DEVELOPMENT OF A PROBE FOR MEASURING HYDROGEN CONCENTRATION IN THE PRESENCE OF MOIST CHLORINE

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ABSTRACT

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The presence of hydrogen gas as an impurity in chlorine gas and caustic soda generated by electrolysis of an aqueous sodium chloride solution in a Chlor-alkali plant leads to lowering plant efficiency and it can be hazardous if the hydrogen concentration exceeds 6 %. The development of an instrument for monitoring hydrogen concentration in moist chlorine gas at various locations of the Chlor-alkali plant has been performed at the Centre for Nuclear Energy Research (CNER). A series of hydrogen and chlorine permeability coefficient experiments was carried out using a test cell to identify effective coating materials for blocking chlorine, but at the same time, allowing the passage of hydrogen . It was found that Fluorodyn Caulk and Derakane Resin are the promising candidates as coating materials for blocking such chlorine.

บทคัดย่อ

นางสาวพรรณี กิจเจริญวงศ์: การพัฒนาเครื่องมือสำหรับวัดความเข้มข้นของก๊าซไฮโดรเจนในก๊าซคลอรีนชื้น (Development of a Probe for Measuring Hydrogen Concentration in the Presence of Moist Chlorine.) อ. ที่ปรึกษา : ศ. ดร. แฟรงค์ สจ็วต และ ผศ.ดร. ธีรศักดิ์ ฤกษ์สมบูรณ์ 105 หน้า ISBN 974-334-145-5

ก๊าซไฮโดรเจนเป็นสิ่งเจือปนในก๊าซคลอรีนและโซเดียมไฮดรอกไซด์ที่เกิดจากปฏิกิริยาอิเล็กโตรไลซิสของสารละลายเกลือหรือโซเดียมคลอไรด์ในโรงงานคลออัลคาไลน์ซึ่งทำให้ประสิทธิภาพการผลิตลดต่ำลง นอกจากนี้ยังเป็นอันตรายเมื่อความเข้มข้นของก๊าซไฮโดรเจนเกิน 6 % ซึ่งเป็นส่วนที่ก๊าซไฮโดรเจนระเบิดได้ ดังนั้นจึงได้มีการพัฒนาเครื่องมือเพื่อทำการวัดความเข้มข้นของก๊าซไฮโดรเจนในก๊าซคลอรีนชื้นที่ตำแหน่งต่างๆของโรงงานคลออัลคาไลน์ โดยได้ทำการทดลองและวัดค่าสัมประสิทธิ์ในการแพร่ผ่านวัสดุต่างๆของก๊าซไฮโดรเจนและก๊าซคลอรีนโดยการใช้เทสต์เซลเพื่อที่จะหาวัสดุที่มีประสิทธิภาพในการป้องกันไม่ให้ก๊าซคลอรีนแพร่ผ่านไปได้ แต่ในขณะเดียวกันสามารถให้ก๊าซไฮโดรเจนแพร่ผ่านไปได้ จากการทดลอง พบว่าฟลูโอโรดินคอล์ค (Fluorodyn Caulk) และ เดราเคน เรซิน (Derakane Resin) เป็นวัสดุที่มีประสิทธิภาพในการป้องกันไม่ให้ก๊าซคลอรีนแพร่ผ่านไปได้

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LIST OF SYMBOLS

a	Anolyte
A	Area of the electrode (cm^2)
$a_{Fe}2+$	Acitivity of Fe^{2+} ion
$a_{Fe}3+$	Acitivity of Fe^{3+} ion
a_{H3O+}	Acitivity of H_3O^+ ion
b	Affinity constant [cm^3 (STP) /cm^3]
B/T	Breakthrough time
c	Catholyte
C_i	Concentration of H_2 in the collection gas at time t_i, (ppm)
C_i, C_o	Concentration of the reacting substance remote from the electrode and immediately adjoining its surface, respectively.
C_{OH}	Catholyte caustic concentration (g/L)
c_S'	Langmuir capacity constant[cm^3 (STP) /cm^3]
$C_z(y)$	Concentration in grams per liter of z in medium y
d	Depleted brine
D_0,P_0, S_0	The constants , cm^2/s , [cm^3(STP) .cm]/ (cm^2.s.cmHg) , and [cm^3(STP)] /cm^3.cmHg) ,respectively.
D_{app}	Apparent diffusivity
D_i	Diffusion coefficient of species i
E	Cell potential E which is the difference of two half cell electrode potentials at interface I and II.

E_0	A constant which is determined by calibration of the sensor with pure hydrogen gas at 1 atm.
E_b	Intramolecular activation energy
E_D	Activation energy for diffusion, cal/(gmol)
E_I	Half cell electrode potential at interface i
E_i	Intermolecular activation energy
E_I^0	Standard electrode potential
E_{II}	Half cell electrode potential at interface II
E_{II}^0	Standard electrode potential for Fe^{3+}/Fe^{2+} redox reaction
E_P	Activation energy for permeation, cal/(gmol)
F	Faraday constant (= 96,487 C/mol)
f	Feed brine
I	the current(A)
I_L	Limiting current(A)
J	The flux of species ($mol.sec^{-1}.cm^{-2}$)
k	a constant
k_g	a constant at a given temperature.($k_g = kK_g^{1/2}$)
$K_g(T)$	The equilibrium constant between hydrogen molecule in bulk gas and H-atom in Palladium
L	Specimen thickness
p	Feed brine flow rate (L/s)
P	Membrane permeability coefficient
p_{H2}	Partial pressure of hydrogen in the contacting gas.
P_{H2} , P_{H2O}	Ratio of hydrogen partial pressure or water vapor pressure to the standard atmospheric pressure,respectively.

$P_i(t_i)$	Permeation rate at any time t_i , (cm^3 H_2 cm^{-2} min^{-1})
q	Depleted brine flow rate (L/s)
Q	Total amount of permeate passing through the polymer from t=0 to t=t [cm^3 (STP) /cm^2]
R	Gas constant
$R(T,x_H = 0)$	Resistance of the pure palladium wire
$R(T,x_H)$	Resistance of a palladium wire containing hydrogen at temperature T
S'	Henry's Law sorption coefficient
S	Segment length
T	Absolute temperature (K)
x_H	Mole fraction of hydrogen atom in palladium
Z	The number of electrons per mol
η_{NaOH}	Caustic efficiency for membrane cells
η_{Cl2}	Chlorine efficiency for membrane cells
δ	Thickness of the diffusion layer
θ	Diffusion time lag
ε	Porosity
$\rho(x_H)$	Ratio of the resistance $R(T,x_H)$ of a palladium wire containing hydrogen at temperature T , to the resistance of the pure palladium wire $R(T,x_H = 0)$
σ_c	Average diameter of the high polymer molecule
α_{ij}	Selectivity which is the ratio of the permeability coefficient of component i and component j
σ_p	Penetrant molecule diameter