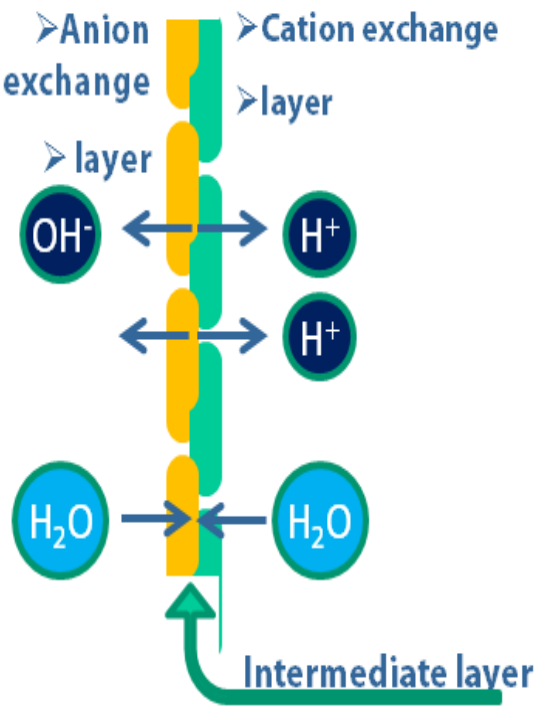
MemBrain®

MEMBRANE INNOVATION CENTRE

Elektrodialysis with bipolar membrane

Electrodialyses with BI-POLAR membranes EDBM
Principle and theoretical background of EDBM



➢Bipolar membrane is a cation-exchange membrane combined together with an anion-exchange membrane, through an intermediate layer (the "junction" layer). This membrane arrangement placed in a high density electric field enhances dissociation (splitting) of water into H^+ and OH^- ions.

➢Basic methods of membrane preparation:

- laminating (heat-pressing or gluing) a CEM and AEM back to back,
- introducing cation exchange groups into a single precursor membrane from opposite sides,
- casting a cation (or anion) exchange polyelectrolyte layer on an anion or cation exchange membrane.

➢The ideal bipolar membrane should have high permselectivity, low electrical resistance and water splitting voltage drop, high current efficiency, good chemical and mechanical stability, long lifetime, and no “ballooning”.

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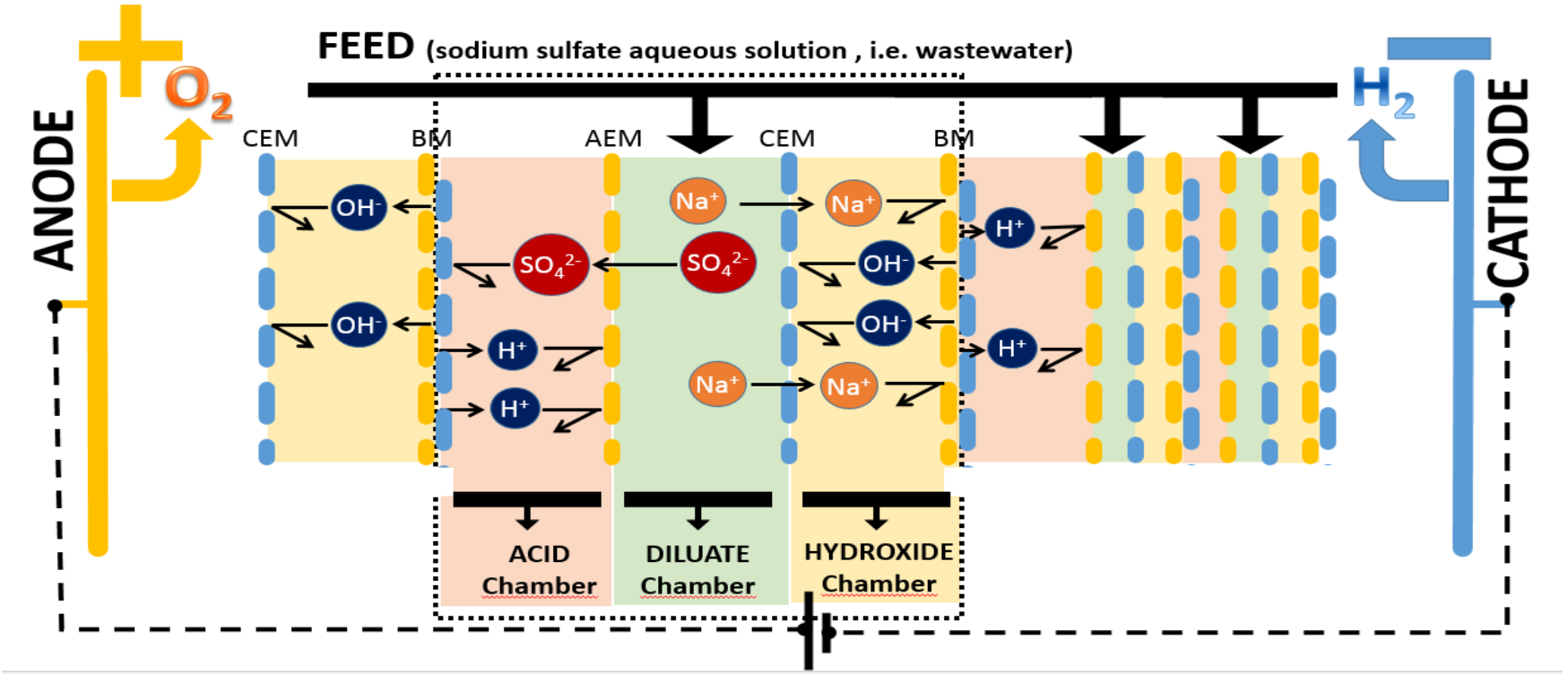
Principle of three chamber arrangement - production acid and hydroxide from salt



Three-chamber arrangement - production of acid and base at the same time, higher current efficiency can achieve higher concentrations of products suitable for processing salts of strong acids or bases (Na2SO4). Concentration of the resulting solutions is about 4% w / w.

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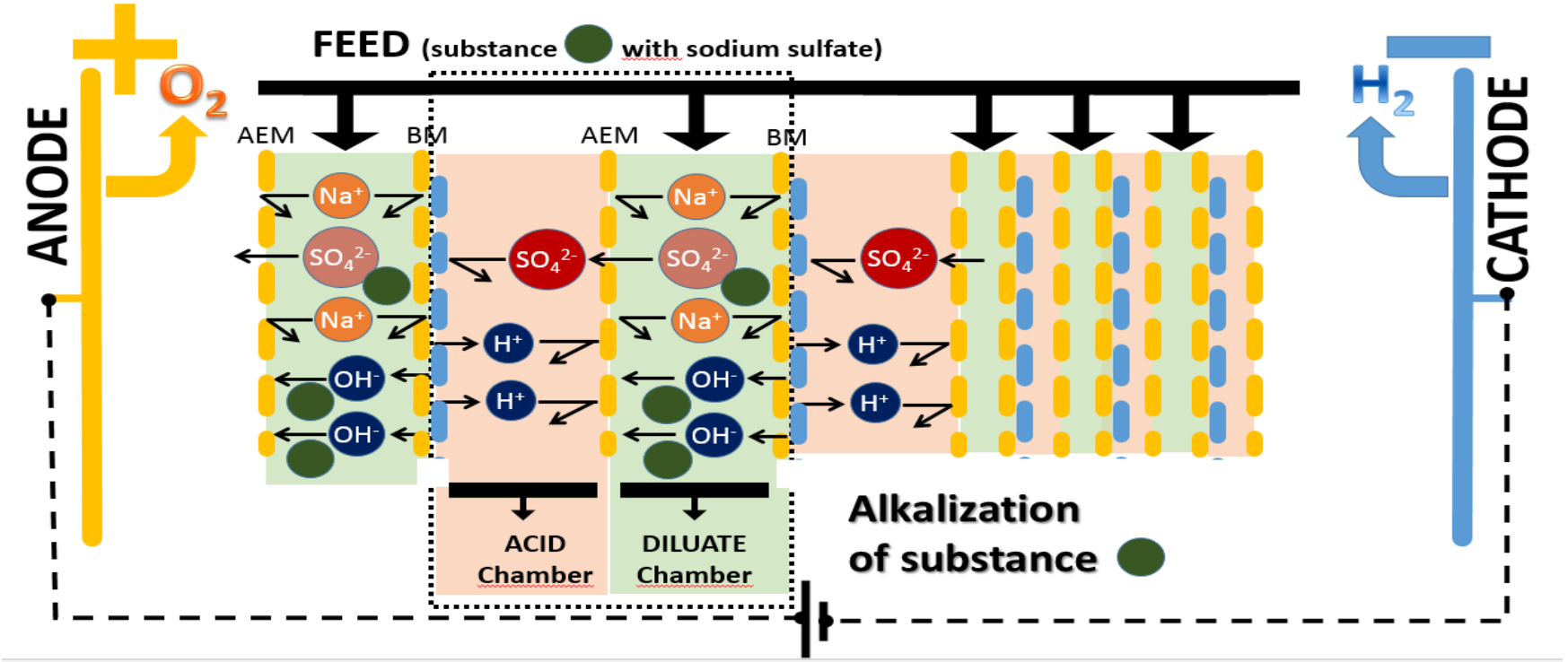
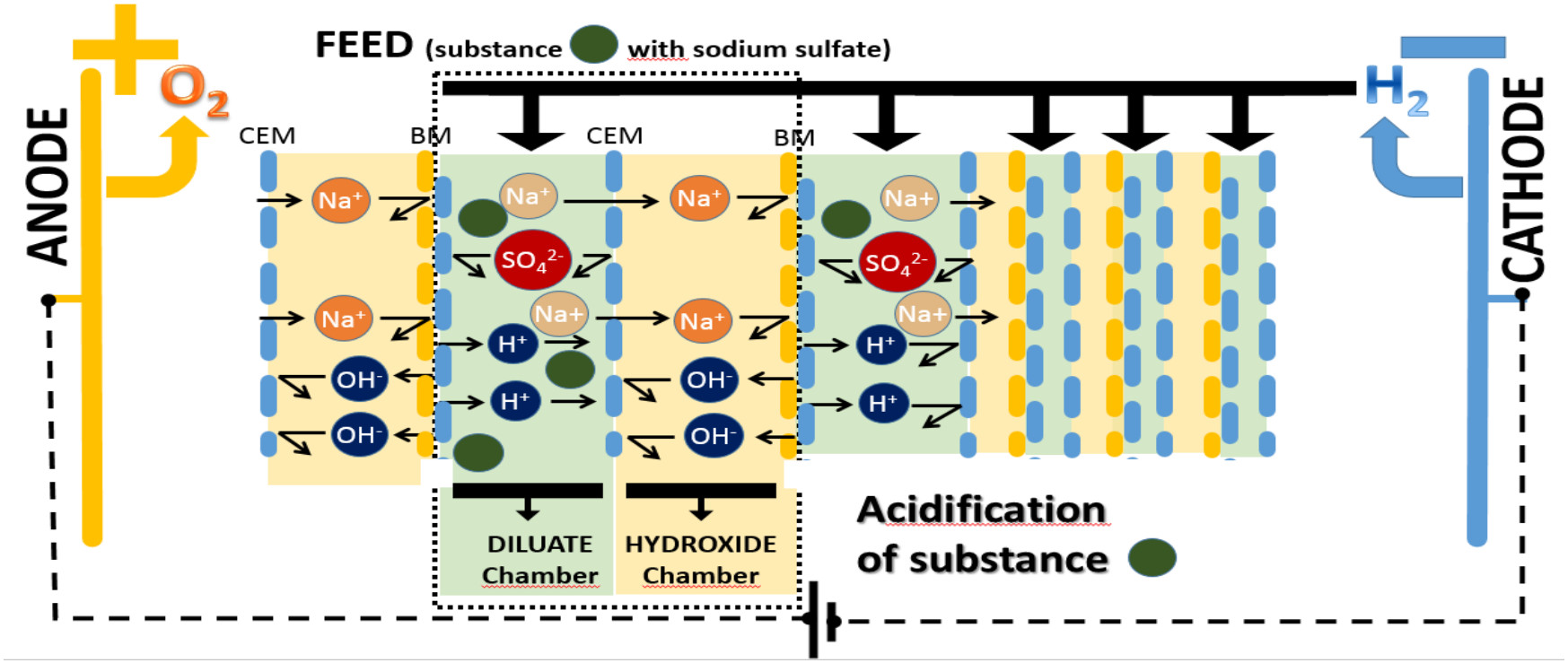
Principle of two chambre arrangement with AEM - – alkalization of substance



Two-circuit arrangement - easier, production of either acid or alkali, less electrical resistance, higher concentrations of H + and OH- at low concentrations, suitable for the treatment of salts of weak acids or alkalis, for acid and alkaline purification of salts and alkalis

Principle of two chambre arrangement with AEM - – acidification of substance



Two-circuit arrangement - easier, production of either acid or alkali, less electrical resistance, higher concentrations of H + and OH- at low concentrations, suitable for the treatment of salts of weak acids or alkalis, for acid and alkaline purification of salts and alkalis

Advantages of EDBM

- **Reducing usage of quantity chemicals and waste salt**
- There are no gases (water dissociates to H + and OH - already at low voltage)
- Only two electrodes on many membrane cells
- Without electrochemical reactions (no undesirable products)
- Small space intensity
- Applications: Chemical production and separation, Biotechnology, Food industry, Environmental protection

Disadvantages EDBM

- Permselectivity of membranes affects product purity (90 to 95%)
- Lower final product concentrations (4 to 5%)
- Spray composition requirements (multivalent cations and organic pollutants)
- Operating temperature limitation below 40 ° C

Production acids and bases

Production of inorganic acids and bases (neutralization)

- Na 2 SiO 3, Na 2 SO 4, Na 2 CO 3, NaCl, NaNO 3, Na 3 PO 4
- Dissociated salts form with OH- and H + ions the respective lyes and acids
- Three EDBM spraying applications containing inorganic salts:
  - ❖ Production of acids and bases
  - ❖ Regeneration of acids and bases
  - ❖ Salt waste stream treatment
  - ○ Two-circuit arrangement - easier, production of either acid or alkali, less electrical resistance, higher concentrations of H + and OH- at low concentrations, suitable for the treatment of salts of weak acids or alkalis, for acid and alkaline purification of salts and alkalis
  - ○ Three-ring arrangement - production of acid and base at the same time, higher current efficiency can achieve higher concentrations of products suitable for processing salts of strong acids or bases (Na2SO4). Concentration of the resulting solutions is about 4% w / w.

Production acids and bases

Production of organic acids (fermentation)

- Milk, citric, succinic, salicylic, acetylsalicylic, formic, acetic, ascorbic, propionic, gluconic, adipic, fumaric, itaconic, malic, oxalic,
- Conventional process - many costly operations only to add OH- and H + ions
  - Fermentation - maintaining neutral pH with added lye (Ca (OH) 2 or NaOH)
  - Precipitation - salt of the acid produced
  - Acidification - Using a strong acid such as H2SO4, the resulting acid is formed
  - Filtration - the resulting CaSO4 sludge must be removed on the filter press
  - In general, many cost-free operations with no added value serving only to add OH- and H + ions
- EDBM – allows the product to be taken in the form of acid and at the same time produces a pH-adjusting lye in the fermenter.
  - Reduce the cost of chemicals - no lye or acid is required
  - Remove operations without added value
  - There is no waste in the form of gypsum
  - It is not possible to produce high concentrations of pure acids (the permselectivity of monopolar and bipolar membranes decreases with increasing concentration, product purity decreases due to migration of co-ions)
  - Risk of crystallisation and precipitation of low-soluble acids (salicylic acid) and limited trade of membranes in basic media

Regeneration

Regeneration of acids and bases to reuse in the previous operation

- Spray is not clean, but it's a mixture of previous operations.
  The produced acids and bases are not clean, it does not have to worry about recycling.
- For greater clarity, EDBM needs to be linked to other technologies (IEX, NF, ...)
- For solutions containing hydrolyzing polyvalent ions (Ca, Mg, Zn, Cu, Ni, Al, Fe,.)
- Pre-treatment to prevent fouling and precipitation in membranes
- Some sprays may be high temperature or corrosive (increased demands on the thermal, mechanical and chemical resistance of membranes and bundles)
- Application:
  - Dropping bath - KNO3 / HF
  - Aluminum casting - dimethylisopropylamine from airbags
  - Manufacture of artificial silk (whether or not rayon, viscose) - Na2SO4
  - Processing of nuclear fuel - NH4NO3
  - Radioactive waste from UF6 - KF production
  - Desalination of flue gases – piperazine - KNO_3 / HF

Acidification and alkalization

The main application is in the food and pharmaceutical industry

- EDBM only introduces H + and OH-ions (without the addition of other ions)
- The supply of H + and OH- ions is fluid and mild (suitable for food or chemical synthesis)
- Beware of fouling membranes - the content of carbonates, sulphate, calcium, magnesium !!!
- Separation of soy proteins
  - Conventional process: extraction, precipitation, rinsing, dissolving, drying.
  - Disadvantage of denaturation of proteins due to local fluctuations in pH, high ash content and altered solubility of proteins after hydration
  - EDBM delivers H + and OH- ions smoothly without further salt increase and less water consumption due to recycling
  - Analogously, whey proteins and fats can be separated, and the skimmed milk is precipitated
- Stabilization of unfiltered apple juice - inhibition of enzymatic browning
  - Conventional process: addition of HCl and then NaOH, removal of NaCl using ED imperfect
  - EDBM allows the inhibition of polyphenol oxidases without the need for subsequent removal of NaCl
  - EDBM can be used to acidify sweet tropical juices
- Synthesis of epihalohydrin - replacement of a conventional process where CaBr2 is formed

Further application

- **Anhydrous solutions**
- Not so far explored
- Production of sodium methoxide from CH3OH and CH3COONa instead of the dangerous and strongly exothermic reaction of CH3OH with elemental sodium
- Preparation of methyl methoxyacetate (sodium methoxide is an input raw material).
- **Production of ultrapure water**
- Combination with EDI - EDBM increases efficiency of ion exchange regeneration
- Pilot installations - processing of permeates from RO using EDBM (ionex filled diluent circuits on both sides)