently foul the membrane. Since this membrane tolerates pH values between 1 to 11, MICRO-90® (pH 9.6), MICRO® GREEN CLEAN (pH 9.8) and MICRO® A07 (pH 3.0) were evaluated. All three cleaners restored the flux rate to baseline.



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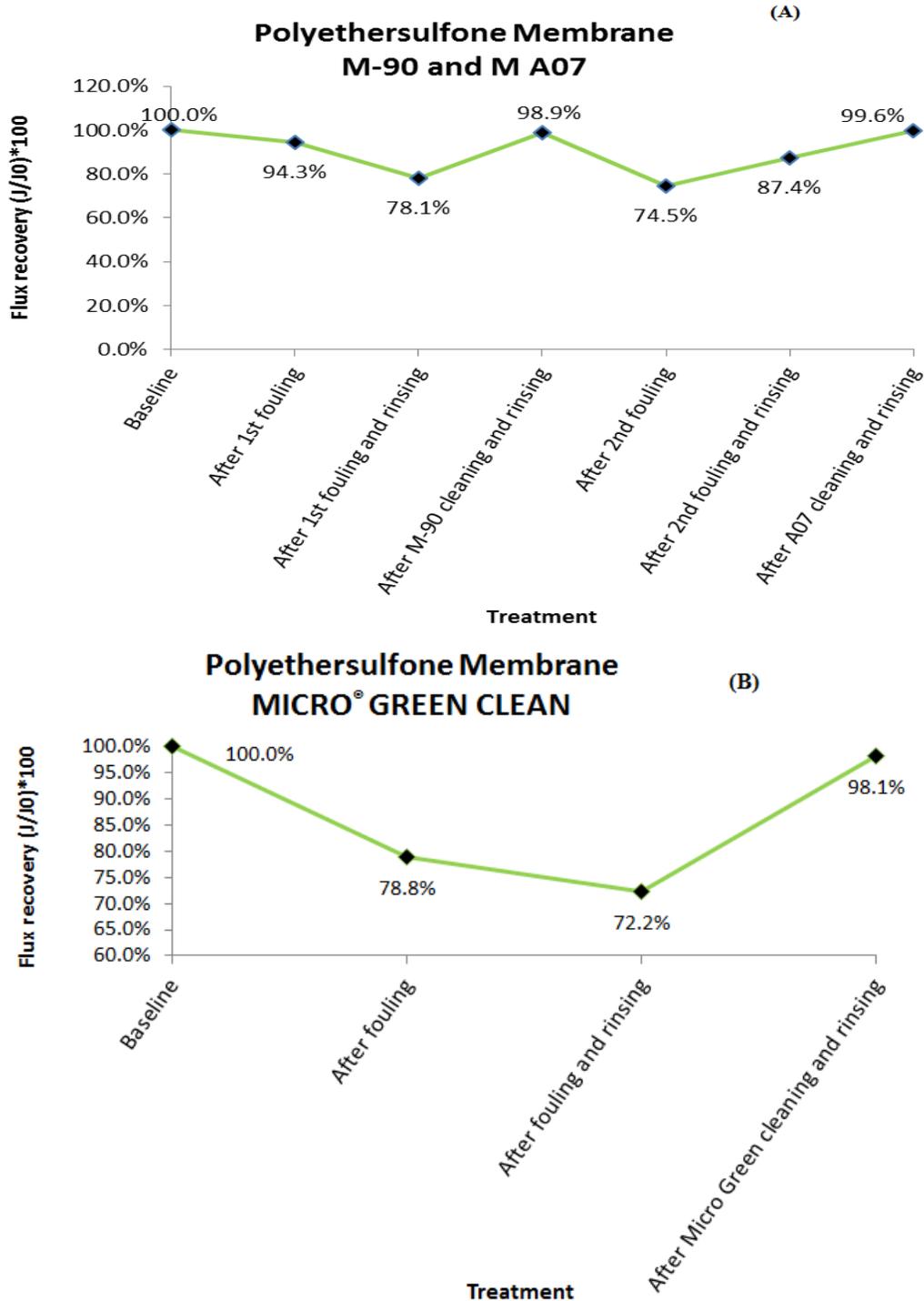


Figure 4. Fouling and cleaning profile of SEPA PES UF membrane with all three cleaners.
A: MICRO-90[®] and MICRO[®] A07; B: MICRO[®] GREEN CLEAN



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The PES membrane was easily fouled after 5 minutes of recirculating a 10 ppm concentration of the synthetic oil emulsion in distilled water. This quick fouling is likely a result of the larger pore size (MWCO dextran: 10 K) absorbing and subsequently trapping the emulsified oil. However, all three cleaners (MICRO-90[®], MICRO[®] GREEN CLEAN and MICRO[®] A07) were effective at cleaning the emulsified oil from the PES membrane. MICRO-90[®], MICRO[®] GREEN CLEAN and MICRO[®] A07 returned 98.9%, 98.1% and 99.6% flux recoveries, respectively.



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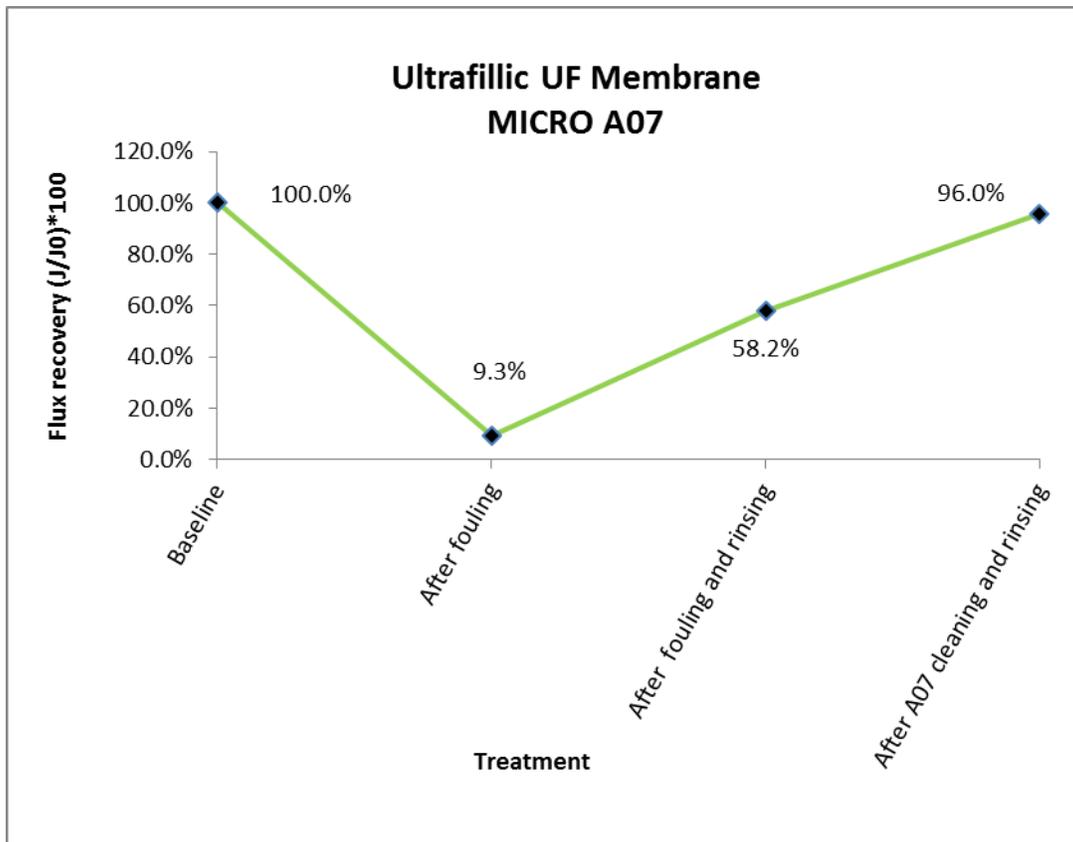


Figure 5. Fouling and cleaning profile of SEPA CF Ultrafillic UF.

The large pore size (MWCO: 50 K protein) of the Ultrafillic membrane required 15 minutes of recirculation in order for the synthetic oil emulsion and calcium acetate mixture to foul it. Because this membrane cannot tolerate pH values above 9.0, MICRO[®] A07 was the only cleaner used. MICRO[®] A07 achieved a flux recovery of 96.0%, which is significant given the low flux after fouling was 9.3%.



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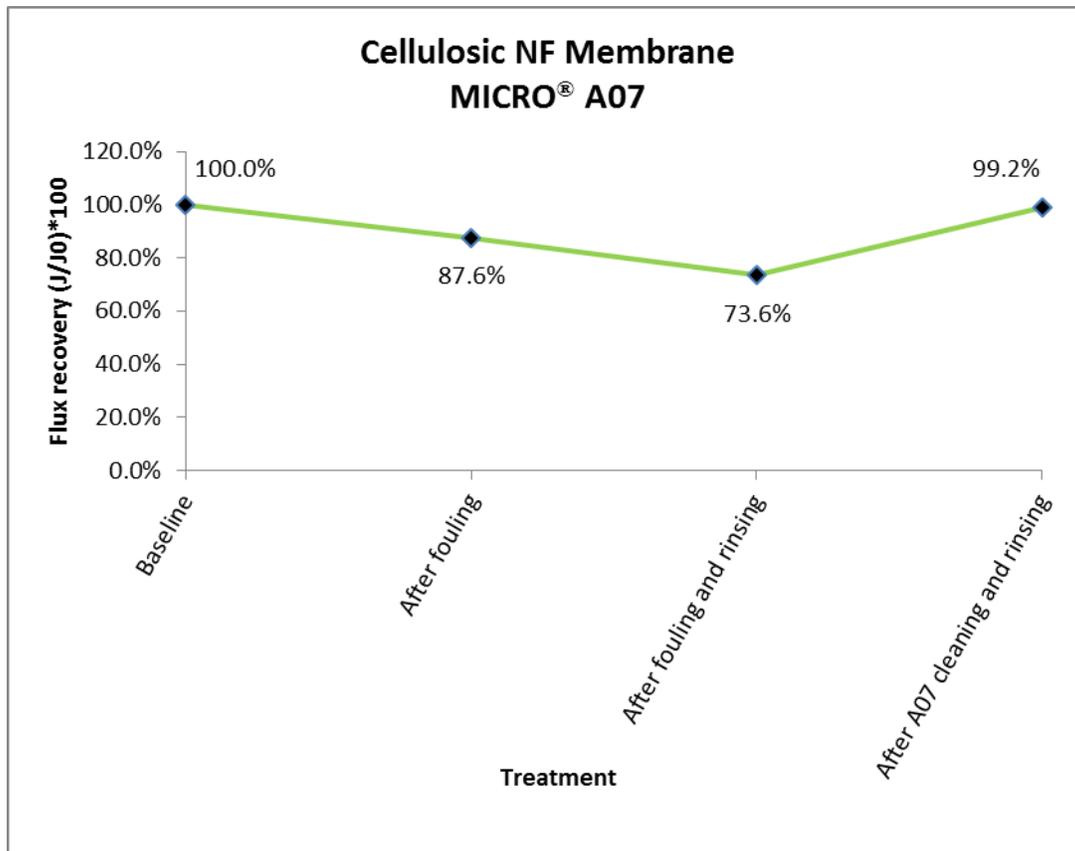


Figure 6. Fouling and cleaning profile of SEPA TF (Cellulosic NF) NF membrane.

The Cellulosic NF membrane required 30 minutes of recirculating the synthetic oil emulsion at 750 ppm in order to sufficiently foul it. The difficulty to foul this membrane may be related to its nano-sized pores; the particle size of the synthetic oil emulsion was too large to be entrapped in the pores. The subsequent cleaning and rinsing with MICRO® A07 proved effective to restore the flux back to 99.2% of the original.



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Global Headquarters *(An ISO Certified Company)*

201 Connecticut Drive, Burlington New Jersey 08016 USA Website: www.ipcol.com

Tel: 609-386-8770 Fax: 609-386-8438 Email: mkt@ipcol.com

For Sales in Europe:

Unit 5, Green Lane Business Park, 238 Green Lane London SE9 3TL U.K.

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Surface-Cleanse/930[®] Neutral Cleaner
Zymit[®] Low-Foam Mild pH Enzymatic Cleaner
Zymit[®] Pro Mild pH Enzymatic Cleaner

P-80[®] Temporary Rubber Lubricating Agents

P-80[®] Emulsion
P-80[®] Emulsion IFC for Incidental Food Contact
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