Monovalent Ion Selective Membranes for Desalination by mMCDI

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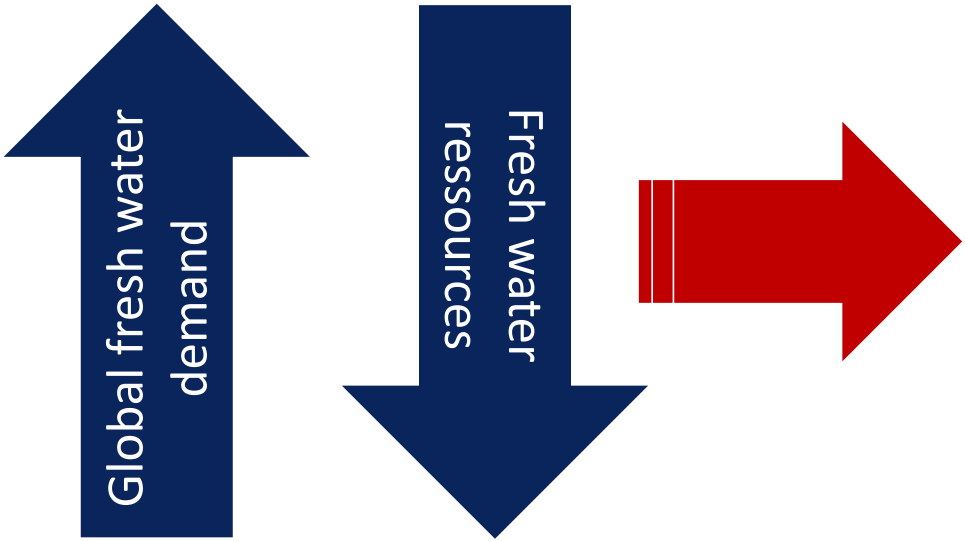
- Background
- MCDI vs. mMCDI
- Approach
- Results
- Summary/Conclusion

Salt contaminated drinking water ressources



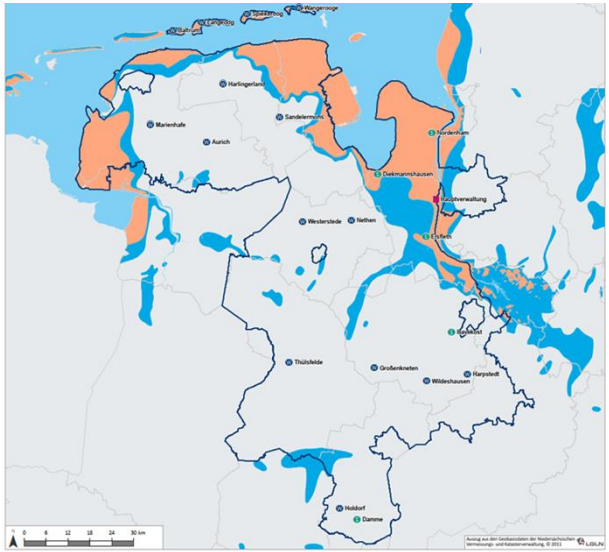
World-wide demand for energy efficient desalination technologies

BUT

Complete desalination is not necessarily required !

Examples of salt contaminated drinking water ressources in Germany

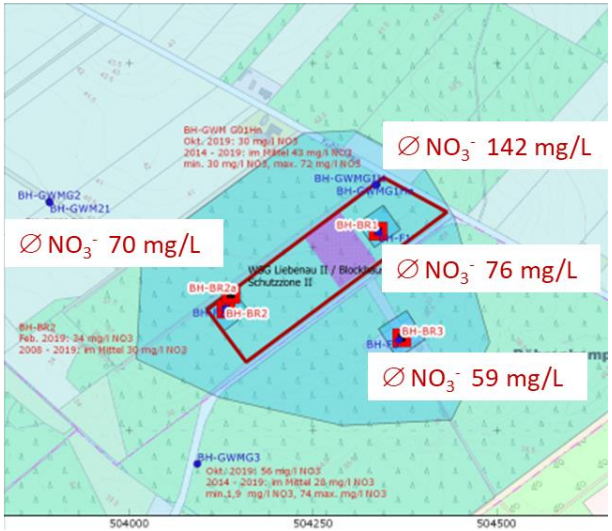
coastal region (OOWV Niedersachsen)



Completely salted aquifier > 250 mg/L Cl^-

Lower part of aquifier salted > 250 mg/L Cl^-

inland (WW Blockhaus Nienburg)



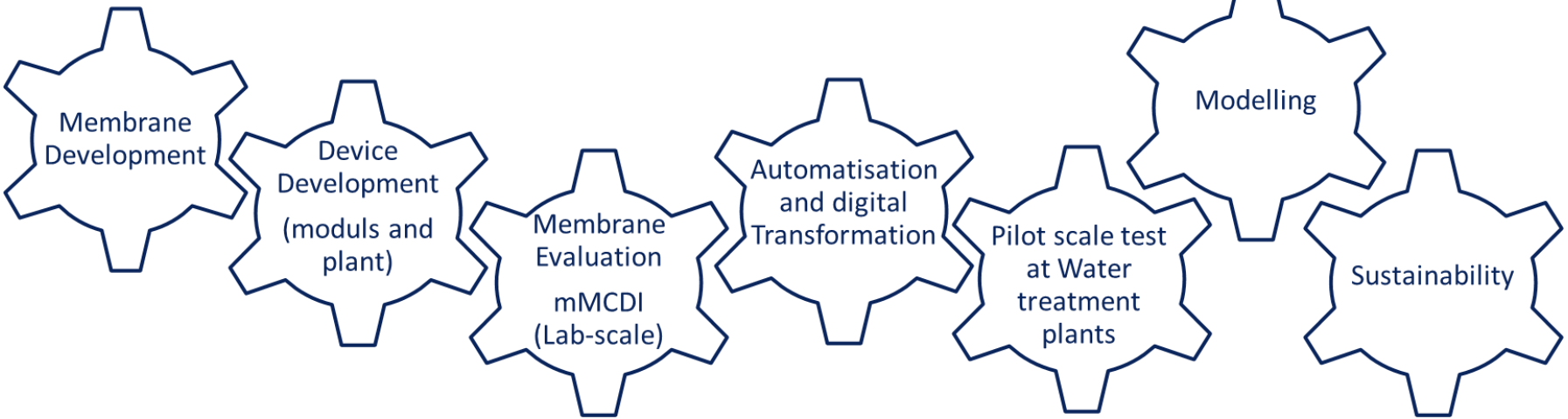
NO_3^- average 5 – 10 years

Main input by salt water intrusion

Main input by agriculture

Groundwater salination in the working area of OOWV [NIBIS® Kartenserver 2021 LBEG, Hannover]; https://nibis.lbeg.de/cardomap3/?TH=HUEK200VERSALZ
Concentrations of nitrate in the catchment area for ground and raw water at “Blockhaus” treatment plant of KWN [KWN]

Project innovatION

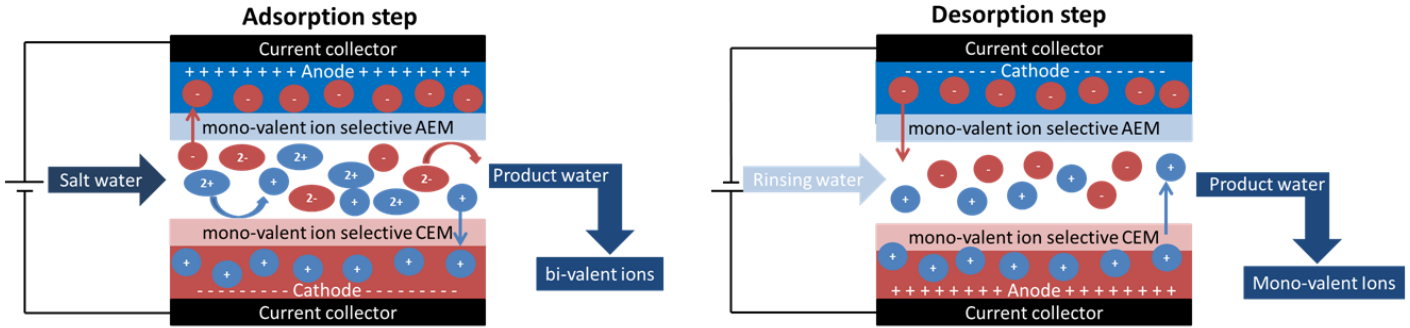


Project innovatION

Objectives

- Development of an energy efficient desalination process
- Selective removal of monovalent ions

↳ **m**onovalent ion selective **M**embrane **C**apacitive **D**e**I**onization **(mMCDI)**

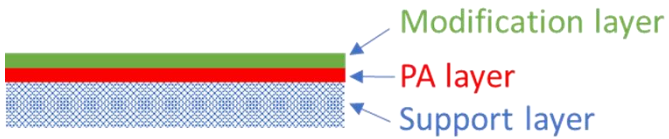


Principle of a mMCDI: left adsorption step right desorption step

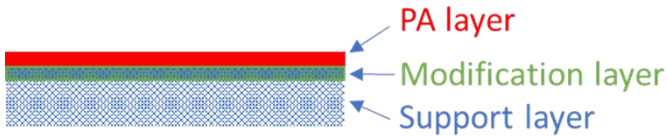
Concepts for preparation of monovalent selective IEMs

Modification of NF-Membranes

Toplayer



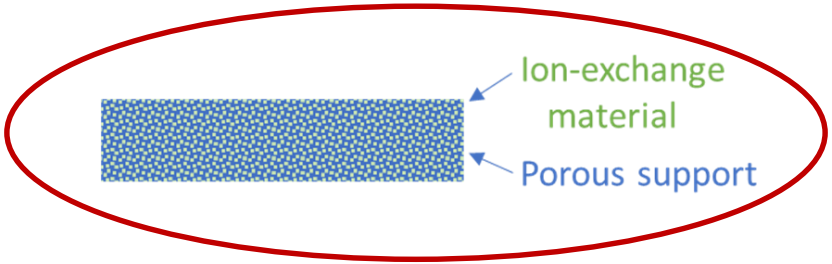
Support layer



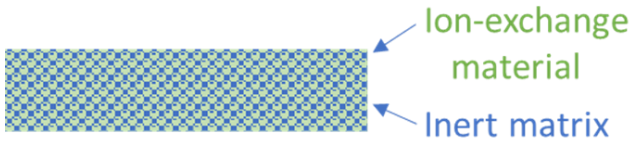
Resistance too high

↳ Low coulombic efficiency

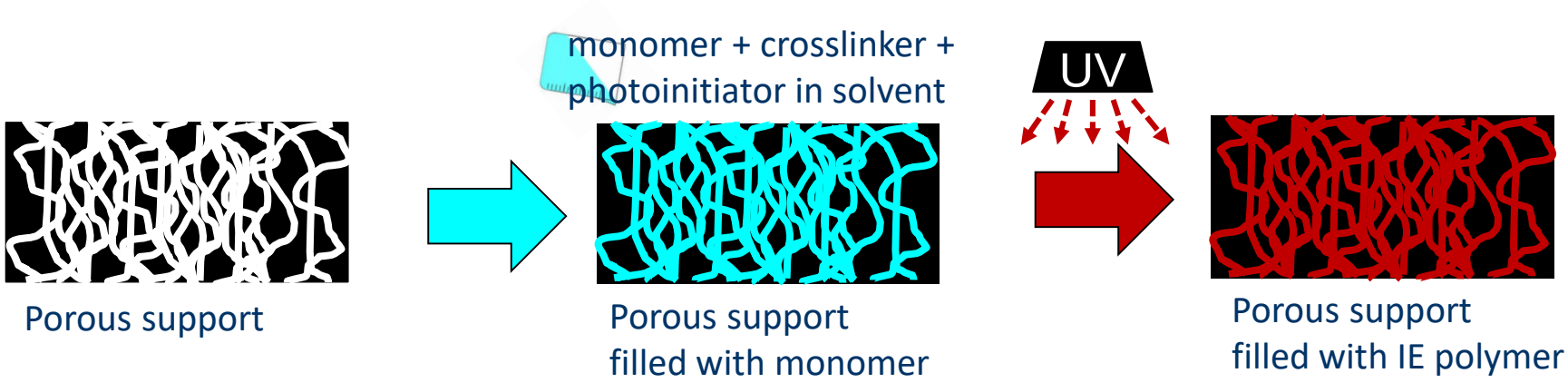
Pore-filled Membranes

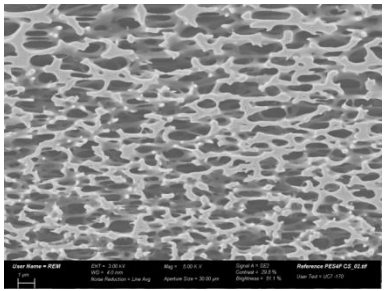


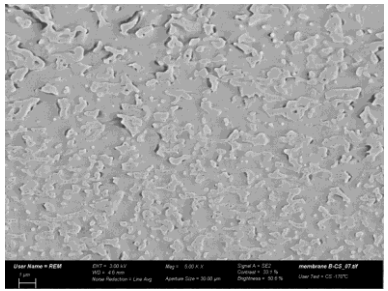
Interpenetrating Network



Preparation of pore-filled AEX membranes







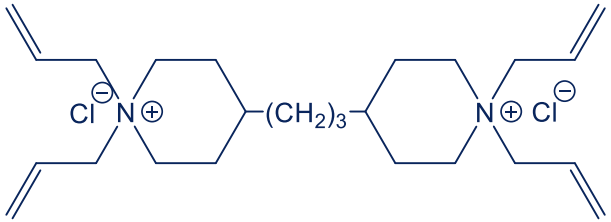
J. Meier-Haack, DE 102017206213; EP 3239193; US 2017326540; KR 10-2035116; JP 2017-087117

Materials

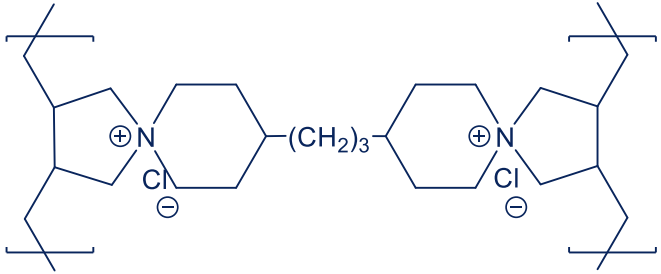
Porous support:	Membrana MicroPES 4F (0.4 µm; PES) Freudenberg non-woven Novatexx 2484 (PET/PBT)
Anion-exchange:	N,N,N‘,N‘-Tetraallyltrimethylenedipiperidinium chloride (TATMDiPipCl)
Cation-exchange:	2-Acrylamido-2-Methylpropansulfonic acid salt (AMPS) + Divinylbenzene (DVB; crosslinker) + glycerol (Gly, phase solidifier)
Solvents:	Ethanol (anion-exchange); DMSO (cation-exchange)
Photocatalyst:	Diphenyl(2,4,6-trimethylbenzoyl)phosphine oxide (TPO)
Polymerisation:	UV irradiation (365 nm) or electron beam irradiation (100 Gy)

Preparation of ion-exchange materials

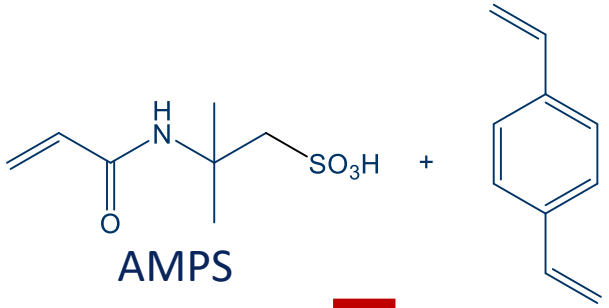
Anion-exchange material



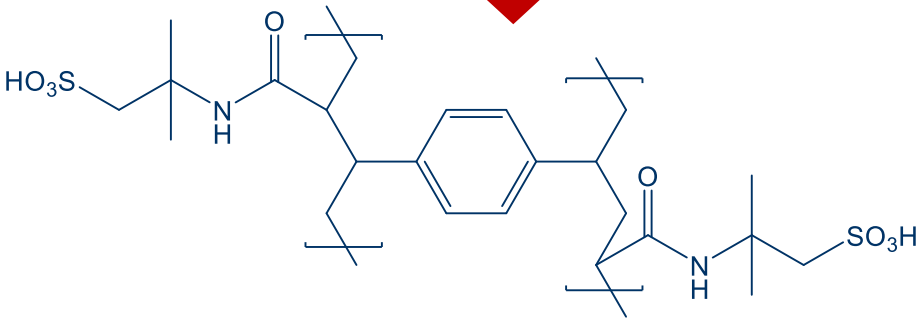
TATMDiPipCl



cation-exchange material

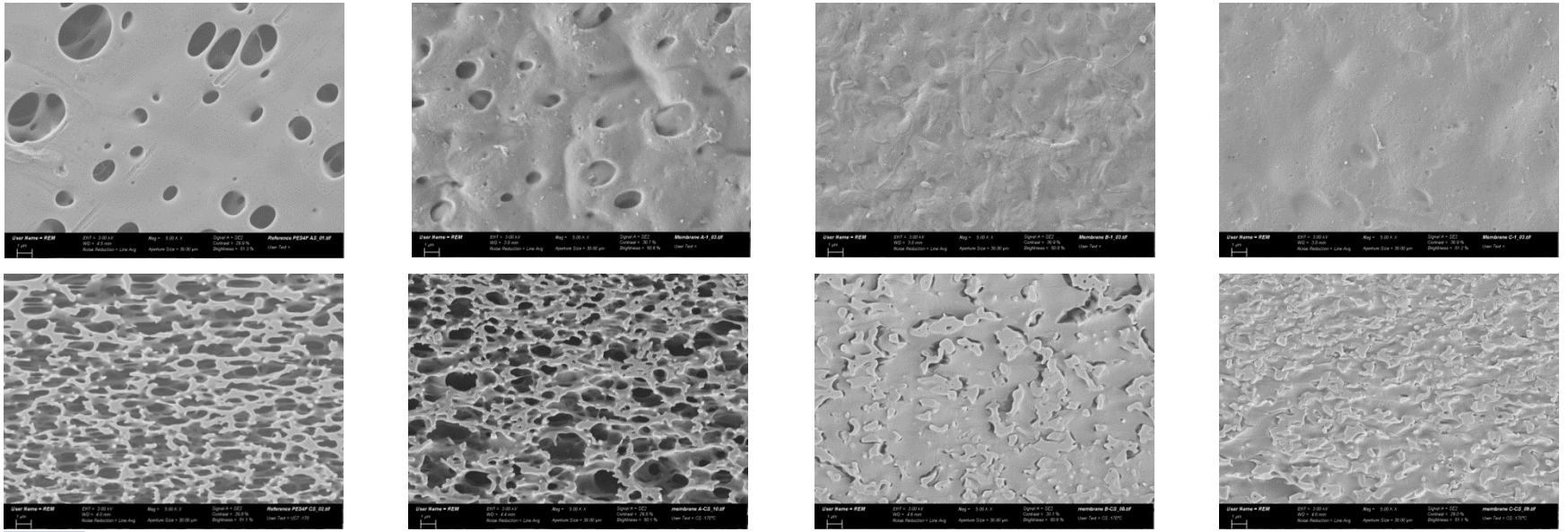


AMPS



MF based pore-filled anion-exchange membranes

Reference | 25 wt.-% | 50 wt.-% | 75 wt.-%

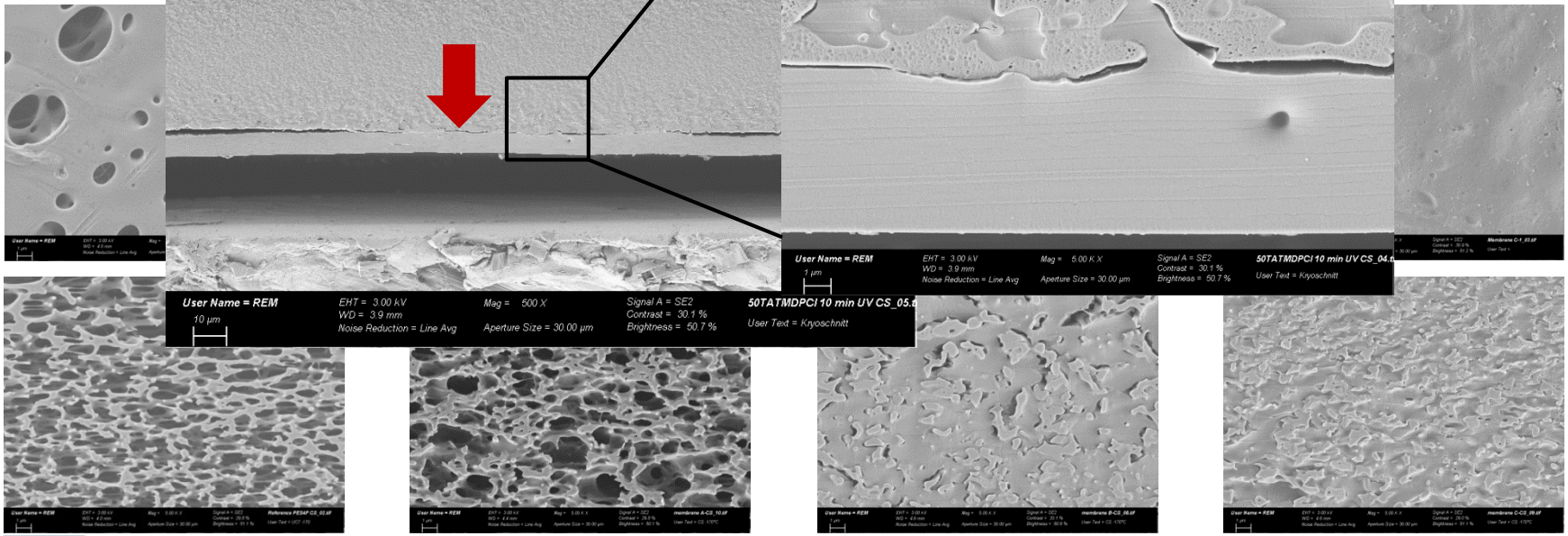


5 µm

MF bas

Refer

t.-%

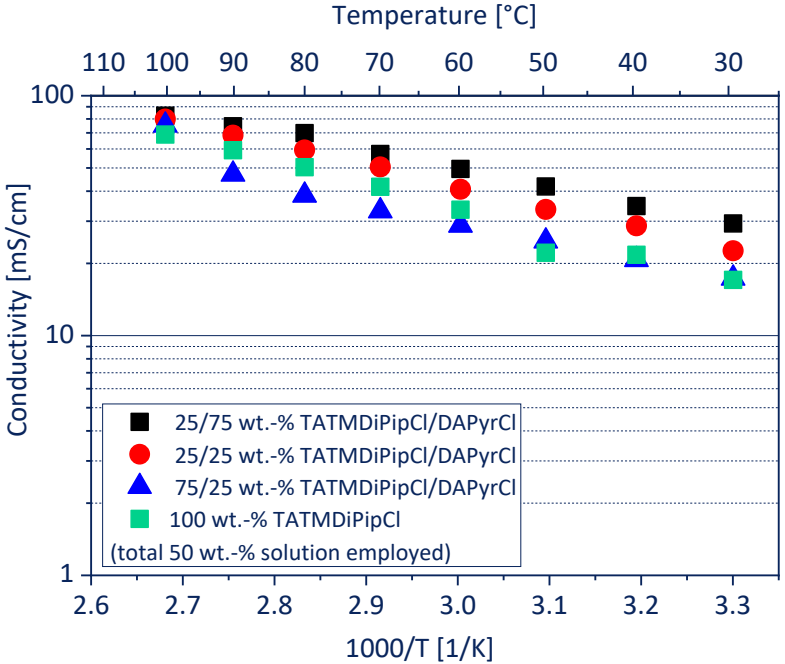


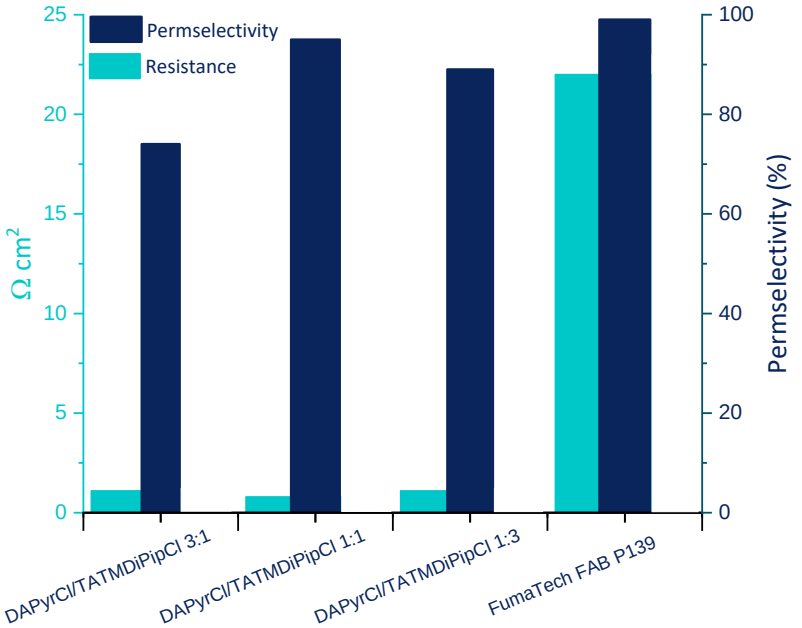
5 µm

25 wt.-% monomer solution: ↳ incomplete filling.

50 + 75 wt.-% monomer solution: ↳ film formation at the surface.

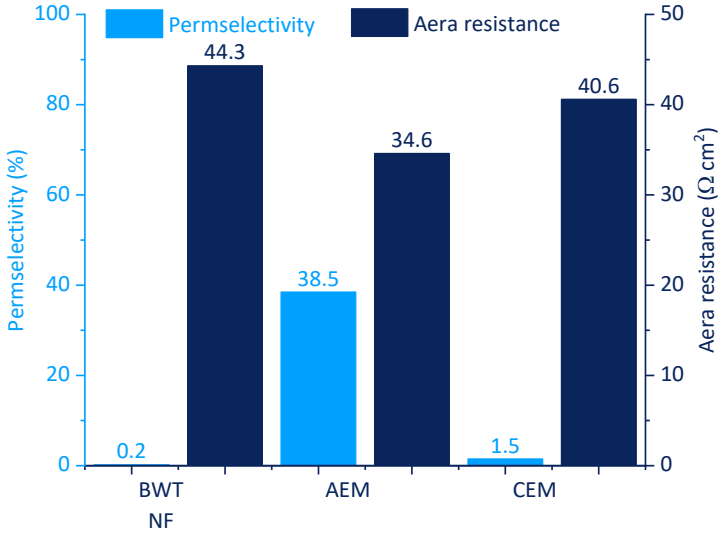
MF based pore-filled anion-exchange membranes

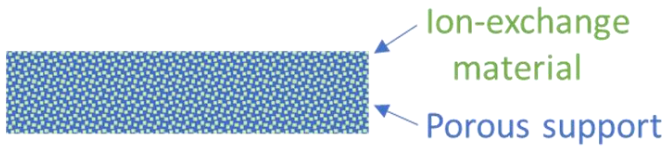




DAPyrCl = Diallylpyrrolidinium chloride

Non-woven based ion-exchange membranes (preliminary results)





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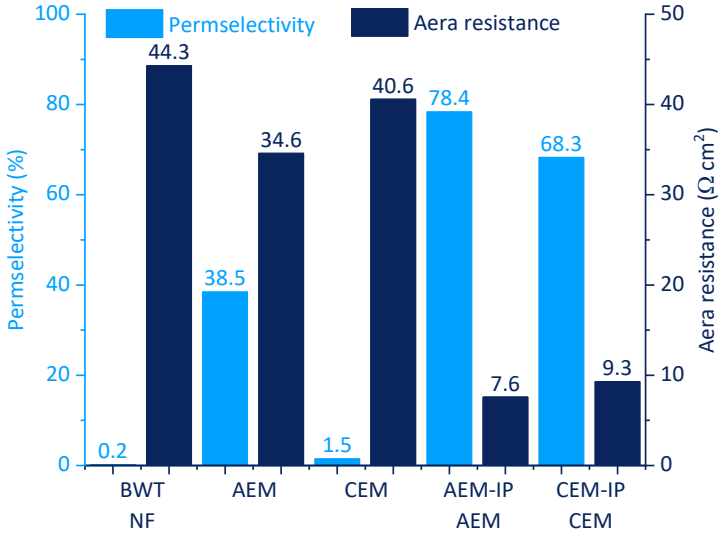

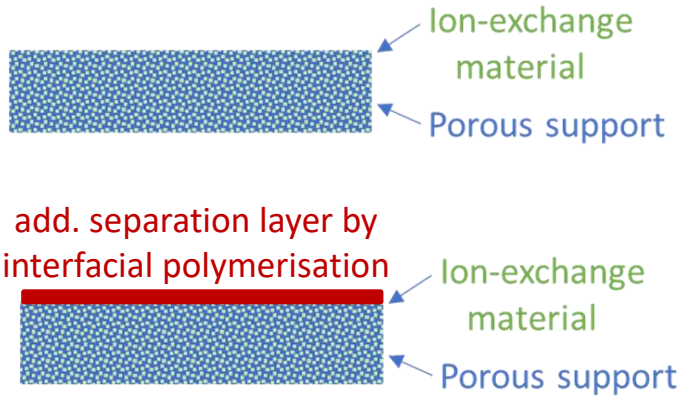

Summary and Conclusion

- Ion-exchange membranes were successfully prepared by pore filling approach
- Easy to perform and commercially available materials (monomers, support) can be used
- Preparation is easily scalable (finally roll-to-roll)
- Properties depend strongly on porous support used and extent of pore filling
- An additional functionalized, NF-like separation layer improves the properties remarkably

Future work

- Testing of monovalent ion selectivity (in progress)
- Optimization of membranes concerning resistance, permselectivity and monovalent ion selectivity

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Thank you very much for your attention!