Electrodialysis: an overview on some industrial applications

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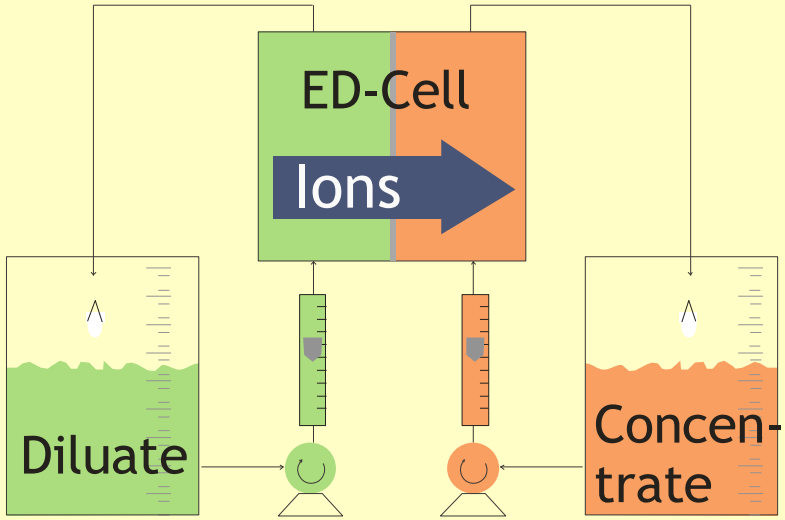
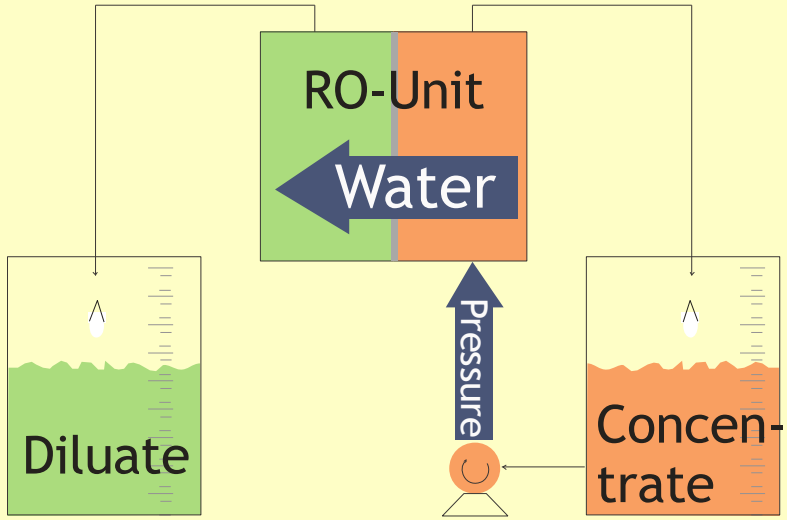
Electrodialysis vs. Reverse Osmosis





- ions move, solution stay
- concentrate „pure“
- uncharged material in diluate
- concentration electrically driven

- water moves, ions stay
- diluate is „pure“
- undesired material in retentate
- concentration by pressure difference

Case 1: $MgSO_4$ Spa Water Management

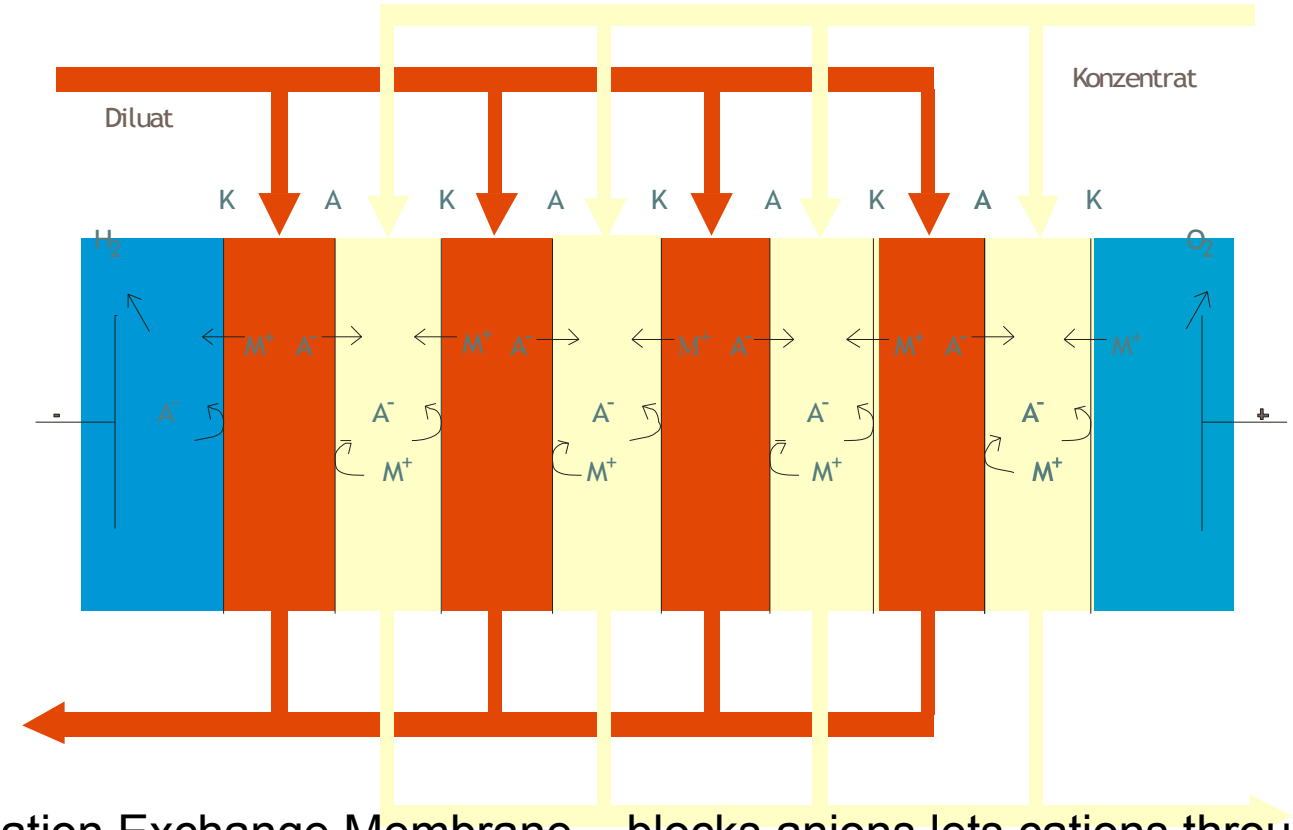
- No effluent draining off possible
- MgSO4 loss in spa need to be reduced
- RO not capable to achieve sufficient concentration level

Solution

- Feed circles between ED (high concentrate production) and RO (pure water production)

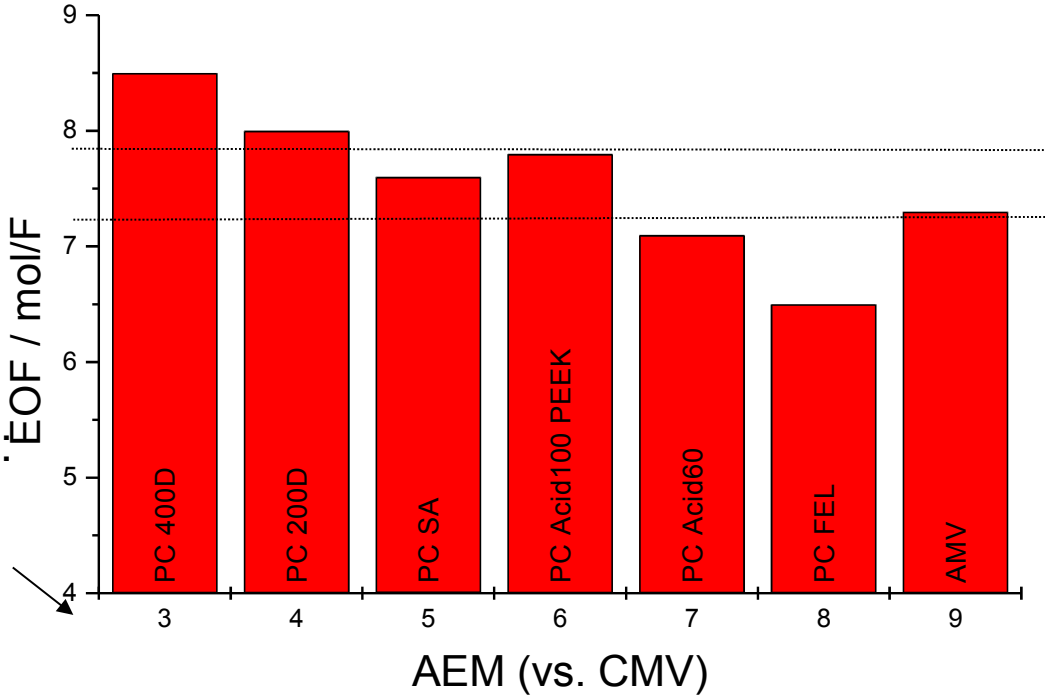
How ions move in ED stack

(and how water accompany ions)



K Cation Exchange Membrane blocks anions lets cations through
A Anion Exchange Membrane blocks cations lets anions through
Ions move through membrane – with hydrate shell
– with additional water

Electroosmotic flow of water with chloride and sodium ions



Open membranes (for large ions)

Standard

High crosslinked (acidblocker)

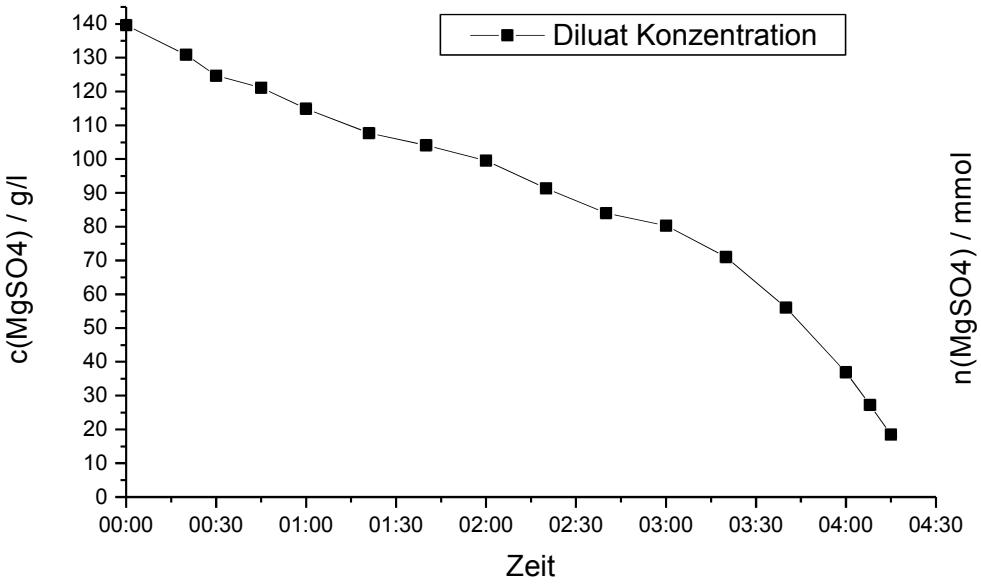
Cation membrane: contributes with approx. 3 water/F

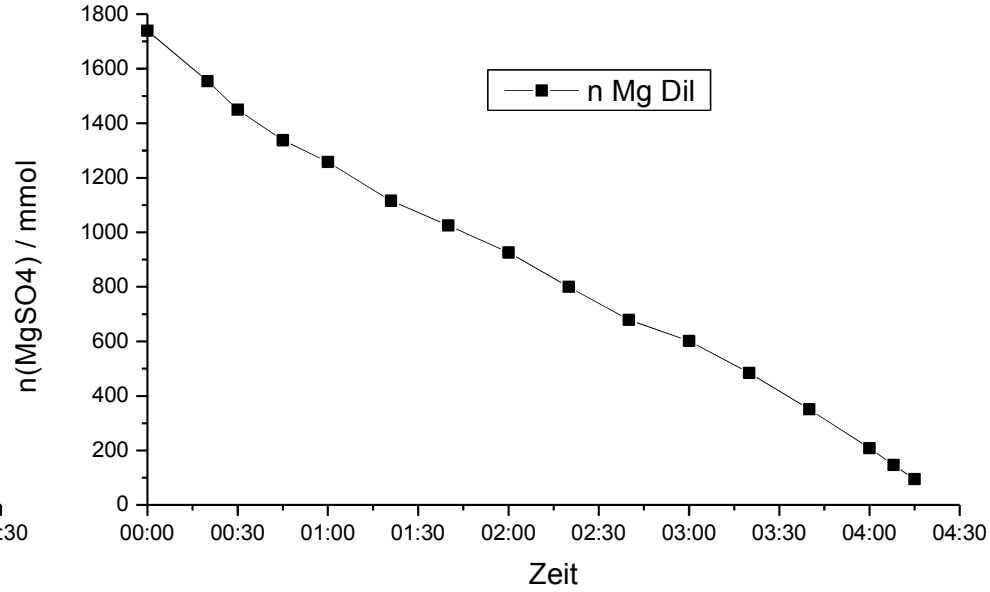
Result:

- Ionic transfer coupled with water transfer.
- Maximum concentration obtainable depends on membrane (in $MgSO_4$-case concentrations range from 14-20%)

Salt removal during batch desalination

i = const = 0,4 kA/m²





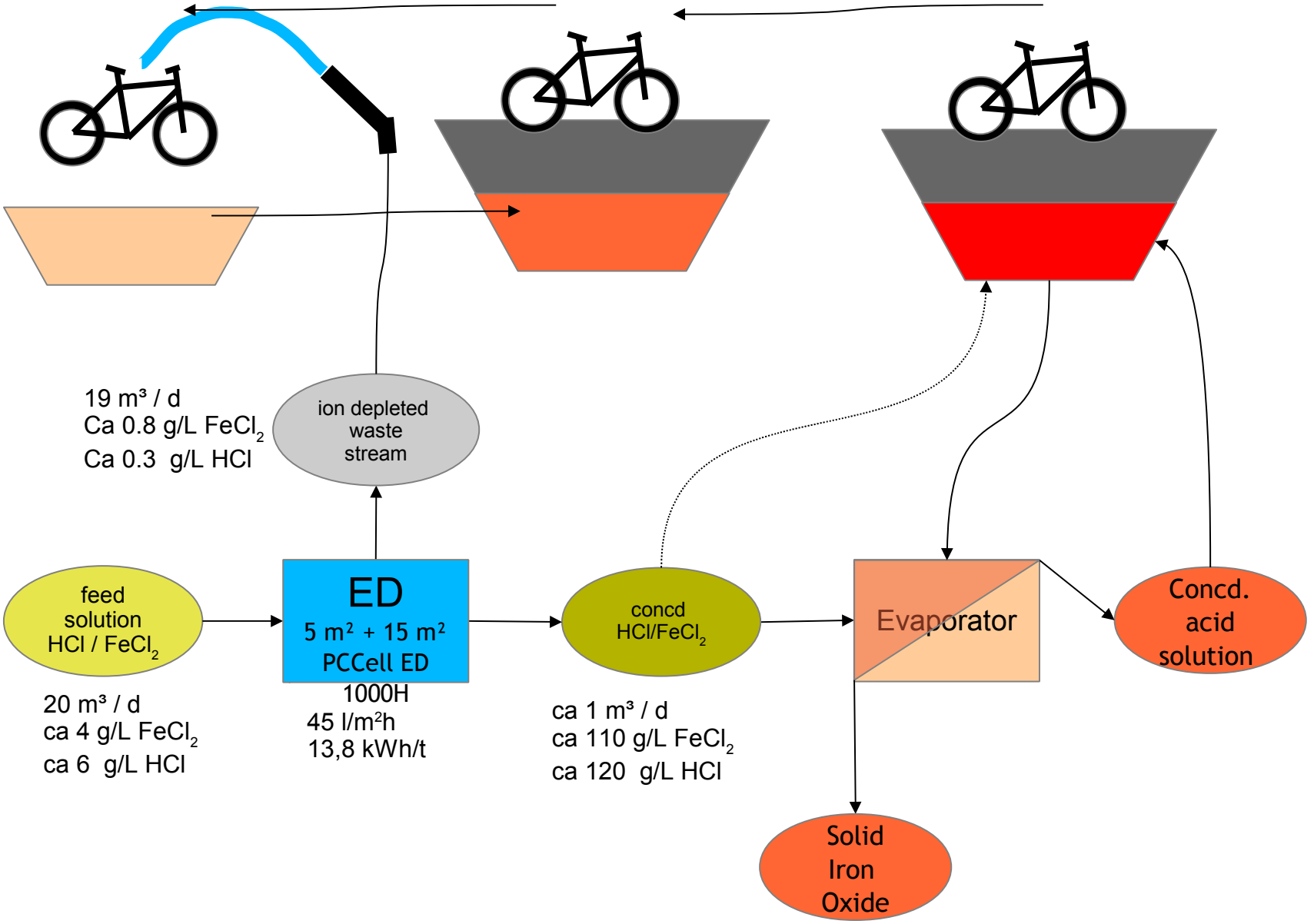
- constant current transfer constant amount of $MgSO_4$.
- The water co-transfer reduces diluate volume → concentration drops down faster and faster.

Case 2: Fe/HCl Scrubber Rinse Water Recycling

- Water reuse / disposal criteria: < 1 g/ L Cl^-
- Iron salts need to be removed because of chloride criteria

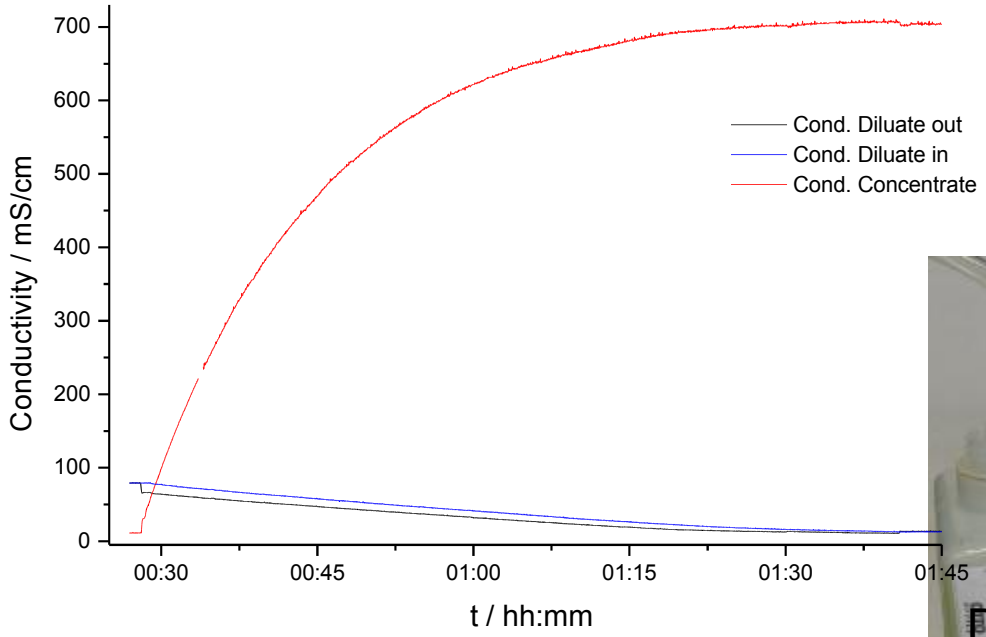
Solution

- electrodialysis with multivalent ion permeation and acidblocker anion exchange membranes
- Excess acid reconcentration with monovalent selective membranes


19 m³ / d
Ca 0.8 g/L FeCl2
Ca 0.3 g/L HCl
ion depleted waste stream
feed solution HCl / FeCl2
20 m³ / d
ca 4 g/L FeCl2
ca 6 g/L HCl
ED
5 m² + 15 m² PCCell ED
1000H
45 l/m²h
13,8 kWh/t
concd HCl/FeCl2
ca 1 m³ / d
ca 110 g/L FeCl2
ca 120 g/L HCl
Evaporator
Concd. acid solution
Solid Iron Oxide

HCl removal from $FeCl_2$/HCl mixture

Pure acid removal with monovalent selective membranes:
Conductivity in diluate and concentrate over time in a bach run with



Feed composition
Ca 0.8 g/L $FeCl_2$
Ca 0.3 g/L HCl

Concentrate shape if multivalent selective membranes are used

Diluate tank (feed)

Case 3: CIP Water Handling

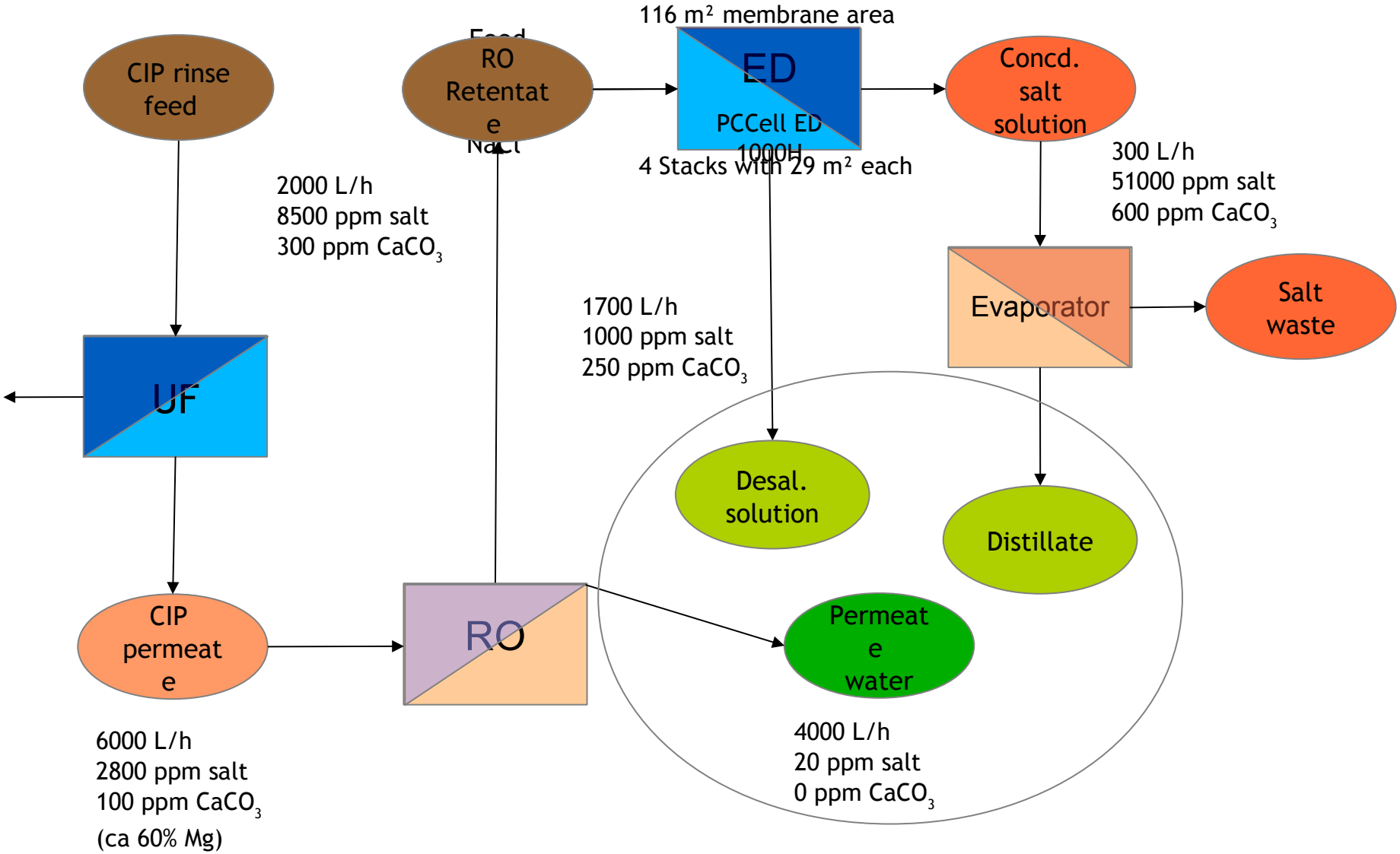
- Concentrate volume reduction to 300 L/h for evaporator
- Hardness in concentrate critical, $CaCO_3$ transfer into concentrate to be minimised

Solution

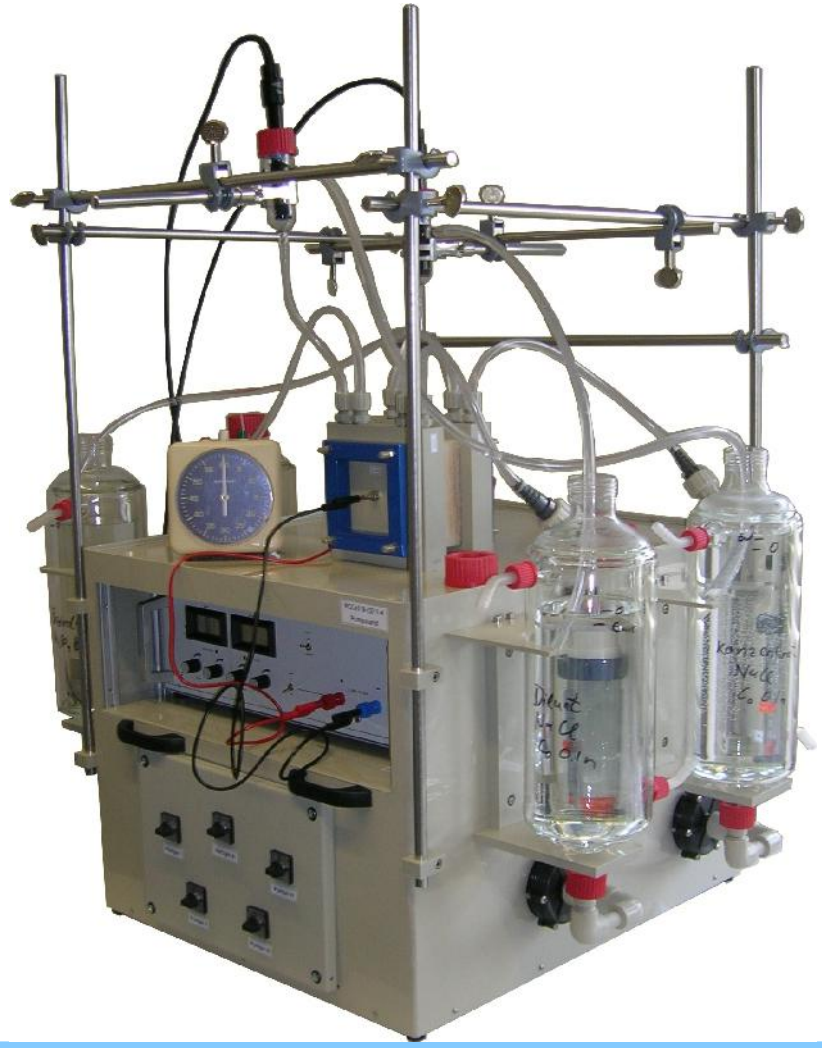
- electrodialysis with monovalent ion permeation
- Pre-concentration with RO

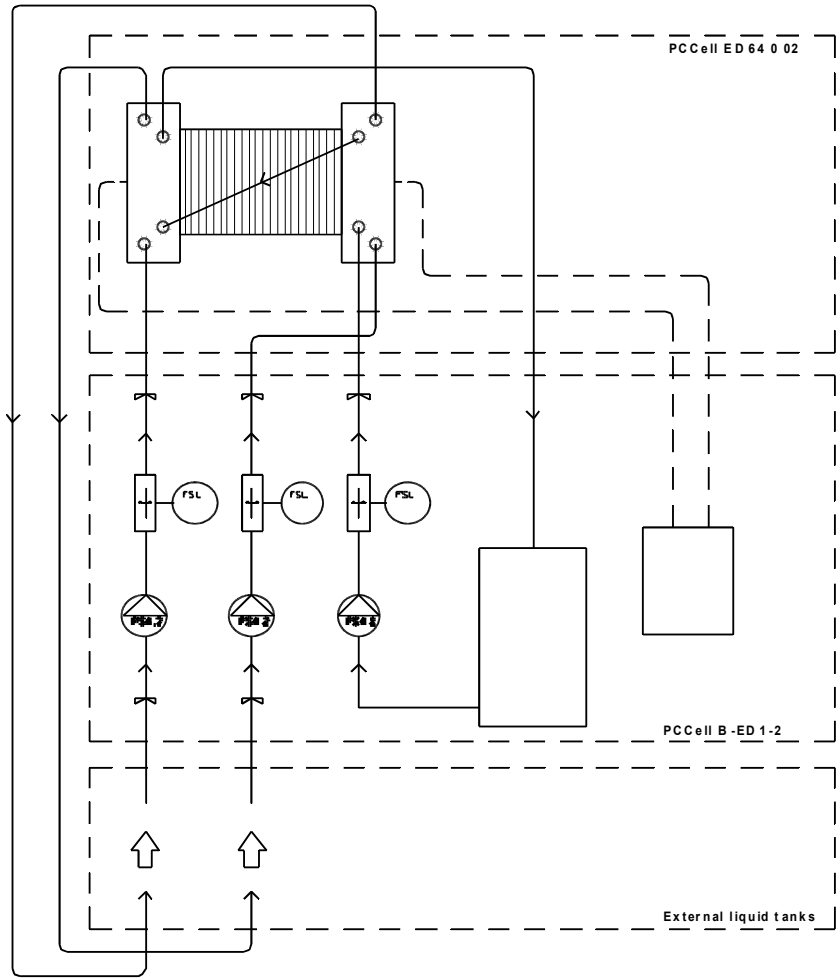
CIP waste rinsing water handling

(high HCO_3^--containing water)

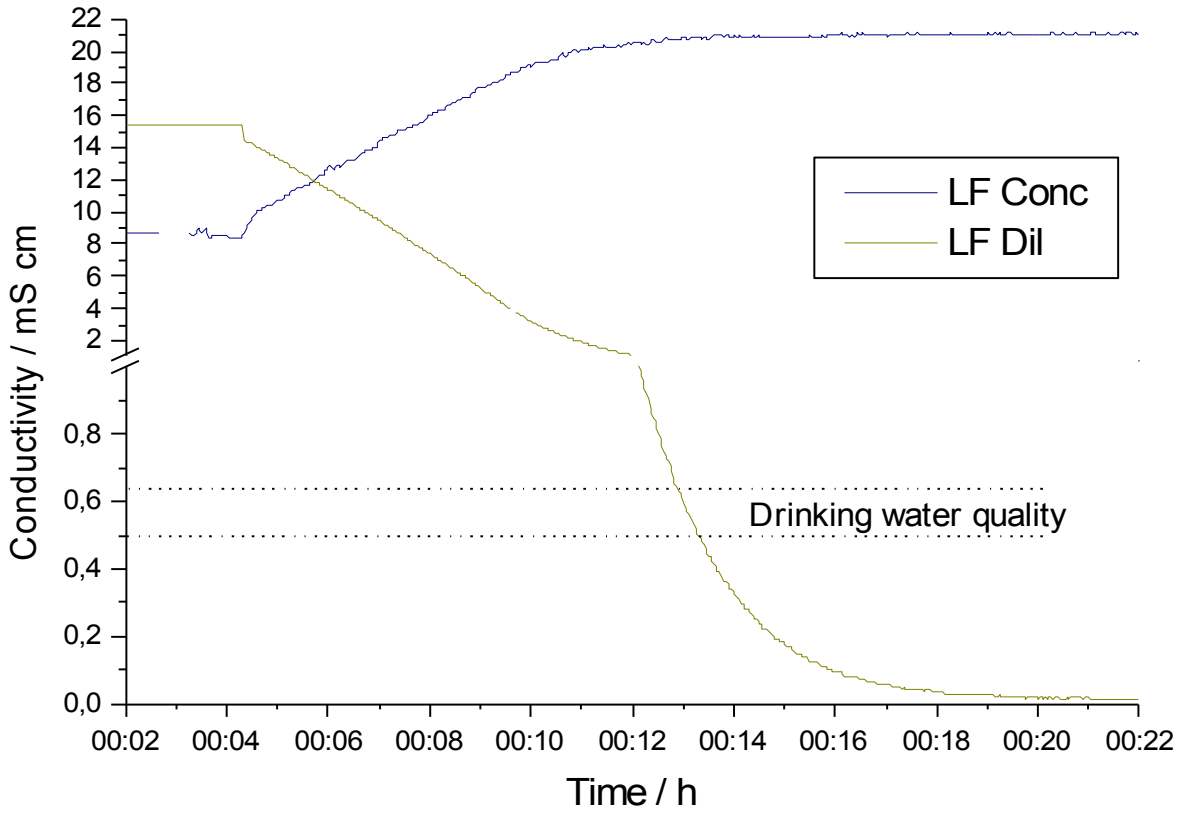


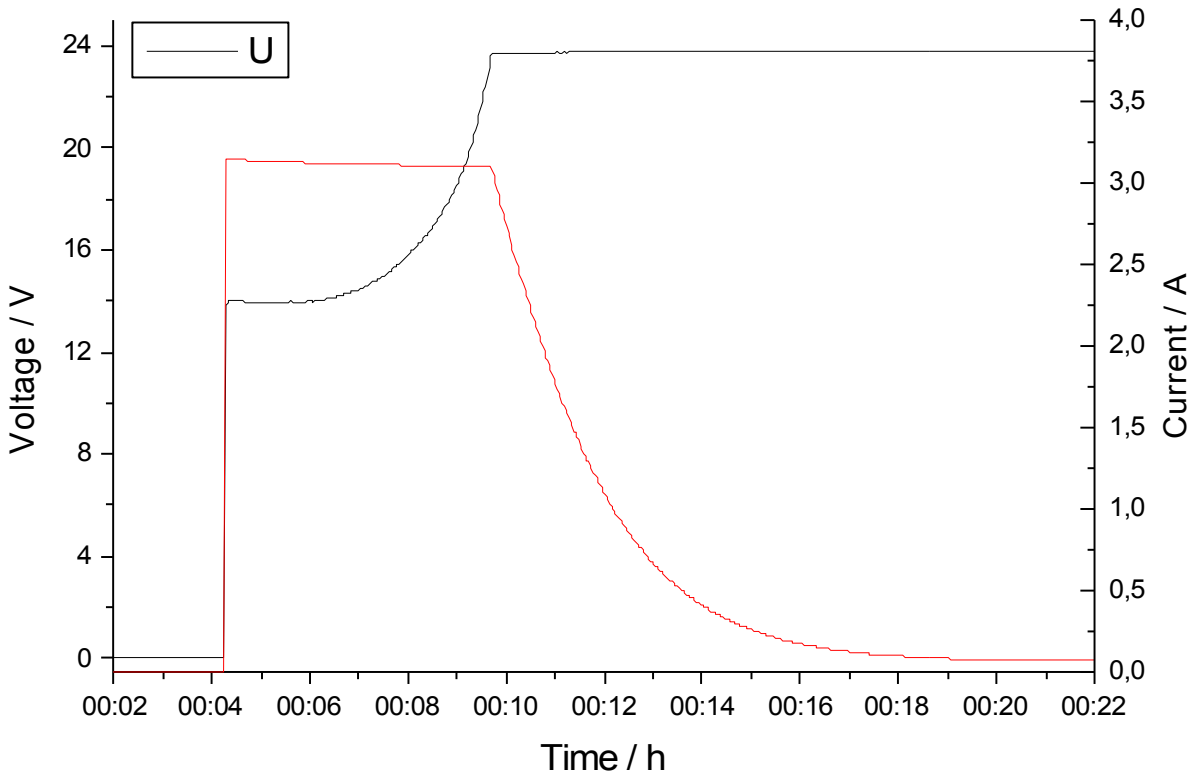
Example of a batch electrodialysis desalination kinetic



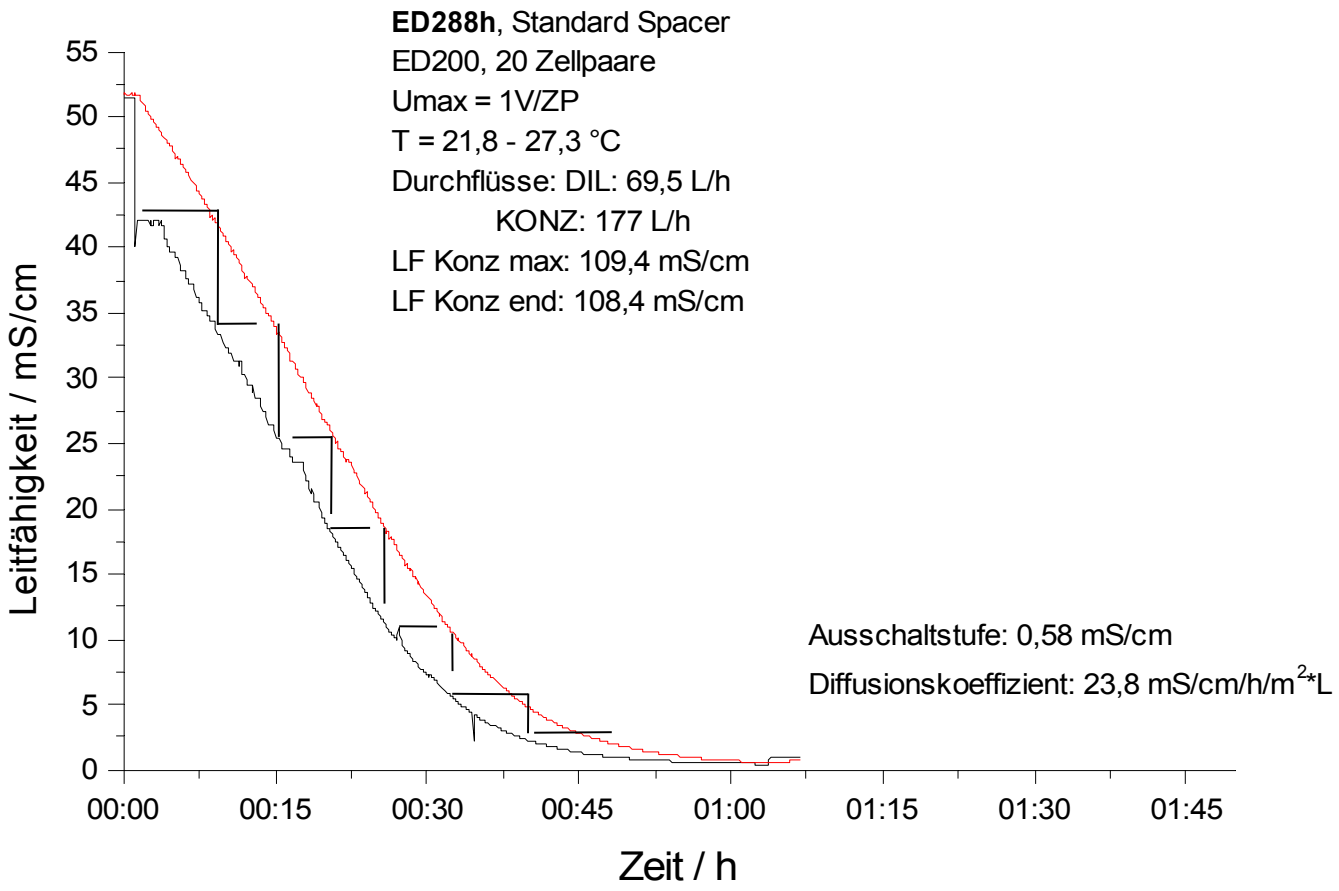


Conductivity during a batch desalination




U
Voltage / V
Current / A
Time / h
24
20
16
12
8
4
0
4,0
3,5
3,0
2,5
2,0
1,5
1,0
0,5
0,0
00:02
00:04
00:06
00:08
00:10
00:12
00:14
00:16
00:18
00:20
00:22

Comparision of the conductivity at inlet and outlet of the cell



Thank you very much for your attention.

Any questions?

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