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ORIGINAL

Mass transfer characteristics of a flow-by fixed bed electrochemical reactor composed of vertical stack stainless steel screens cathode

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Abstract

Mass transport properties of a flow-by fixed bed electrochemical reactor composed of a vertical stack of stainless steel nets operated at a batch-recycle mode were characterized using cathodic deposition of copper as a test reaction. The electrochemical reactor was operated at constant potential in which reduction of copper happened under mass transport control. This potential was selected from the application of hydrodynamic voltammetry using a borate/chloride solution as supporting electrolyte on stainless steel rotating disc electrode. A linear relationship was observed between the flow rate and the mass transfer coefficient. The electrochemical reactor was efficient in removing copper and able to reduce the levels of this metal to lower than 0.4 ppm starting from an initial concentration of 49.7 ppm at 80 min using a ratio of cathode volume/catholyte volume equal to 0.0075. A mathematical correlation between the Sherwood number and Reynolds number were obtained which characterized the mass transport properties of the reactor as follows: $Sh = 0.2254Re^{0.4228}Sc^{1/3.}$

Nomenclature

a	Specific surface area cm^2 cm^{-3}
A	Cross sectional area of electrode cm^2
b	Power of Reynolds Number in Eq. 10 –
B	Opening size of screen cm
C(0)	Initial Concentration at time = 0 $mol.cm^{-3}$ or ppm
C(t)	Concentration at time = t $mol.cm^{-3}$ or ppm
C_b	Bulk concentration $mol.cm^{-3}$ or ppm
d	Diameter of wire screen cm
D	Diffusivity cm^2 s^{-1}
E	Cell potential mV
E_{max}	Maximum electrode potential mV
E_{min}	Minimum electrode potential mV
F	Faraday number(96500) C $mo1^{-1}$
i	Current density mA cm^{-2}
i_{lm}	Limiting current density mA cm^{-2}
I_L	Limiting current mA
j_D	Chilton-Colburn j-factor –
k_m	Mass transfer coefficient cm s^{-1}
L	Length of electrode cm
L_i	Length of wire segment in Eq. (3-c) cm
m	Constant in Eqs. 10 and 11 –
N	Mesh size number Wire/in.
n	Power of Reynolds Number in Eq. 11 –
Q	Volumetric Flow rate cm^3 s^{-1} or dm^3 h^{-1}
t	Time s
u	Flow velocity of solution m s^{-1}
V_r	Volume of reservoir cm^3
w	Thickness of electrode cm
z	Number of electrons –

Dimensionless numbers

Re	Reynolds number ($Re = ud/\varepsilon\nu$) –
Sh	Sherwood number dimensionless($Sh = k_m d/D$) –
Sc	Schmidt number dimensionless($Sc = \mu/\rho D$) –
X	Geometric dimensionless parameter –

Greek symbols

ρ	Fluid density g cm^{-3}
μ	Viscosity of fluid g m^{-1} s^{-1}
ν	Kinematic viscosity of fluid cm^2 s^{-1}
ε	Void fraction or porosity –
ω	Rotation velocity rad s^{-1}

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