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APPLICATION OF SODIUM DEOXYCHOLATE FOR SEPARATION OF HEAVY METALS

A thesis presented in partial fulfilment of the requirements for the degree of
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ABSTRACT

Sodium deoxycholate (NaDC) and sodium taurodeoxycholate (NaTDC) have been used to bind and subsequently remove nickel, copper and zinc ions from aqueous streams by ultrafiltration.

The mixture of metal and NaDC solutions forms a precipitate of insoluble metal deoxycholate. This precipitate can be removed from the solution in most cases by conventional techniques such as filtration and centrifugation. Ultrafiltration membranes made of polyethersulphone can also retain the precipitate effectively, producing an environmentally accepted effluent. The exception is the high copper and NaDC mixture where none of the operations works at room temperature because of the gelatinous nature of copper deoxycholate.

The removal of metal ions by precipitating them as metal deoxycholate is affected by such parameters as equilibration time, surfactant-to-metal (S/M) ratio, feed concentration, temperature and pH. An equilibration time of 3 hours or greater is required to have a major part of precipitation completed. A S/M ratio of 2.5 is sufficient, except in the case of low nickel concentration when a higher S/M ratio is necessary. A higher temperature (e.g., $>40^{\circ}\text{C}$) does not significantly affect the metal removal, but increases the process flux markedly. The high copper and NaDC mixture can also be operated with reasonable flux at a higher temperature. The use of NaDC to precipitate metal ions is inappropriate below or above the neutral pH value because DCA starts to precipitate as the pH is lowered to around 6, and metal ions precipitate as metal hydroxide at a high pH.

Because different metal ions have a differential affinity for the deoxycholate ions, NaDC can potentially separate one metal from mixtures of metals. The separation of individual metals from copper/nickel mixture is good compared to poor separations for copper/zinc, zinc/nickel and copper/zinc/nickel mixtures. This is evident from the molar ratios of two metals of 1:67, 1:2.5 and 1:7 respectively in the respective permeates.

The mixture of metal and NaTDC solutions is homogeneous and metals are removed by micellar-enhanced ultrafiltration (MEUF). Since NaTDC is expensive and difficult to recover, its application may not be economically feasible.

Based on the present research, two NaDC-mediated processes are proposed: (1) a process for removing metal ions from single-metal systems, and (2) a process for separating copper/nickel mixtures.

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NOMENCLATURE

AA	atomic absorption
BOD	biochemical oxygen demand, mg/L
C_0	initial solute concentration in the sample, mg/L
C_p	solute concentrations in the permeate, mg/L
C_r	solute concentration in the retentate, mg/L
C_f	solute concentration in the feed, mg/L
C_G	solute concentration in the gel layer, mg/L
C_B	solute concentration in the bulk feed, mg/L
c_i	ionic concentration, M
cmc	critical micelle concentration, mM
CA	cellulose acetate
CIP	clean-in-place
COD	chemical oxygen demand, mg/L
CP	concentration polarization
CTAB	cetyltrimethylammonium bromide
D	diffusion coefficient, m^2/s
DCA	deoxycholic acid
EDTA	ethylenediaminetetra-acetic acid
EHPNA	2-ethylhexyl phosphonic acid mono-2-ethylhexyl ester
I	ionic strength, M
J_w	pure water flux, $L/m^2/h$
LM	ligand-modified
LIX 54	1,3-isodecanedione, 1-phenyl
LIX 63	5,8-diethyl-7-hydroxy-6-dodecanone oxime
LIX 64N	2-hydroxy-4-nonylbenzophenone oxime
LIX 84	1-(2-hydroxy-5-nonylphenyl)ethanone oxime
LIX 860	5-dodecyl-2-hydroxy-benzaldehyde oxime
MEUF	micellar-enhanced ultrafiltration
MWCO	molecular weight cut-off

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MF	microfiltration
NaC	sodium cholate
NaDC	sodium deoxycholate
NaTDC	sodium taurodeoxycholate
NF	nanofiltration
PONPE10	polyoxyethylene nonyl phenyl ether with 10 ethylene oxide units
PS	polysulphone
PEI	polyethylenimine
PES	polyethersulphone
PEG	polyethylene glycol
P_T	applied transmembrane pressure, kPa
R	solute rejection coefficient
RC	regenerated cellulose
RO	reverse osmosis
R_M	intrinsic membrane resistance, kPa/LMH
R_G	resistance due to concentration polarization, kPa/LMH
R_F	resistance due to fouling, kPa/LMH
SDS	sodium dodecyl sulphate
S/M	surfactant-to-metal ratio
TCA	taurocholic acid
TDCA	taurodeoxycholic acid
UF	ultrafiltration
V_0	initial volume, L
V_p	permeate volume, L
V_r	retentate volume, L
V_f	feed volume, L
z_i	valency of the ion
ρ	density, kg/m ³
μ	viscosity, cP
α	separation factor