

EFFECTS OF ANTIFOAM WITH INVERTED CLOUD POINT ON PERMEATION AND SOLUTE REJECTION IN MEMBRANE FILTRATION PROCESS

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Key Words: Membrane Separation, Biochemical Engineering, Crossflow Filtration, Non-ionic Surfactant, Antifoam, Fouling

Antifoams are usually used in many aerobic fermentations to suppress foaming. But certain antifoams decrease oxygen transfer rate drastically and/or foul membranes during downstream processing. Recently, the antifoam effects on ultrafiltration were investigated.¹⁻³⁾ However, few studies of rejection of antifoam by the membrane or of the effect of antifoam on the rejection property of the membrane have been reported.

In this work, the antifoam effects on membrane filtration were investigated in the light of flux reduction and rejection of antifoam firstly, using antifoam with inverted cloud point and with a ceramic or synthetic

membrane. The effect of antifoam fouling layer on solute rejection of the membrane was then investigated.

1. Experimental

1.1 Antifoam and membrane

The antifoam used was a non-ionic surface-active agent (polyoxyethylene alkylether, DISFOAM CE-1 20R, Nippon Oil & Fats Co., Ltd.). The inverted cloud point of the antifoam is about 293 K in 1% aqueous solution.

Membranes used were a porous ceramic filter (module: Dynaceram DC-0005, TDK Corp.) and commercial synthetic polysulfone membrane (nominal cutoff molecular weight 50,000; module: crossflow

* Received February 22, 1989. Correspondence concerning this article should be addressed to K. Yamagiwa.

type with thin channel $33.8 \text{ mm}^W \times 0.8 \text{ mm}^H$, effective membrane area 60 cm^2).

1.2 Apparatus

The experimental apparatus used was almost the same as that used in the previous works.^{4,5} Temperature was controlled within $\pm 0.5 \text{ K}$ of set value by a precise temperature controller. Both permeate and concentrate were returned to the feed tank to keep the concentration of the antifoam constant. Concentrations of the antifoam and solutes were kept constant $0.500 \text{ kg} \cdot \text{m}^{-3}$ and $0.100 \text{ kg} \cdot \text{m}^{-3}$, respectively. Pressure was kept at 98 kPa .

1.3 Procedure

Flux and observed rejection of the antifoam were measured firstly. The solution was then replaced with pure water and solute rejection of the antifoam-fouled membrane was tested. Solutes used were glucose, polyethylene glycols and dextrans of various molecular weights. Solute rejection was evaluated by observed rejection. Concentration of antifoam was measured by turbidimetry. Solute concentration was determined by GPC analysis (Shimadzu, LC-6A, column: Shim-pack Diol 150, detector RI).

2. Results and Discussion

2.1 Crossflow filtration of antifoam

1) Synthetic UF membrane Figure 1 shows the changes of flux J_V and observed rejection R_{obs} with time during the filtration of antifoam with the synthetic UF membranes. Fluxes decreased rapidly and then slowly. Flux reached constant value at a temperature below the cloud point. But at 303 K , flux decreased gradually during the filtration and did not reach steady state. Flux at 323 K was decreased to almost zero.³⁾ Even at temperatures below the cloud point, flux reduction was as much as 65%.

The antifoam was rejected almost completely at temperatures above the cloud point ($R_{\text{obs}} > 0.99$), while a rejection of only 0.7 was obtained below the cloud point.

2) Ceramic filter Figure 2 shows the changes of J_V and R_{obs} with time during the filtration of antifoam with the ceramic filter. Fluxes reached constant value within the first 30 minutes for all temperatures tested. This flux change with time was quite different from the results obtained with the polysulfone membrane. The flux reductions were as low as about 10% for all the temperatures tested.

The effect of temperature on rejection of the antifoam by the ceramic filter was similar to that observed with the synthetic membrane. Observed rejection below the cloud point was only 0.5. These results indicated that the hydrophilic ceramic filter was more suitable for concentrations of the antifoam above the cloud point than was the hydrophobic polysulfone membrane, since the former gave a larger

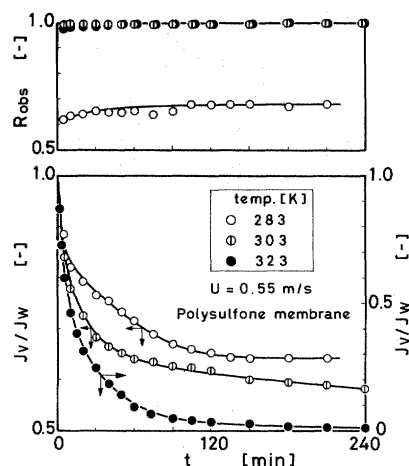


Fig. 1. Crossflow filtration of antifoam by synthetic polysulfone membrane

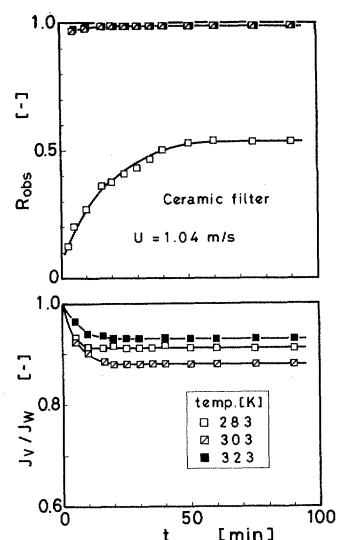


Fig. 2. Crossflow filtration of antifoam by porous ceramic filter

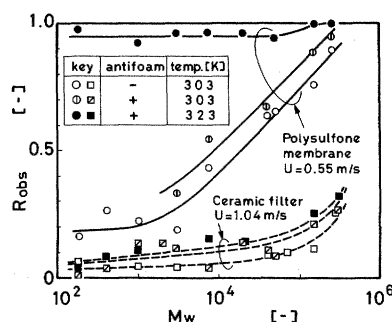


Fig. 3. Effect of antifoam-fouling layer on solute rejection of membrane

—; clean membrane, +; antifoam-fouled membrane used in the filtration experiments with antifoam ($C_A = 0.5 \text{ kg} \cdot \text{m}^{-3}$).

flux.

2.2 Effect of antifoam fouling layer on rejection property of membrane

Figure 3 shows solute rejections of the membranes with and without the antifoam-deposit layer at

temperatures above the cloud point. In the figure, open keys (\circ , \square) denote non-fouled clean membranes and the other keys denote antifoam-fouled membranes which used in the crossflow filtration of the antifoam in the above section. The rejection property of the antifoam-fouled ceramic filter was almost the same as that without the fouling layer. The effect of the antifoam deposit layer on the rejection property inherent to the membrane was more pronounced in the case of the synthetic polysulfone membrane. The rejection curve of the antifoam-fouled UF membrane shifted to the lower-molecular weight side compared to that of the clean membrane. And a drastic change in rejection was observed with the synthetic UF membrane at 323 K. All the solutes tested were rejected almost completely ($R_{\text{obs}} > 0.9$) by the antifoam-fouled UF membrane.

It was found that the separation properties of the antifoam and the effect of antifoam on solute rejection depended largely on temperature (above or below inverted cloud point) and on the membrane material (hydrophilic or hydrophobic).

Nomenclature

C_A	= concentration of antifoam	$[\text{kg} \cdot \text{m}^{-3}]$
J_V	= volume flux	$[\text{m} \cdot \text{s}^{-1}]$
J_W	= flux of pure water	$[\text{m} \cdot \text{s}^{-1}]$
M_W	= molecular weight	$[-]$
R_{obs}	= observed rejection	$[-]$
t	= time	$[\text{s}]$
U	= liquid linear velocity in module	$[\text{m} \cdot \text{s}^{-1}]$

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