Exercise no. 1. **Building: A2, room 110**

Environmental protection in chemical technology - laboratory

HYBRID SYSTEMS IN REMOVAL OF HARMFUL IONS FROM AQUEOUS SYSTEMS

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Introduction

Currently, water sources polluted with metallic and metalloid ions cause serious environmental problems. Some water contaminating species include chromium, mercury, copper, nikel, cadium and arsenic. Chromium ions in the water present different oxidation states, e. g. the trivalent chromium Cr(III) and hexavalent chromium Cr (VI). Cr(VI) is the more toxic ionic species and causes serious health problems such as cancer. This toxicity depends on the concentration and exposure period. The Word Health Organization (WHO) recommends a maximum concentration limit of 0.05 mg/L for Cr (VI) or Cr(III) [1].

Donnan dialysis is a membrane-based equilibrium process and is different from the classical dialysis technique [2]. In this process an ion-exchange membrane separates two solutions: the feeding solution (that contains ions that should be removed) and the receiving solution (containing the electrolyte with a relatively high concentration). The difference of chemical potentials of the components present on opposite sides of the membrane results in the counter-ion flux from the receiver to the feed, and arising electrical potential evokes the transport of counter-ions in the opposite direction: from the feed to the receiver. The process of ion exchange between solutions lasts until the so called Donnan equilibrium is obtained that can be described by the following equation[3]:

$$\left(\frac{c_{i_r}}{c_{i_f}}\right)^{\frac{1}{z_i}} = K$$

where *cir*, *cif* are activities of the *i*-ion, respectively, in the receiver and in the feed; *zi* stands for the ionic valence, and *K* is constant for all counterions.

Donnan dialysis with the anion-exchange membrane offers the biggest application potential. This process is used mainly for the removal of troublesome anions from drinking water. Although Donnan dialysis has slow kinetics compared to electrodialysis, it has some advantages, i.e. economical, energy saving and need simple technology, etc.

Interpolymer anion-exchange membrane which is used in this exercise is a system of:

polyetylene// poly(styrene-co-divinylobenzene)

with the chemically substituted benzene rings in the polystyrene with the amino groups:

$-[\Phi\text{-}CH_2\text{-}N^+\text{-}H_2\text{-}R]Cl^-$

During the exercise, students will perform Diffusion dialysis and the second Donnan dialysis and and compare effectiveness of both membrane processes.

Experimental

Group A

a. Put a membrane to the dialyzer
b. Prepare a mixture prepare the solution of $K_2Cr_2O_7$ (a teacher will tell you the solution concentration) in the beaker with the capacity of 50 mL, (prepare 40 mL of each mixtures)
c. Fill the right side of dialyzer with 35 mL of the distilled water
d. Fill the left side of dialyzer with 35 mL of mixture of $K_2Cr_2O_7$
e. Begin the process (the time of the process will tell you a teacher) and measure the chromium concentration every 10 min. using the spectrophotometer UV-Vis,
f. Prepare the calibration curve for chromium VI: prepare the solution of Cr (VI) with concentration: 0.1, 0.2, 0.5, 0.7 and 1.0 mmol/L in the water and measure adsorption of this solutions using UV-Vis spectrophotometer (λ=345 nm),
g. After process measure the concentration of chromium in the both of sides of dialyzer .
h. Open the dialyzer and clean the apparatus,
i. Measure the active surface of the membrane.

Group A

a. Put a membrane to the dialyzer
b. Prepare a mixture prepare the solution of $K_2Cr_2O_7$ (a teacher will tell you the solution concentration) in the beaker with the capacity of 50 mL, (prepare 40 mL of each mixtures)
c. Fill the right side of dialyzer with 35 mL of the distilled water
d. Fill the left side of dialyzer with 35 mL of 1 M NaCl solution
e. Begin the process (the time of the process will tell you a teacher) and measure the chromium concentration every 10 min. using the spectrophotometer UV-Vis,
f. Prepare the calibration curve for chromium VI: prepare the solution of Cr (VI) with concentration: 0.1, 0.2, 0.5, 0.7 and 1.0 mmol/L in the water and measure adsorption of this solutions using UV-Vis spectrophotometer (λ=345 nm),
g. After process measure the concentration of chromium in the both of sides of dialyzer .
h. Open the dialyzer and clean the apparatus,
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Attention!!! both group compare all obtained results from Donnan and diffusion dialysis

Calculations

1. The flux of Cr(VI) (J_a) from the equation :

$$J = \frac{C_t}{A \times t}, \quad [\frac{mol}{cm^2 \times s}] \ (1)$$

where:
C_t – the concentration of Cr(VI) after time (t) and the process, mol/L,
t – measurement time, s,
A – the active surface of membrane, cm^2.
Plot a graph of J(t) for two processes in a single graph.

2. The percentage of chromium removal from the equation:

$$R = \frac{(C_0 - C_t)}{C_0} \times 100\%, \, (2)$$

Where:
C_0 – is the concentration of Cr(VI) at the beginning, mmol/L,
C_t – the concentration of Cr(VI) after time (t), mol/L,

Plot a graph of R (t) for two processes in a single graph.

[1] Y. Tapero, B.L. Rivas, J. Sanchez, M. Bryjak, N. Kabay., Polypropylene membranes modified with interpenetrating polymer network for removal of chromium ions, DOI: 10.1002/aoo.41953

[2] A. Tor, Removal of fluoride from water using anion-exchange membrane under Donnan dialysis condition, *Journal of Hazardous Materials,* 141 (2007) 814–818.

[3] J. Wiśniewski, A. Różańska, Donnan dialysis for hardness removal from water before electrodialytic desalination, *Desalination*, 212 (2007) 251–260.

Attention

The report should contain:

1. **The object of exercises,**
2. **Short introduction,**
3. **The measurements results in the tables,**
4. **All calculations,**
5. **Conclusions**