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DESALINATION OF BRAKISH WATER BY ELECTRODIALYSIS - A REVIEW

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ABSTRACT

Most widely applied and commercially proven desalination technologies fall into two categories of thermal (evaporative) and membrane based methods. Membrane methods are less energy intensive than thermal methods and since energy consumption directly affects the cost-effectiveness and feasibility of using desalination technologies membrane methods such as reverse osmosis (RO) and electro dialysis (ED), are attracted great attention lately. In this paper water desalination using a laboratory ED setup was described and evaluated. To support a sustainable industrial growth, chemical engineering today faces a crucial challenge of meeting the increasing demand for materials and energy. One possible solution is to decrease the equipment size/productivity ratio, energy consumption, and waste generation via process integration and optimization. This review focuses on the integration of electrodialysis with traditional unit operations and other membrane separations. Such integrations, due to their diversity and practicability, can be versatile tools to meet specific needs from chemical, biochemical, food, and pharmaceutical industries. Desalination process separates nearly salt free water from sea or brackish water. So, desalination process is becoming a solution for water scarcity all over the world. Two membrane methods of water desalination namely electro dialysis (ED) and reverse osmosis (RO) are used in this study as complementary methods. The results show that both ED and RO can be used as integrated system. This system is economic and cost effective compared with each individual method provided using the ED system before the RO. The salt in brine seriously affects the soda ash recycling in the production process of soda ash, which not only results in low quality of soda ash recycling and wastes resources. Consequently, the brine should be desalted. The treatment of brine using bipolar membrane electro dialysis can reduce the concentration of sodium chloride effectively. Desalination with two compartment of a bipolar membrane electro dialysis composed of anion exchange membrane and cation exchange membrane was investigated in this study. Some parameters such as the membrane stack voltage, material flux, temperature and concentration were adjusted. The effect of the parameters on desalination rate, current efficiency and electricity consumption was researched.

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Keywords: Brine, Desalination, Electro dialysis, Reverse osmosis, Bipolar membrane

I INTRODUCTION

Many people in different countries are not having proper water for drinking, for cooking, and for their daily use. Many country people are having seas, oceans as their source of water which is not used for drinking purpose as the water is salt and source. So as to purify the ocean water. There are different types of techniques for purifying salt water to drinking water.

The process involved in this process is

1. Electro dialysis
2. Reverse osmosis

Electrodialysis (ED) is used to transport saltions from one solution through ion-exchange membranes to another solution under the influence of an applied electric potential difference. This is done in a configuration called an electrodialysis cell. The cell consists of a feed (dilute) compartment and a concentrate (brine) compartment formed by an anion exchange membrane and a cation exchange membrane placed between two electrodes. In almost all practical electrodialysis processes, multiple electrodialysis cells are arranged into a configuration called an electrodialysis stack, with alternating anion and cation exchange membranes forming the multiple electrodialysis cells. Electrodialysis processes are different from distillation techniques and other membrane based processes (such as reverse osmosis (RO)) in that dissolved species are moved away from the feed stream rather than the reverse. Because the quantity of dissolved species in the feed stream is far less than that of the fluid, electrodialysis offers the practical advantage of much higher feed recovery in many applications.

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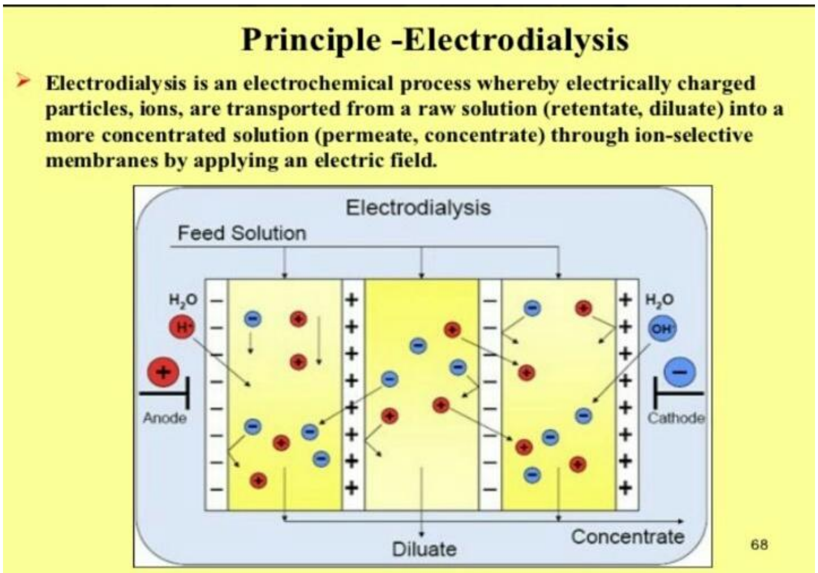


II METHOD

In an electrodialysis stack, the dilute (D) feed stream, brine or concentrate (C) stream, and electrode (E) stream are allowed to flow through the appropriate cell compartments formed by the ion exchange membranes. Under the influence of an electrical potential difference, the negatively charged ions (e.g., chloride) in the dilute stream migrate toward the positively charged anode. These ions pass through the positively charged anion exchange membrane, but are prevented from further migration toward the anode by the negatively charged cation exchange membrane and therefore stay in the C stream, which becomes concentrated with the anions. The positively charged species (e.g., sodium) in the D stream migrate toward the negatively charged cathode and pass through the negatively charged cation exchange membrane. These cations also stay in the C stream, prevented from further migration toward the cathode by the positively charged anion exchange membrane. As a result of the anion and cation migration, electric current flows between the cathode and anode. Only an equal number of anion and cation charge equivalents are transferred from the D stream into the C stream and so the charge balance is maintained in each stream. The overall result of the electrodialysis process is an ion concentration increase in the concentrate stream with a depletion of ions in the dilute solution feed stream

REACTIONS AT ANODE AND CATHODE

Reactions take place at each electrode.

At the cathode,

$$2e^{-} + 2\ H_2O \rightarrow H_2\ (g) + 2\ OH^{-}$$

while at the anode,

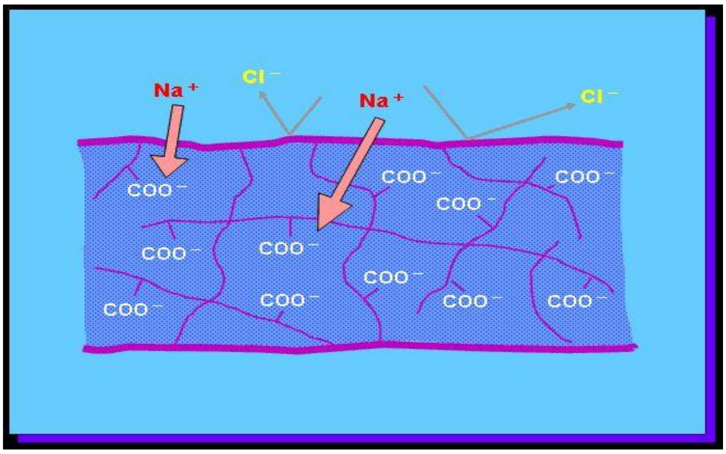
$$H_2O \rightarrow 2\,H^+ + \tfrac{1}{2}\,O_2\,(g) + 2e^- \text{ or } 2\,Cl^- \rightarrow Cl_2\,(g) + 2e^-$$

Small amounts of hydrogen gas are generated at the cathode and small amounts of either oxygen or chlorine gas (depending on composition of the E stream and end ion exchange membrane arrangement) at the anode. These gases are typically subsequently dissipated as the E stream effluent from each electrode compartment is combined to maintain a neutral pH and discharged or re-circulated to a separate E tank. However, some (e.g.,) have proposed collection of hydrogen gas for use in energy production

MEMBRANE TECHNOLOGY

Electro Dialysis (ED) is a membrane process, during which ions are transported through semi permeable membrane, under the influence of an electric potential.

The membranes are cation- or anion-selective, which basically means that either positive ions or negative ions will flow through. Cation-selective membranes are polyelectrolytes with negative charged matter, which rejects negatively charged ions and allows positively charged ions to flow through.



By placing multiple membranes in a row, which alternately allow positively or negatively Charged ions to flow through, the ions can be removed from wastewater. In some columns concentration of ions will take place and in other columns ions will be removed. The concentrated saltwater flow is circulated until it has reached a value that enables precipitation. At this point the flow is discharged.

This technique can be applied to remove ions from water. Particles that do not carry an electrical charge are not removed. Cation-selective membranes consist of sulphonated polystyrene, while anion-selective membranes consist of polystyrene with quaternary ammonia.

Sometimes pre-treatment is necessary before the electro dialysis can take place. Suspended solids with a diameter that exceeds 10 µm need to be removed, or else they will plug the membrane pores. There are also substances that are able to neutralize a membrane, such as large organic anions, colloids, iron oxides and manganese oxide. These disturb the selective effect of the membrane.

Pre-treatment methods, which aid the prevention of these effects are active carbon filtration (for organic matter), flocculation (for colloids) and filtration techniques.

Membranes

Ion exchange membranes fall into 2 broad categories: homogeneous and heterogeneous. Most ion exchange membranes are produced as homogeneous films 50 - 200 mm thick. Typically the membrane is reinforced by a net or fabric to maintain the shape and to minimise swelling.

In homogeneous membranes, the charged groups are uniformly distributed through the membrane matrix. In heterogeneous membranes, the ion exchange groups are contained in small domains distributed throughout an inert support matrix, which provide mechanical support.

Homogeneous Membranes

Cation-selective membranes are usually made of cross-linked polystyrene (with divinyl benzene) that has been sulfonated (with 98% sulphuric acid) to produce sulfonate (---- SO^{3-}) attached to the polymer.

Anion-selective membranes are usually made of cross-linked polystyrene containing quaternary ammonium groups (----- NR^{3+}). This can be achieved by post-treating the polystyrene with monochloromethyl ether and aluminium chloride to introduce chloromethyl group into the benzene ring followed by formation of quaternary amines with trimethylamine.

A particularly important category of ion exchange membrane is the perfluorocarbon type made by Du Pont under the trade name Nafion. The base polymer is made by polymerisation of a sulfinol fluoride vinyl ether with tetrafluoroethylene. The co-polymer formed is then hydrolysed:

Heterogeneous Membrane

The simplest form has very finely powdered cation or anion exchange particles uniformly dispersed in polypropylene. A much finer heterogeneous dispersion of ion exchange particles, and consequently a more stable membrane, can be made with a poly vinyl chloride plastisol.

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