Considerations for the selection and dosing of inhibitors for CaCO₃-scaling in reverse osmosis and nanofiltration plants

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Today's agenda



What is the problem?



How do antiscalants work?



How much antiscalant is necessary?



What is the challenge for analytics?



What is the problem?





Membranes 2022, 12(12), 1287; https://doi.org/10.3390/membranes12121287



https://aqua-technik-gmbh.de/produkte-undchemikalien-antiscalants-membranreiniger/



https://complete-water.com/blog/reverse-osmosismembrane-failure-no-flow-high-conductivity



How do antiscalants work?

Scale formation without antiscalants





https://doi.org/10.1016/j.petrol.2019.106380

How do antiscalants work?





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The morphology of the scaling layer depends on the AS-dosage.









CS24 20 kV 26 mm BE 563,3 µm 100 µm-100 µm-1





How much antiscalant is necessary?





https://ars.els-cdn.com/content/image/1-s2.0-S0920410516303576-fx1_lrg.jpg

https://www.genesysro.com/sdi-particlecounting-turbidity-jar-test-tests.php

Jar tests are easy to carry out, but are the data obtained reliable?



Investigating the effect of antiscalants with a test plant is more complex, but provides more reliable data.





How does our membrane test plant look like?



Membrane area 2 x 80 cm² Feed-flow rate 1.2 L/h Max. pressure 60 bar





Permeate-flux 30 L/m²/h Permeate-flow rate 480 cm³/h Concentrate-flow rate 240 cm³/h



What are the typical test phases?



1 = Concentration phase

- 2 = Period of pressure increase
- **3** = Period of rapid membrane blocking



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Different test water compostions for the test runs

		RFWC				
Parameter	Unit	0.8	1	1.3	1.5	1.7
Cations						
Na⁺	mg/L	81.8	102.2	132.9	153.3	173.7
Mg ²⁺	mg/L	10.4	13.0	16.9	19.5	22.1
Ca ²⁺	mg/L	74.4	93.0	120.9	139.5	158.1
Anions						
CI	mg/L	96.0	120.0	156.0	180.0	204.0
SO4 ²⁻	mg/L	55.4	69.2	90.0	103.8	117.6
NO ₃ -	mg/L	79.5	99.4	129.2	149.1	169.0
HCO ₃ -	mg/L	180.6	225.8	293.5	338.7	383.9
рН		8.2	8.2	8.2	8.2	8.2
LSI of the feed water		0.85	1.07	1.25	1.58	1.70
Calculated LSI of the concentrate		1.8	2.0	2.2	2.4	2.5

Variation of Ionic Concentrations at different

Relative Feed-Water Concentration ratios (RFWC)



Pressure development vs. time for different PCA-dosing





Pressure development vs. time for different PCA-dosing





There is a risk of overdosing.





Critical PCA-concentration vs. Ca-Concentration in the concentrate

Pressure development vs. time for different PCA-dosing





Membrane SEM-images for increasing PCA-dosage





How can we measure the scaling layer thickness?

XRF can be used to estimate the layer thickness.



Clean Membrane

Scaled Membrane



What happens if we use polycarboxylates?



PAA

AA/EA

Acrylic acid partially neutralized

P- free N- free Acrylic Acid / Ethylacrylate

> P- free N- free



AA/AMPS

Acrylic Acid / Acryl-amido-propyl-sulfonic acid

P- free



Scaling layer morphology depends on AS-dosage and AS-type.



Cologne Membrane Lab

AA/AMPS, RFWC 0.8

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Scaling layer morphology depends on AS-dosage and AS-type.



AA/EA, RFWC 0.8

What is the challenge for the analytics?

- We know that AS work
- However, it is also known that too much AS can promote membrane blockage and unnecessarily pollute the environment

So Charly Calcite asks:

How can the concentration of the effective AS components be measured during the operation of an RO/NF system?



