THE EFFECTS OF AIR SPARGING ON ULTRAFILTRATION OF WHEY

TAN CHING SOON

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Abstract

This work concerns the use of gas-liquid two-phase flow to reduce whey proteins and particle membrane fouling in hollow fibre dialyzer by injecting air directly into the whey feed stream. The effects of air bubbles on the permeate flux of the air sparged ultrafiltration system were studied experimentally. In comparison to single phase flow, over the range of operating conditions studied, the gas-liquid two-phase flow increases the ultrafiltration flux by 15% to 87%. The highest gas injection ratio $F_{gas}/(F_{liq}+F_{gas})$ was found to be in the range of 0.4 to 0.5. Within this range, the bulk concentration of whey proteins increases to approximately 210% after 3 hours, in comparison to a value of less than 100% for the single phase operation. Dimensionless numbers were introduced and a correlation was suggested to model the flux enhancement.

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Symbols and Abbreviations

A	membrane area (m^2)
ABS	UV adsorption
BOD	biological oxygen demand (mg/L)
BSA	Bovine Serum Albumin
C	solute concentration (mg/L)
C_f	feed concentration (mg/L)
C_b	bulk concentration (mg/L)
C_w	concentration at membrane surface/wall (mg/L)
C_p	solute concentration of permeate (mg/L)
C_s	saturation concentration (mg/L)
C_g	gelation concentration (mg/L)
d_p	channel diameter (μm)
D	diffusivity of macromolecules (m^2s^{-1})
Da	Dalton
E	electrical field (V)
Eqn.	equation
F	force ($kgms^{-2}$)
F_{liq}	liquid flowrate (L/min)
F_{gas}	gas flowrate (L/min)
IgG	immunoglobulin G
J,	permeate flux (m/s or mL/m^2s)
$J_{obtained}$	permeate flux obtained in operation (m/s or mL/m^2s)
$J_{single\text{-}phase}$	permeate flux for single-phase operation (m/s or mL/m^2s)

J_w	flux of pure water (m/s or mL/m^2s)
k	mass transfer coefficient (m/s)
LPM	liter per minute (L/min)
MF	micro filtration
MW	molecular weight
MWCO	molecular weight cutoff
NF	nano filtration
OD	outer diameter (m)
PAGE	polyacrilamide gel electrophoresis
ppm	part per million
P_F	feed pressure (kg/ms^2)
P_p	permeate pressure (kg/ms^2)
P_T	applied transmembrane pressure (kg/ms^2)
Rf	hydraulic retention due to total fouling (m^{-1})
R_m	hydraulic retention due to membrane (m^{-1})
Re	Reynolds number (dimensionless)
RO	reverse osmosis
Sc	Schmidt number (dimensionless)
SDS	sodium dodecyl sulphate
Sh	Sherwood number (dimensionless)
t	time (s)
TEMED	N,N,N',N'- tetramethylethylenediamine.
TMP	transmembrane pressure (kg/ms^2)
T_{ob}	observed tranmission
UF	ultrafiltration

U_L	liquid velocity (m/s)
U_g	gas velocity (m/s)
V_p	volume of permeate (mL)
Z	net charge (C)
Π_F	difference in osmotic pressure in feed (kg/ms^2)
Π_p	difference in osmotic pressure in permeate (kg/ms^2)
μ	dynamic viscosity of liquid ($kgms^{-1}$ or $Ns./m^2$)
ε	porosity of membrane (m^2)
Δ	delta
δ_b	concentration boundary layer (m)
Υ	shear rate (s^{-1})