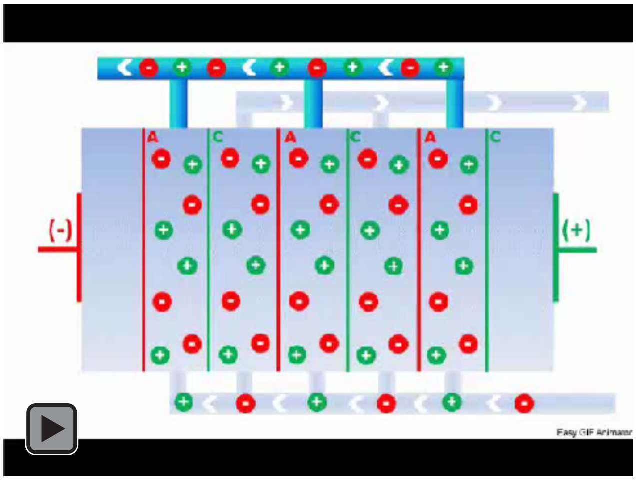

Electrodialysis/ED Reversal

Electrodes create an electric field which pushes negative and positive ions through semipermeable anion and cation membranes with attached positively or negatively charged species respectively. ED is used in multiple stages to concentrate the brine to saturation levels.

1) Introduction
2) Process Function
3) Advantages and Disadvantages
4) Process Industry Applications

1) Introduction

Electrodialysis is a membrane process that uses alternating Anion–selective membranes (AMs) and Cation-selective membranes (CMs), placed between an Anode (+) and a Cathode (-). Due to the applied electric field, anions will move towards the Anode and cations will move towards the Cathode. Anions are stopped by the CMs and the cations by the AMs, creating a process flow with low ion concentration (Dilutant) and a process flow with high ion concentration (Concentrate).

A pair of a CM and a AM and both areas between these membranes is a Cell Pair. A Cell Pair is the basis unit of a stack, and is repeated ⍰(n)⍰ times. The number of cell pairs in an actual stack varies depending on

Advantages (+)	Disadvantages (-)
Treating >70,000 ppm (RO limit), No concentration limit	Current Density Limit
No applied Pressure → ↓Fouling	Doesn't remove microorganisms and organic contaminants
↓Fouling & No regeneration chemicals required → ↓↓Chemicals	↑Energy as ↑Salt Feed Concentration
<Energy than Distillation processes (MED, MVC)	↑CAPEX for ↓Salt Feed Concentration
↑Membrane life	-
↑↑Recovery	-

Energy Consumption; 6.73 KWh/m^3 (high salinities require high SEC)

Applications

1) **Treatment of >70,000 ppm saline solution (Brine)**
2) **Demineralization (e.g. Boiler Feed, Food, Chemical industries)**
3) **Recovery of Electrolytes, Acids**
4) **Desalination of Industrial Wastewater for Reuse**

the electrodialysis system, with as many as 600 cell pairs in a typical industry-scale system.

In electrodialysis suspended solids which carry positive or negative electrical charges can increase the resistance of the membrane dramatically, are deposited on the membrane surface. However, in electrodialysis the problem has been eliminated to a large extent by reversing in certain time intervals the polarity of the applied electrical potential which results in a removal of charged particles that have been precipitated on the membranes. This technique is referred to as ***electrodialysis reversal (EDR).***

2) Process Function

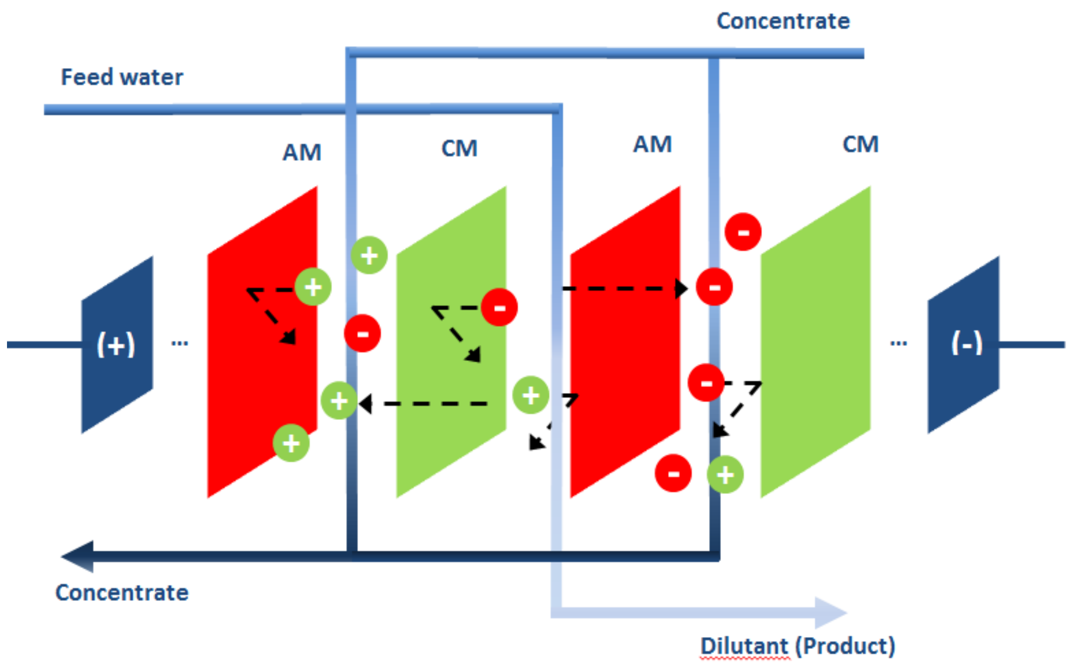

Fig.1, Schematic description of the electrodialysis reversal process

In each EDR stack there are two electrodes on the outer side which are submerged in a watery salt solution that is able to conduct electrical current and allows for an electrical field to be placed around the stack. The salt solution is pumped around in order to maintain the ion balance. Because salt solution (feed current) is also found between the ion exchange membranes, the electrical field will result in ion transport. In the spaces between electrodes, marked as Dilutant, the cations will diffuse through the CM to the negative electrode (cathode) while the anions will diffuse through the AM to the positive electrode (anode).

The ions leaving the dilutant feed are moving to the neighboring concentrate feed chamber which leads to a drop in concentration of ions in the dilutant chambers of the EDR process. In the concentrate chambers, the cations will try to move to the negative electrode but they will be blocked by the AM and the anions will try to move to the positive electrode but will be blocked by the CM. This leads to an increase of their respective concentrations in the concentrate chambers.

In EDR, the voltage at the electrodes is reversed every 30 - 60 min which reverses also the direction of ion transport and causes the removal from the membrane surface of electrically charged substances that may cause serious, perhaps irreparable damage. It is generally recommended to remove in advance,

- dispersed particles,
- colloid
- humus acids
- oils and fats

The average life-span of ED membranes is between 5 and 7 years.

3) Advantages and Disadvantages

Advantages:

EDR has advantageous characteristics that constitute it as a success. First is EDR’s ability to perform at very high water recovery sue to its polarity reversal which allows for treatment, without any chemicals, of feeds with concentrated salt scale factors well beyond saturation. With the addition of an antiscalant EDR pushes its salt tolerance even further.

Unlike RO, which is a pressure driven process, EDR works by flowing feed water over the surface of ion exchange membranes, while an electric field removes ions across the latter. EDR doesn’t have a compact fouling layer like RO which limits its recovery efficiency.

Disadvantages:

A major drawback is that beyond a particular current density (Current Density Limit), the diffusion of ions through the EDR membranes is no longer linear to the applied voltage but leads to water dissociation (water splitting into H^+ and OH^- ions) and lowers the system’s efficiency. So EDR must always operate below the current density limit. Experimental measuring procedures are available to determine the CDL for a particular feed.

Another disadvantage of EDR is that it doesn’t remove microorganisms and organic contaminants, thus a post treatment is always necessary if high quality water is required.

4) Process Industry Applications

1.	***Brine Concentration***
2.	***Demineralization (e.g. Boiler Feedwater)***
3.	***Desalination of Industrial Wastewater for Reuse***
4.	***Demineralization of food products***
5.	***Recover of valuable electrolytes or acids from rinsing baths in metal (surface) treatments***
6.	***Sectors where ions need to be removed from a process flow or must be concentrated (e.g. chemicals industry)***