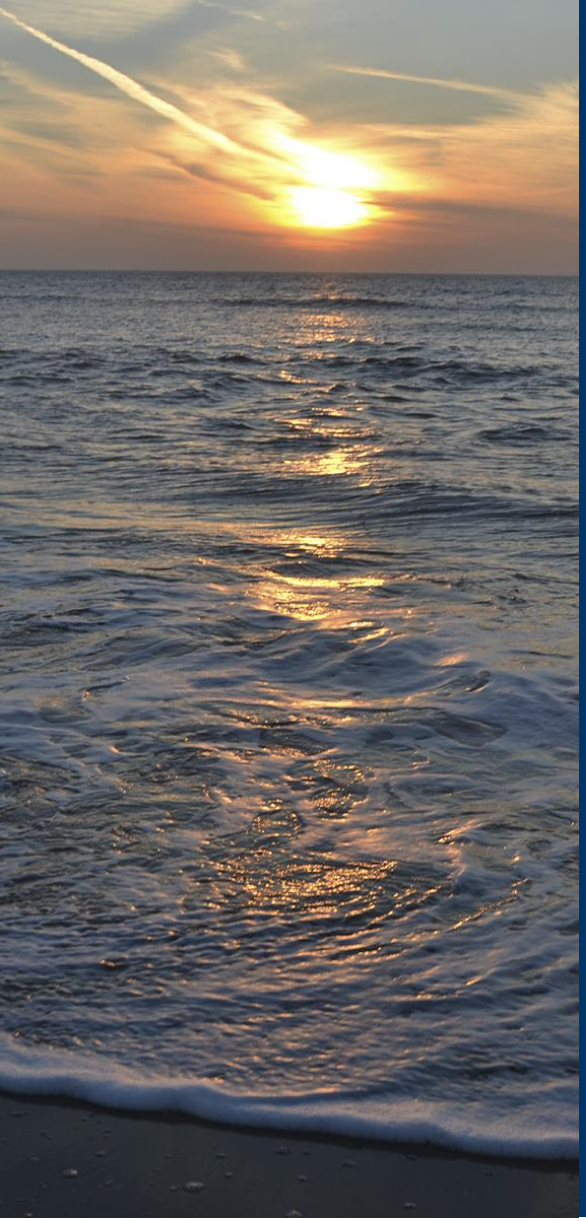

Atomic layer deposition for ceramic tight NF membranes

Bas Heijman

Ran Shang

Irene Caltran

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Spent regenerant from ion exchange

Na^+	15	g/l
Cl^-	10	g/l
SO_4^{2-}	8	g/l
HCO_3^-	4	g/l
NO_3^-	0,2	g/l
NOM	0,5	g/l

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Ceramic NF
450 Da

>>

Polymeric NF
200-400 Da

A higher organic rejection

Ceramic NF with MW < 450 Da?

A higher multi-valent ion rejection

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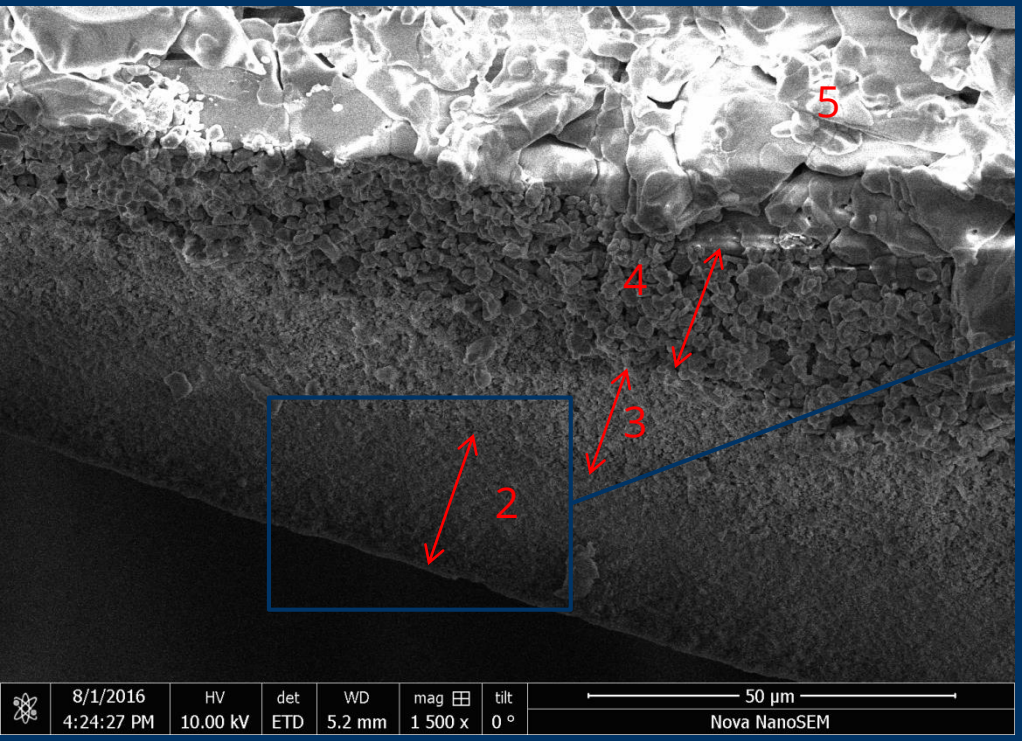

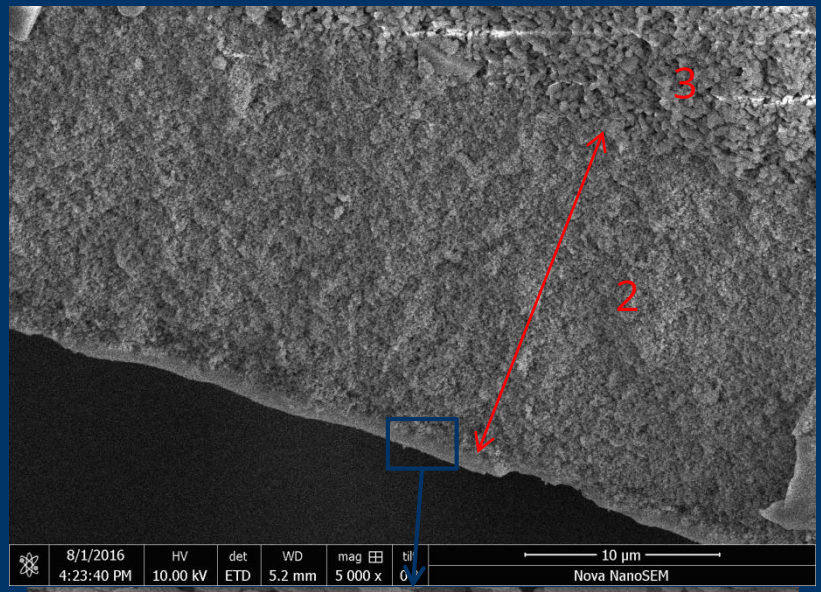

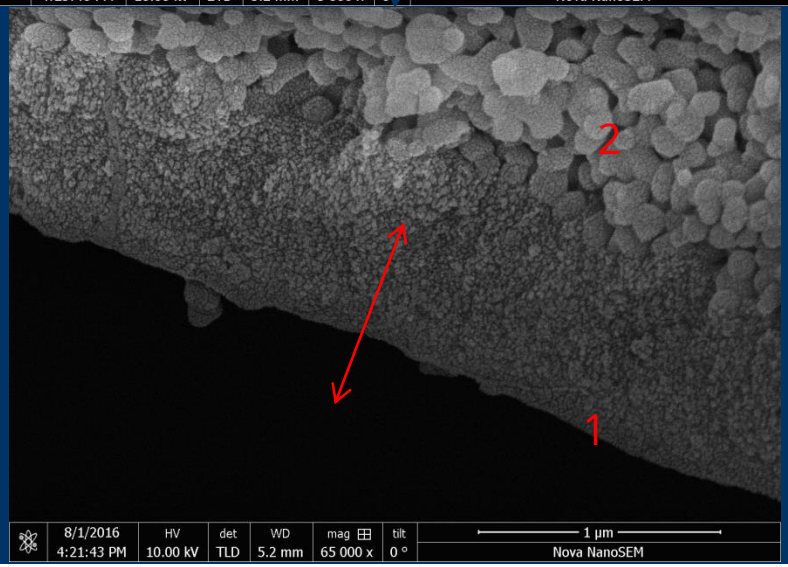

- The 450 Da membrane consists at least 5 layers.
- Thickness of each layer:
  1: 0.8 µm; 2: 18 µm; 3: 15 µm; 4: 18 µm;

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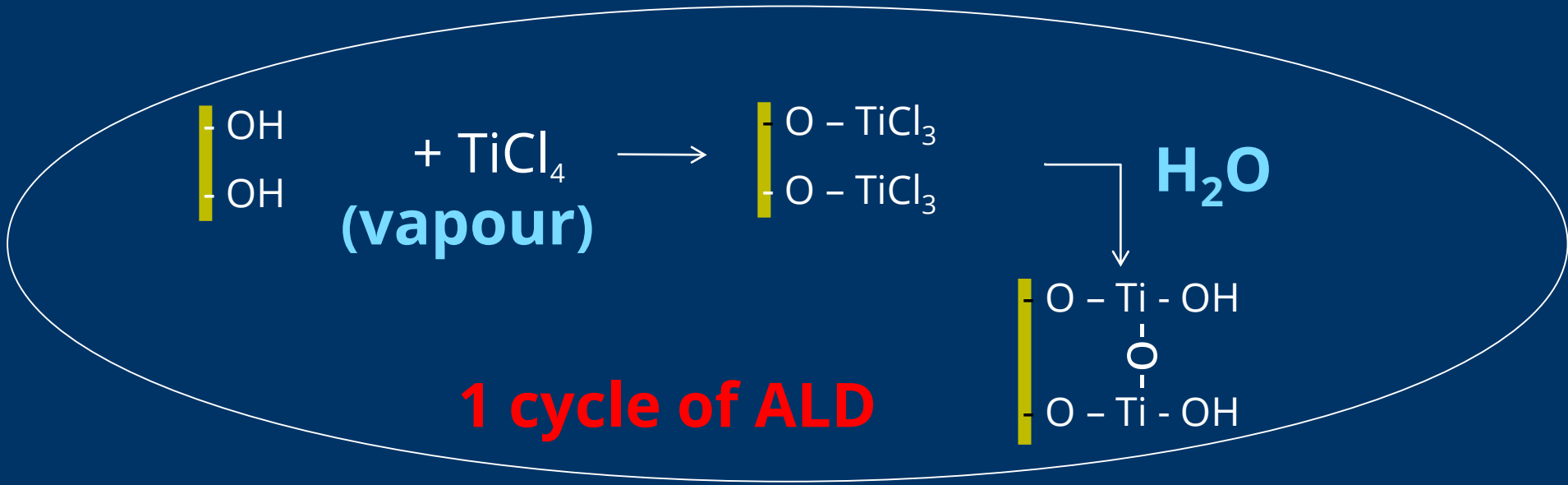
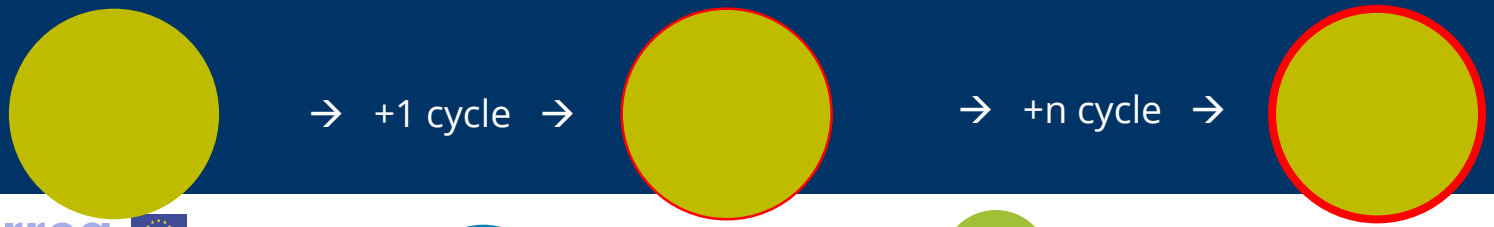
Current routes to produce ceramic NF

Method	Substrate	Finished MWCO	Water permeability, L m^{-2} h^{-1} bar^{-1}	Reference	Commercialization
Particulate sol-gel	Mesoporous substrate	200 Da	0.5	Tsuru et al. (1998)	No
Polymeric sol-gel	Mesoporous substrate	450 Da	20	Puhlfürß et al. (2000)	Yes
Polymeric sol-gel	Mesoporous substrate	200 Da	2 ~ 4	Van Gestel et al. (2002)	No

Example: ALD of TiO_2

$$TiCl_4 + 2\ H_2O \rightarrow TiO_2 + 4\ HCl$$





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To tailor the pore size of ceramic NF

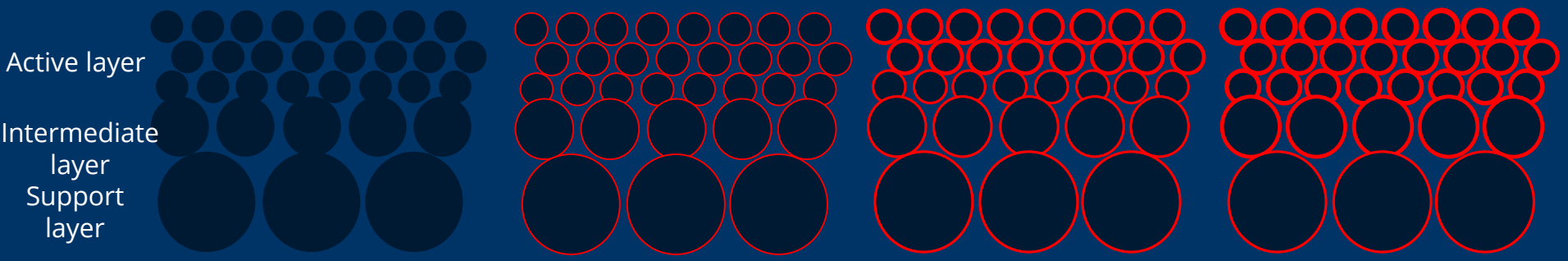
ALD:

Formation of homogeneous layer of < 0.06-0.4 nm per cycle

+1 cycle

+2 cycles

+3 cycles



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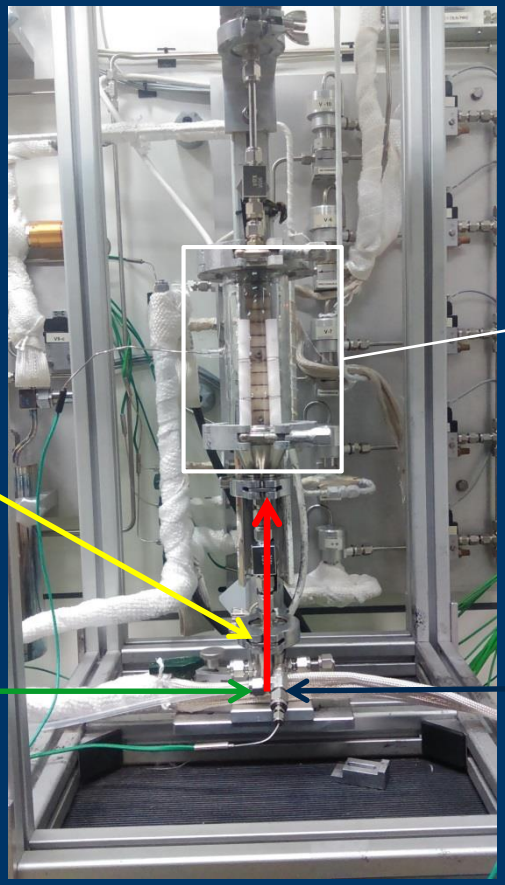
The atmospheric ALD (APALD) setup

MWCO: 450Da



Purging:

N_2

N_2

N_2 +$TiCl_4$

N_2 +H_2O

N_2

$TiCl_4$

H_2O

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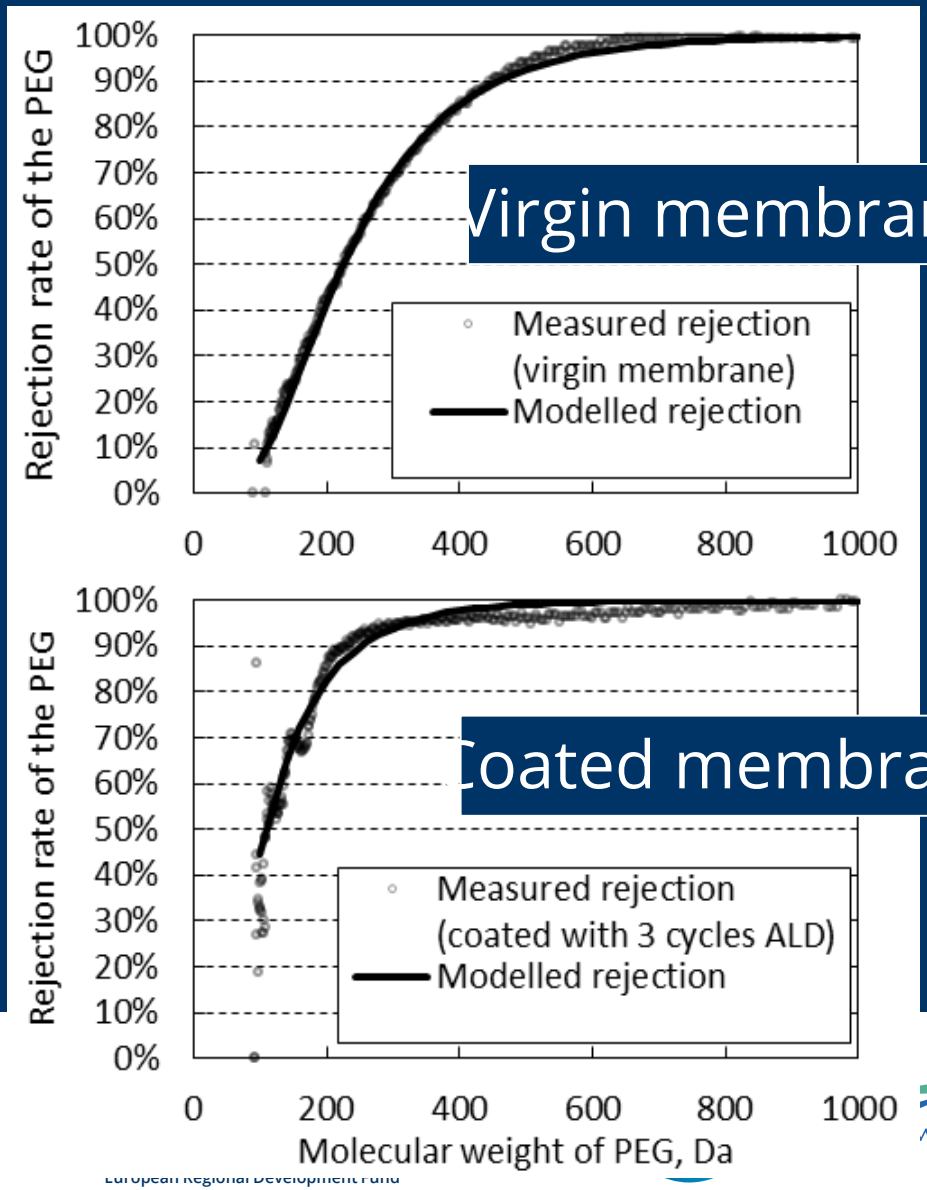
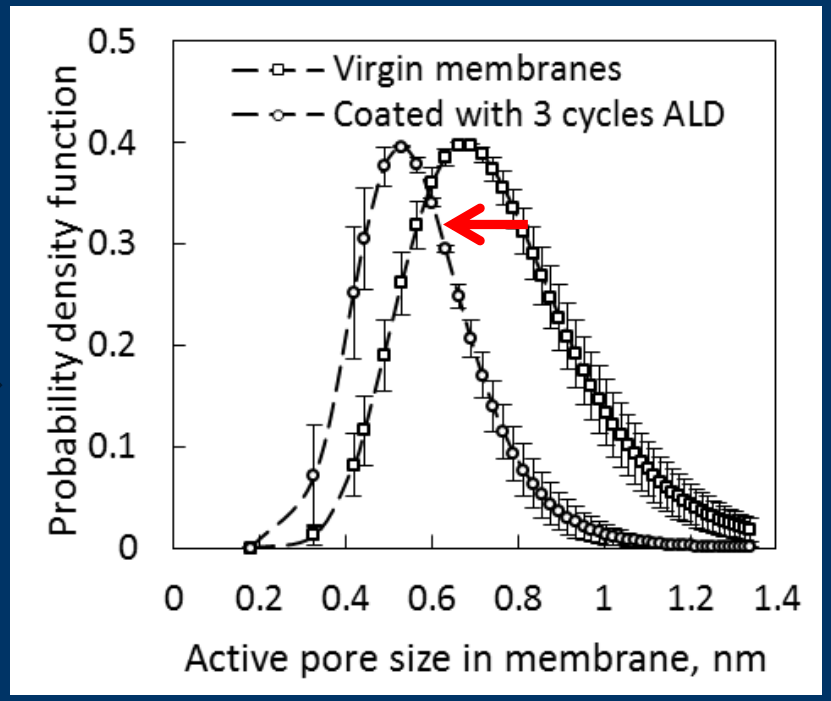
Results ALD-coating





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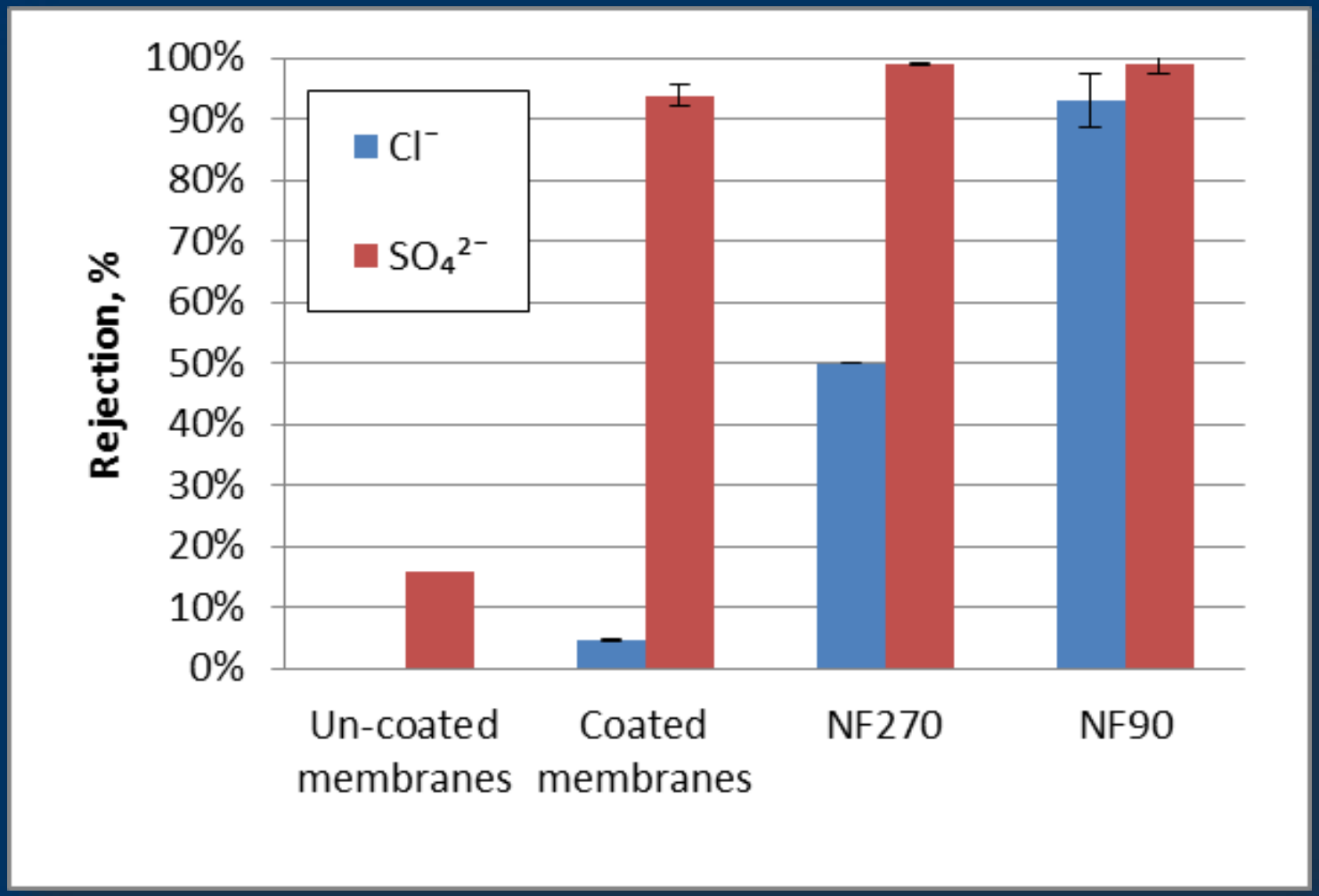
Permeability

Type of membrane	MWCO (measured), Da	Permeability, L m^{-2} h^{-1} bar^{-1}
450 Da CNF	463 ± 46	26 ± 7
Coated sample 1	287 ± 27	16 ± 5
Coated sample 2	333 ± 62	14 ± 0.3
Coated sample 3	277 ± 47	11 ± 3
DOW Filmtec NF90	About 200~300	7 ± 1
DOW Filmtec NF270	About 300~400	12 ± 2

Ion rejection



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Conclusion

- Pore size reduced with ALD-technology
- MWCO reduced from 450 D to 300 D
- Sulphate rejection high
- Chloride rejection low
- Next step: scale up to larger modules
- Try larger modules in a pilot plant

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