

Insights into antiscalant effectiveness to inhibit scaling in reverse osmosis

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INTRODUCTION

- Scaling is a major form of inorganic fouling in NF/RO, caused when concentration of sparingly soluble salts exceeds their solubility limit & precipitate
- Common RO scales : CaCO_3 , CaSO_4 , BaSO_4 , SiO_2
- Consequences of scaling: Reduced permeability, increased energy consumption, shortened membrane lifetime
- Addition of antiscalants (AS) typical during NF/RO operation - chemicals made specifically to inhibit scaling

OBJECTIVE

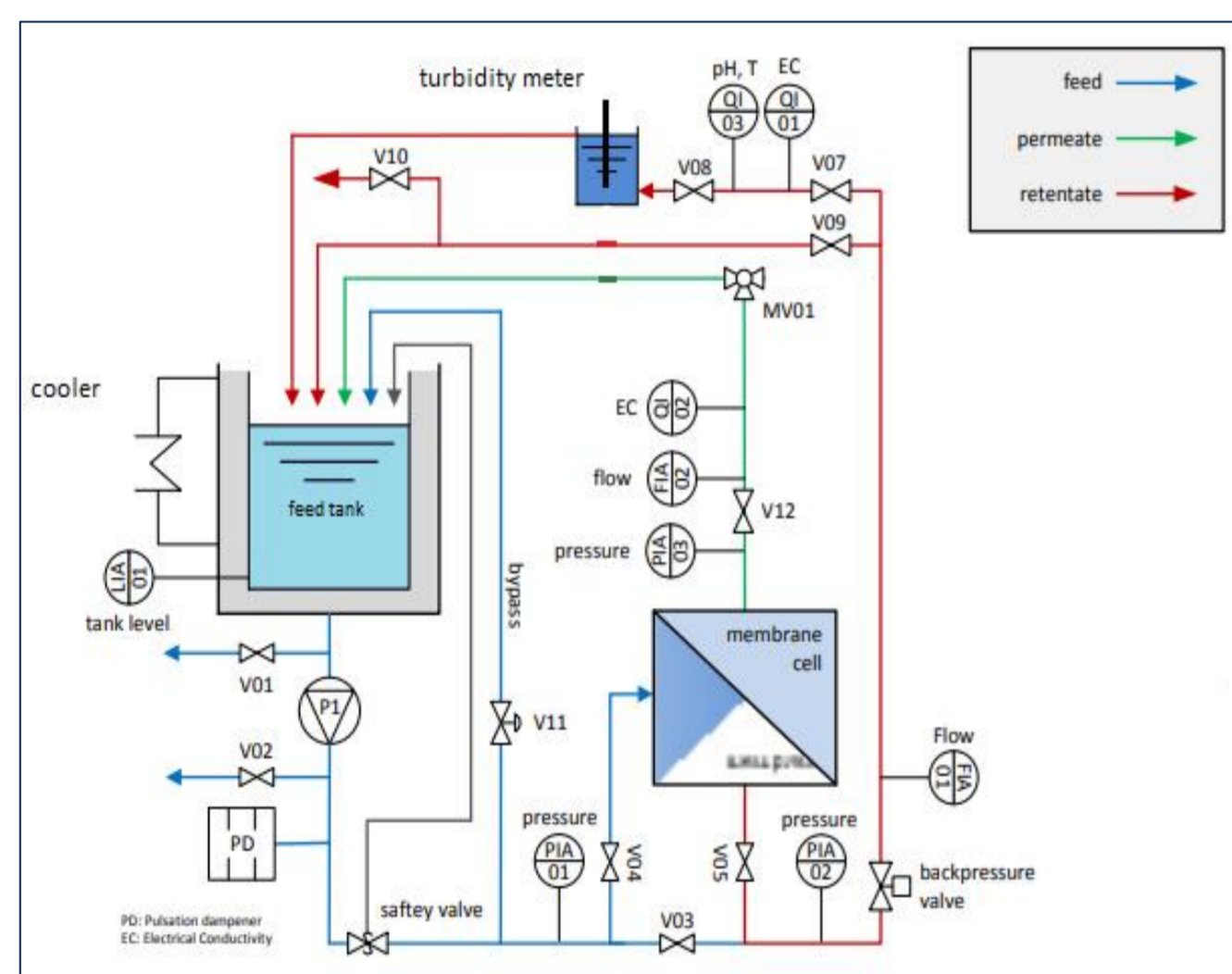
Test effectiveness of commonly used antiscalants in drinking water treatment in Germany & develop a reliable method for antiscalant testing

MATERIALS & METHODS

CaSO₄ Scalant 68 mM / 25 mM Na₂SO₄ + CaCl₂

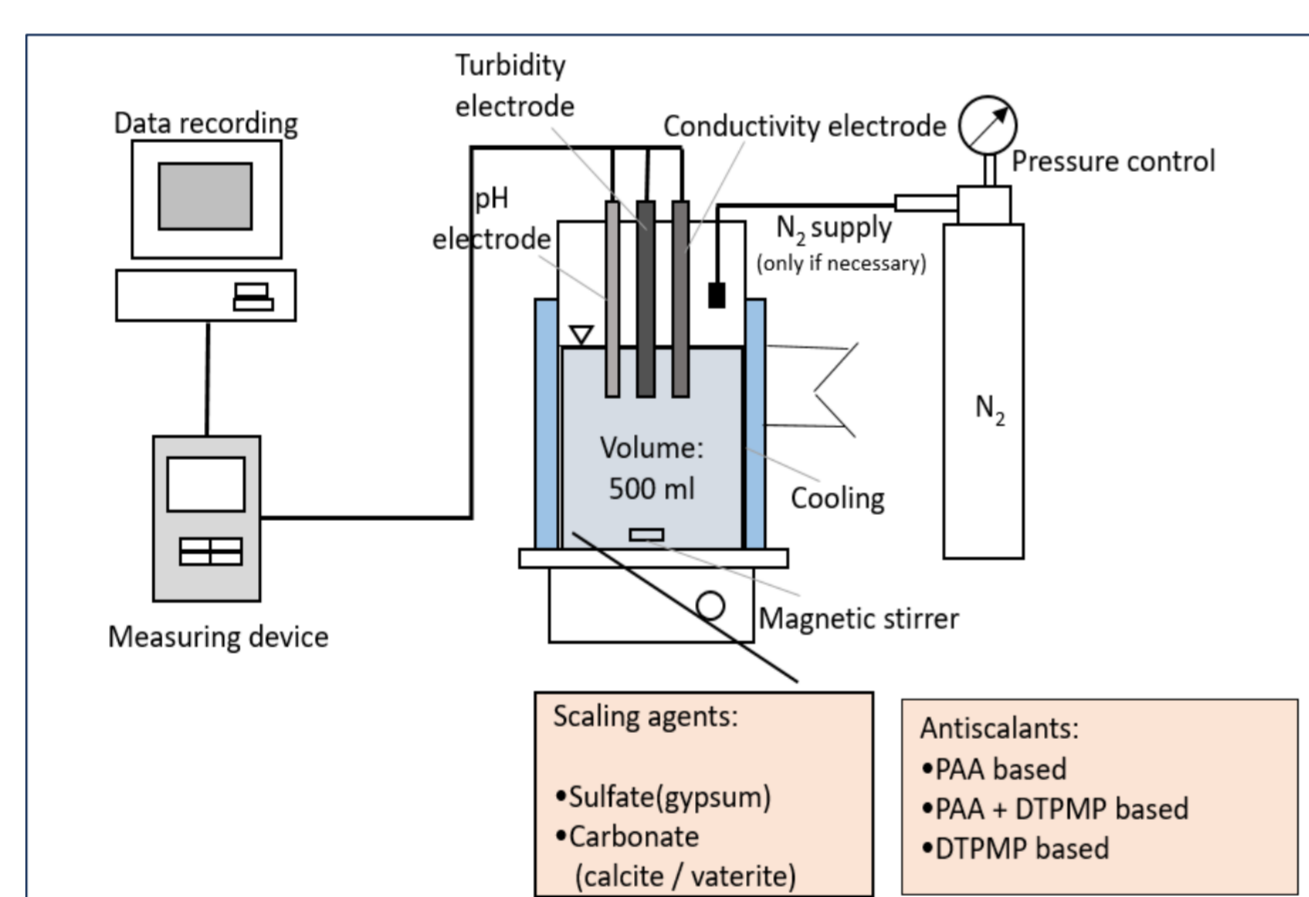
Commercial Antiscalants (active ingredient)	PAA (P-free)	PAA + DTPMP	DTPMP	ATMP	PBTC
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Lab-scale RO Pilot Plant



- Cross-flow operation with flat-sheet RO membrane (without spacers)
- Feed 6L; 25 mM sulfate + Antiscalant
- Recirculation mode; $u = 0.1$ m/s; TMP = 25 bar (constant)
- Measure rate of flux decline
- Fast flux decline: low inhibition
- Slow flux decline: high inhibition

Stirred-Beaker Test



- Beaker with 500 ml solution (68 mM sulfate + Antiscalant)
- Continuous stirring @ 100 / 200 rpm
- Measure rate of turbidity increase & define Induction time (t_{ind}) at 1 NTU
- Low t_{ind} : low inhibition
- High t_{ind} : high inhibition

LIMITATIONS OF ANTISCALANT USE

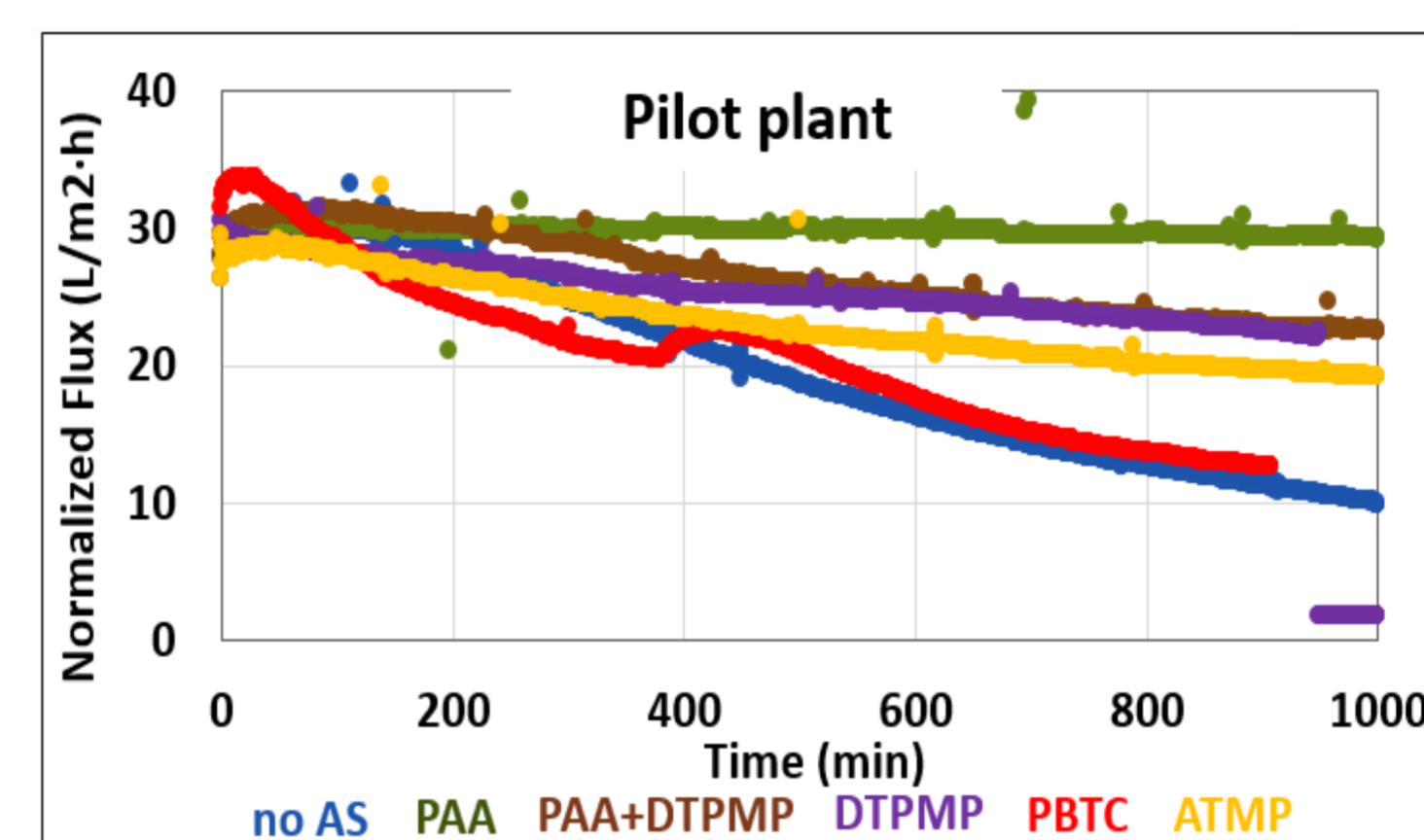
- Feed dosing limit 2.5 mg/L Dry Matter (TrinwV, Liste §20, former §11)
- Persisting concentrations in retentate stream (need for disposal, regulations)
- Minimum dosages desired by water utilities to reduce material costs
- Difficulty in determining the appropriate AS and its dosage
- Lack of clarity about effectiveness of AS against specific scalants

CONCLUSION

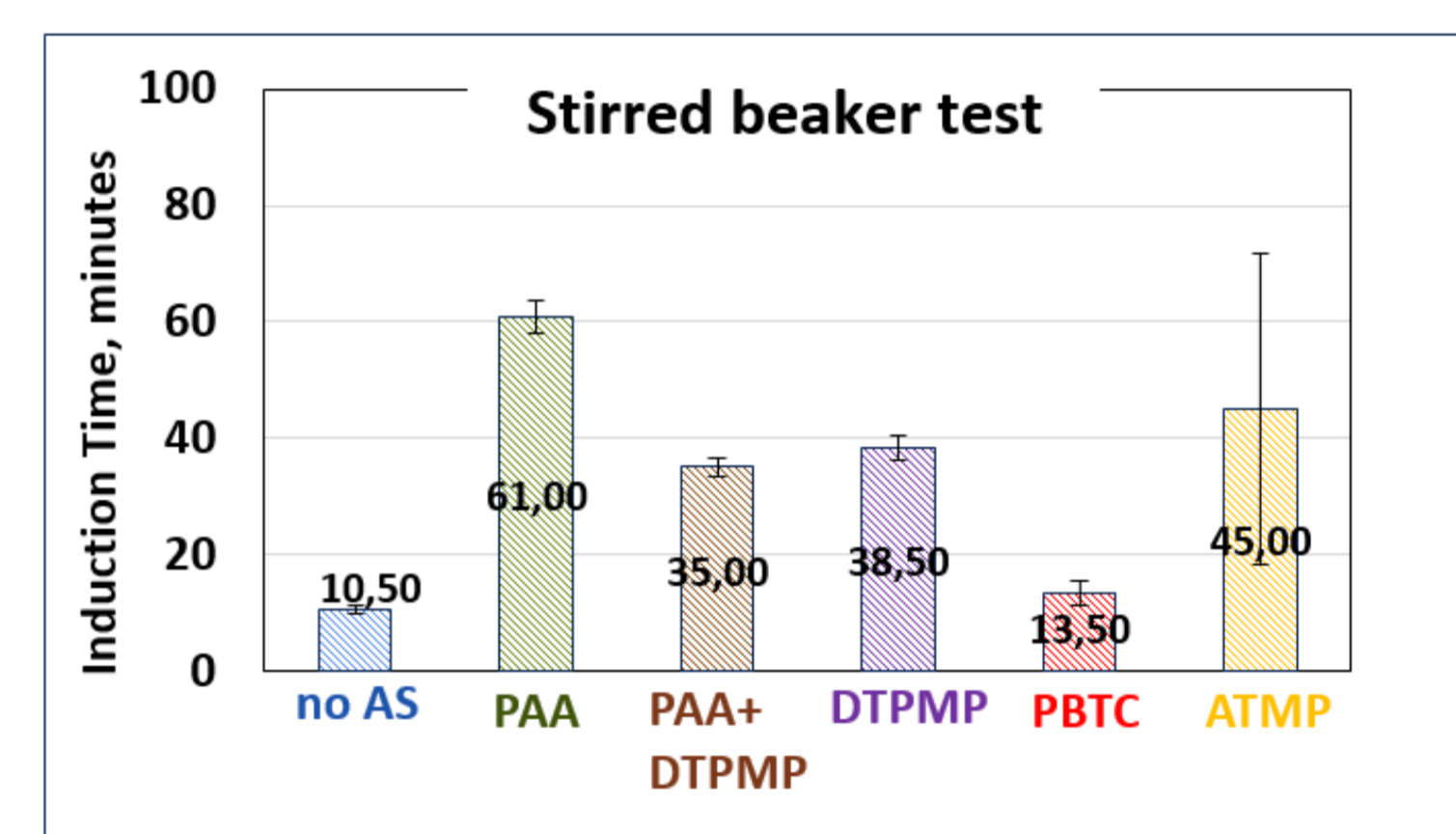
- Easy-to-implement stirred-beaker test proved to be a good pre-determination step for scale inhibition
- Varying effectiveness of antiscalants based on dosage: PBTC unsuitable for CaSO_4 inhibition, while other phosphonates have good threshold inhibition at higher dosages (1 mg/L)
- PAA shows good scale inhibition, but associated with small monomers potentially permeable through membrane and highly bioavailable

RESULTS & DISCUSSION

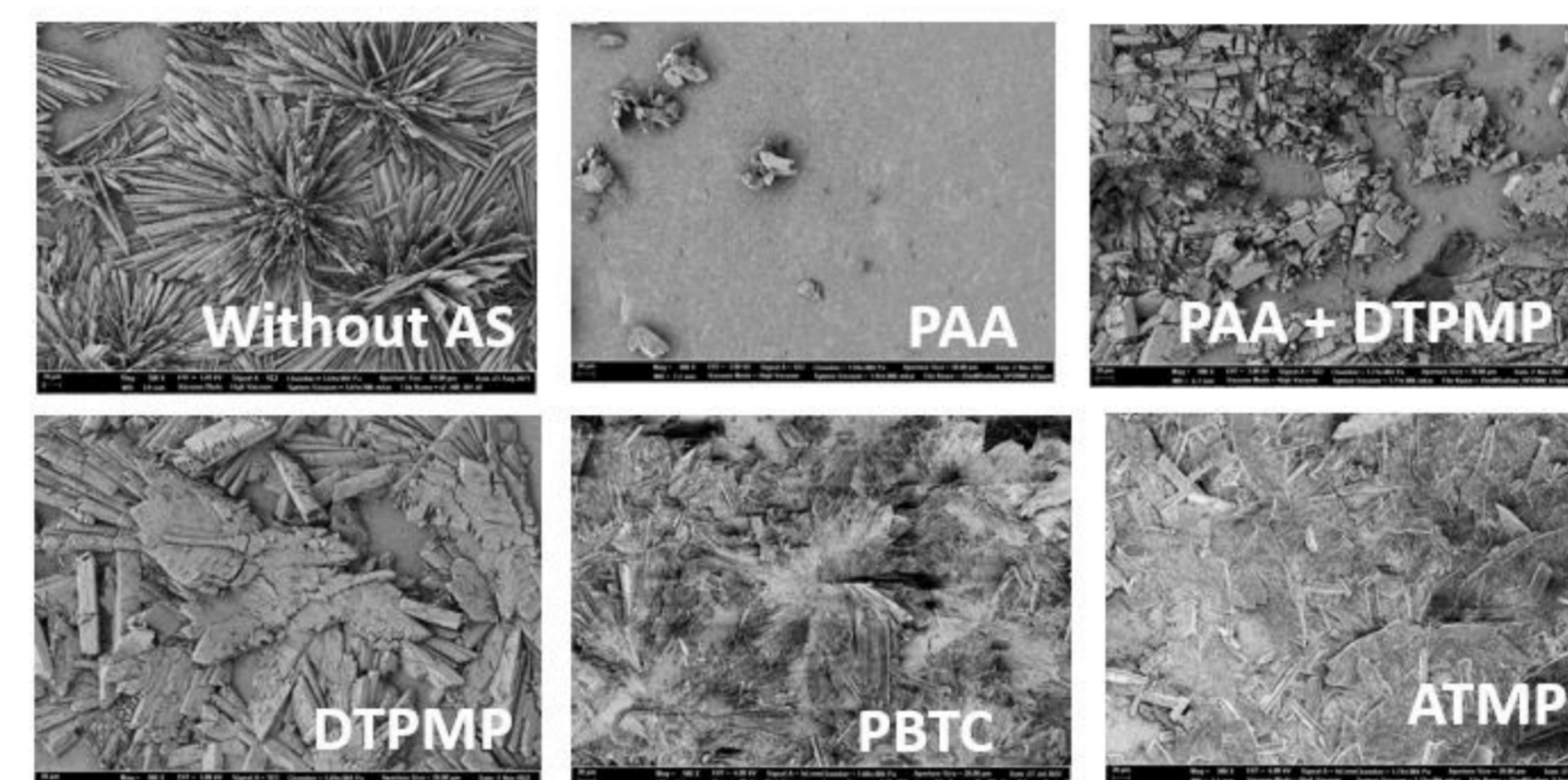
(a) Low antiscalant dosage



25 mM Na₂SO₄ & CaCl₂ + 0.5 mg TS/L AS
Recirculation mode; TMP = 25 bar; T ≈ 11 °C



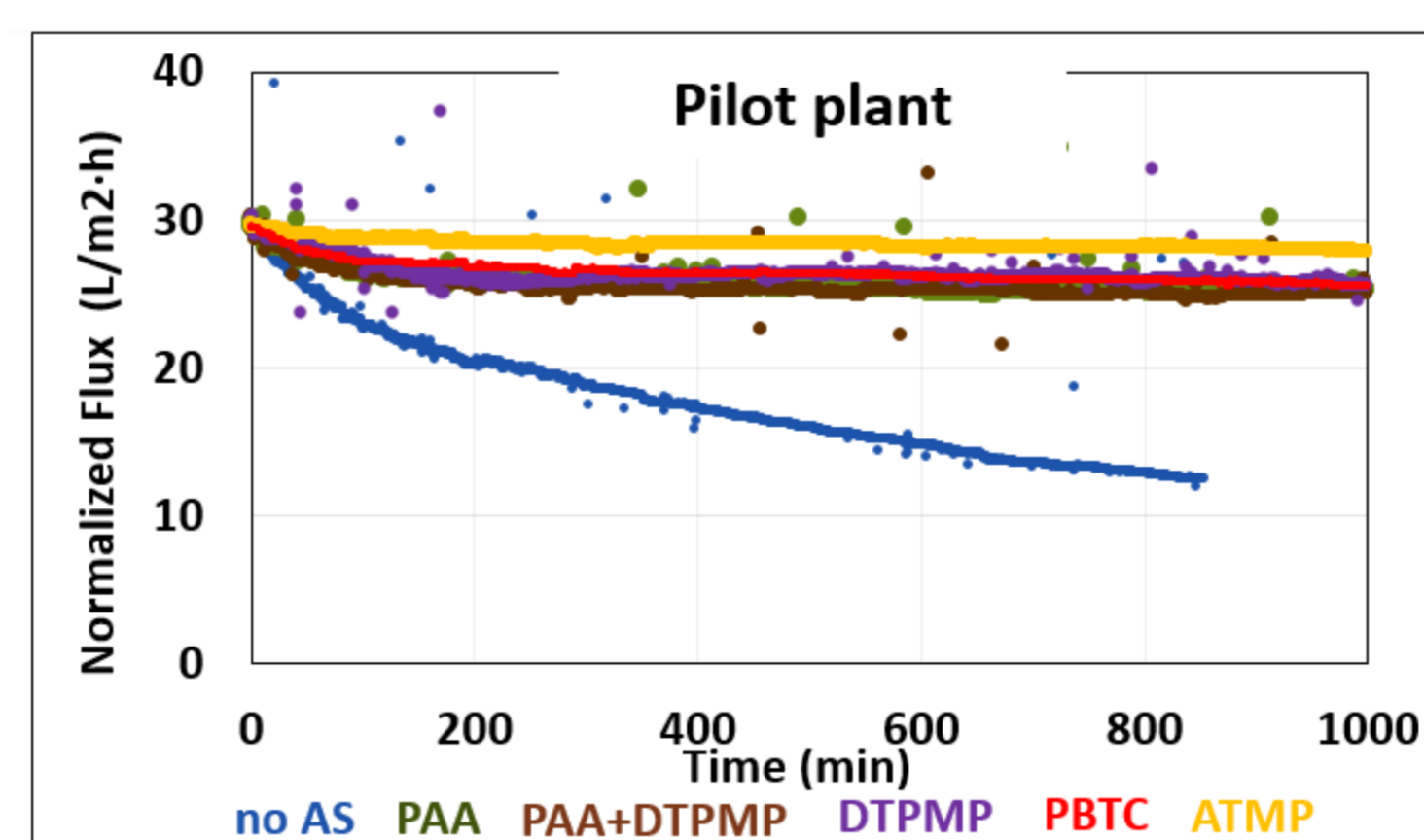
68 mM Na₂SO₄ & CaCl₂ + 0.5 mg TS/L AS
Magnetic stirring; T ≈ 11 °C, Induction time at 1 NTU, n=2



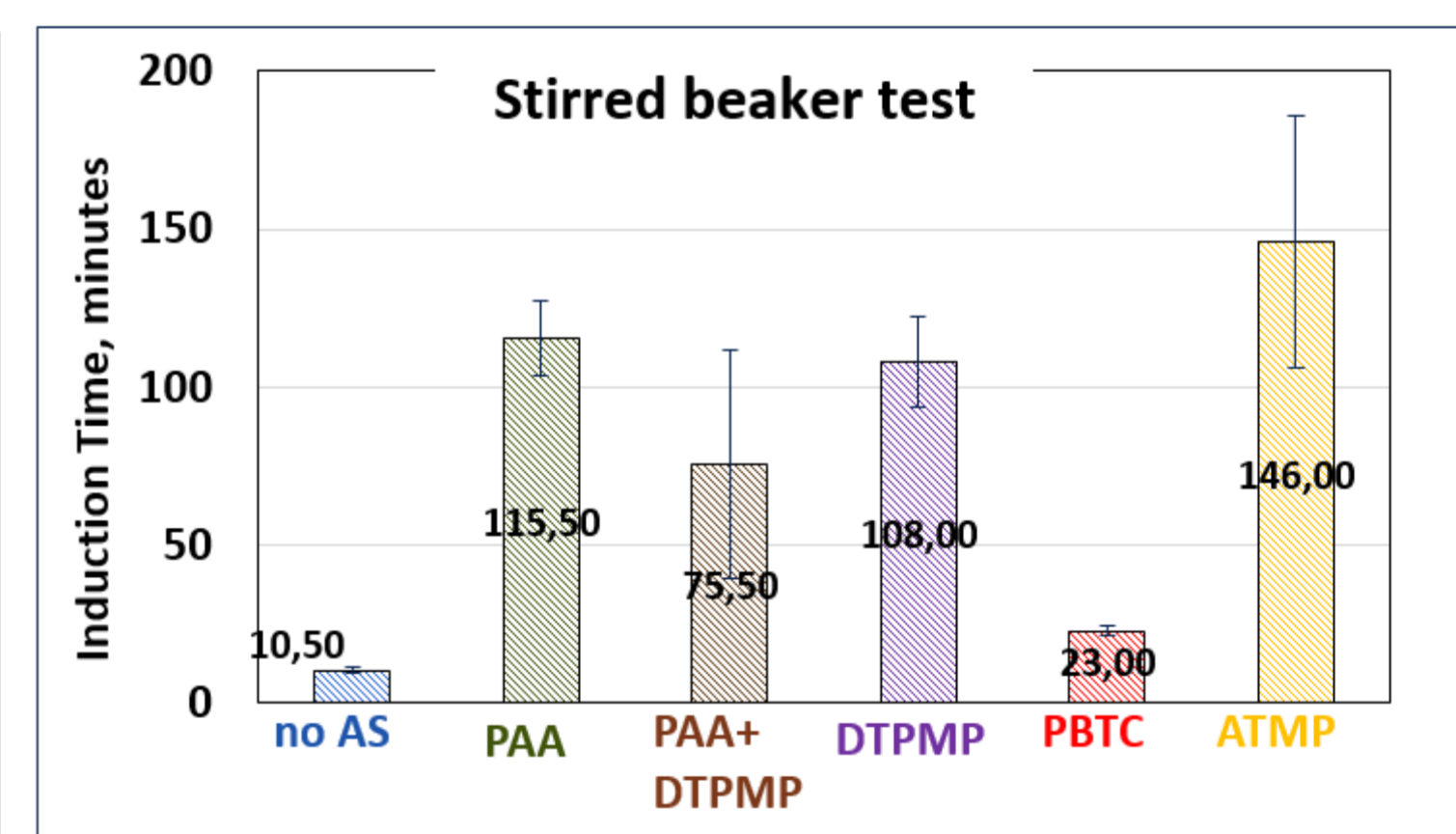
SEM of scaled RO membrane after filtration

- PAA maintains most stable flux at 0.5 mg TS/L by threshold inhibition & dispersion mechanism
- PBTC unsuitable for sulfate inhibition

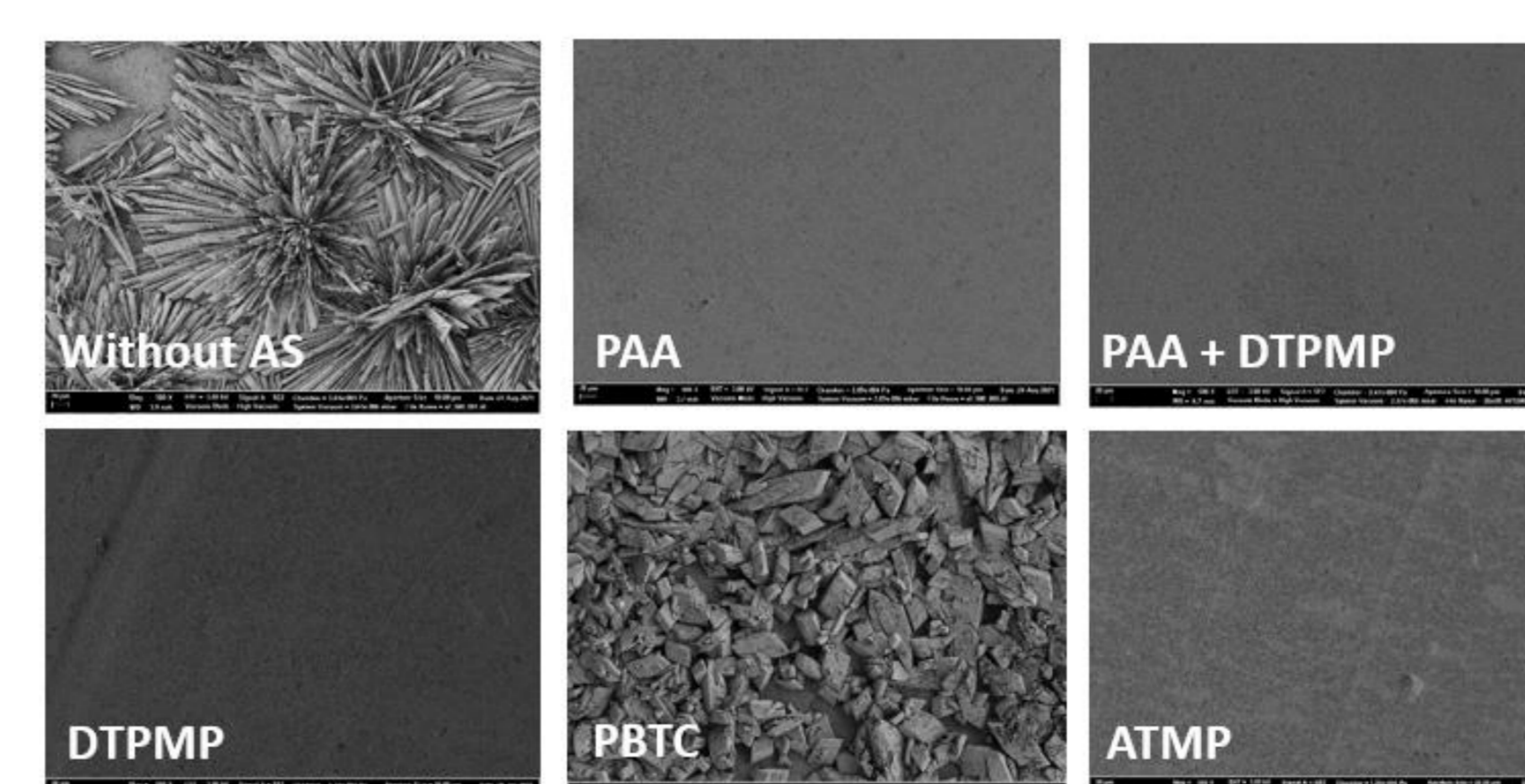
(b) High antiscalant dosage



20 mM Na₂SO₄ & CaCl₂ + 1 mg TS/L AS
Recirculation mode; TMP = 25 bar; T ≈ 11 °C



68 mM Na₂SO₄ & CaCl₂ + 0.5 mg TS/L AS
Magnetic stirring; T ≈ 11 °C, Induction time at 1 NTU, n=2



SEM of scaled RO membrane after filtration

- All antiscalants show relatively stable flux
- PBTC unsuitable as SEM shows several crystals on its surface, thus verifying stirred-beaker test results