BWA™
Water Additives

Scale Inhibitor Selection & Testing

Clear solutions for water treatment

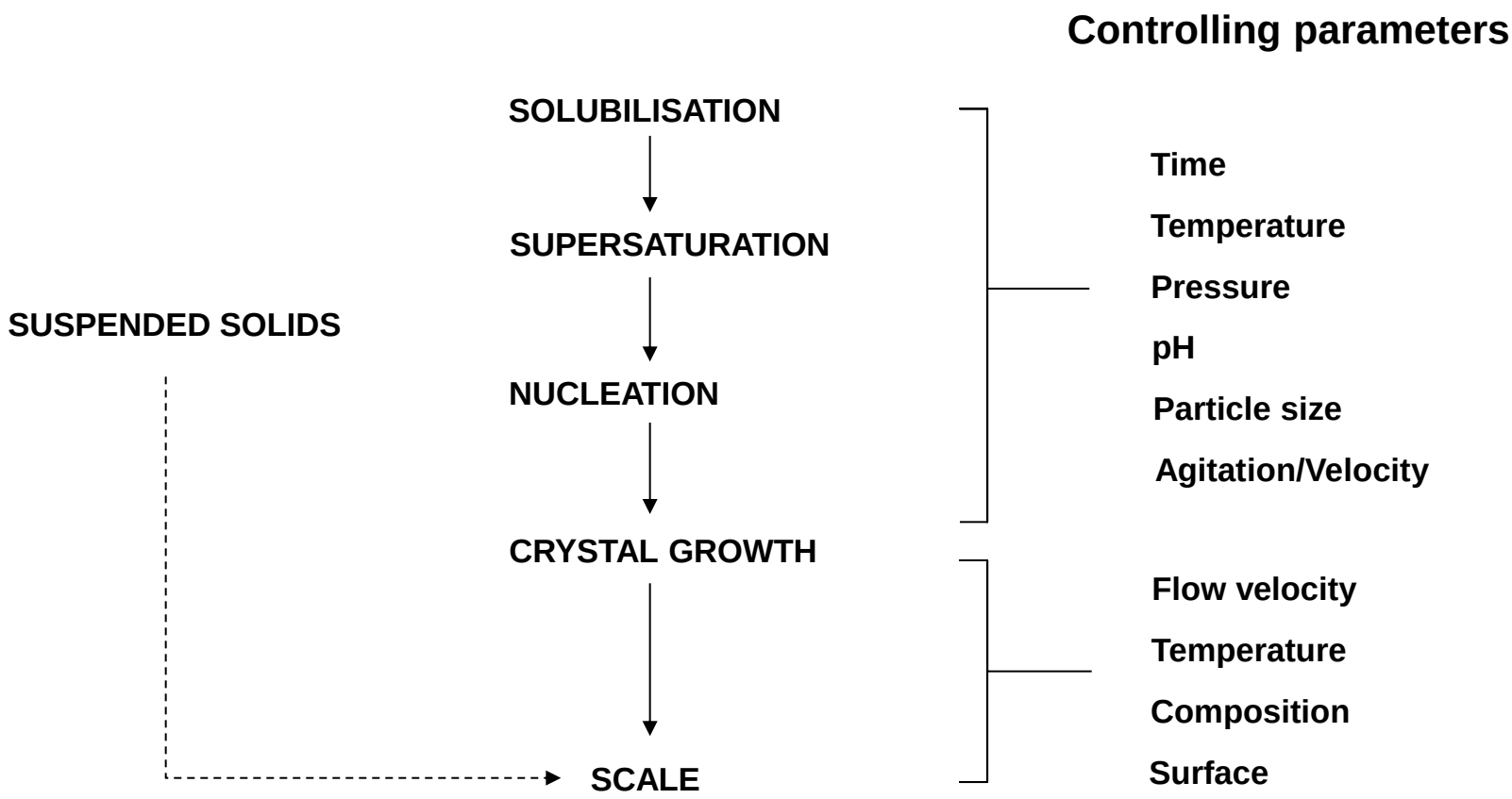
Presentation Outline

- Introduction to scale
  - Definition
  - Scale formation
  - Inhibition mechanisms
- Test methods
- Predictive scale modeling
- Conclusions

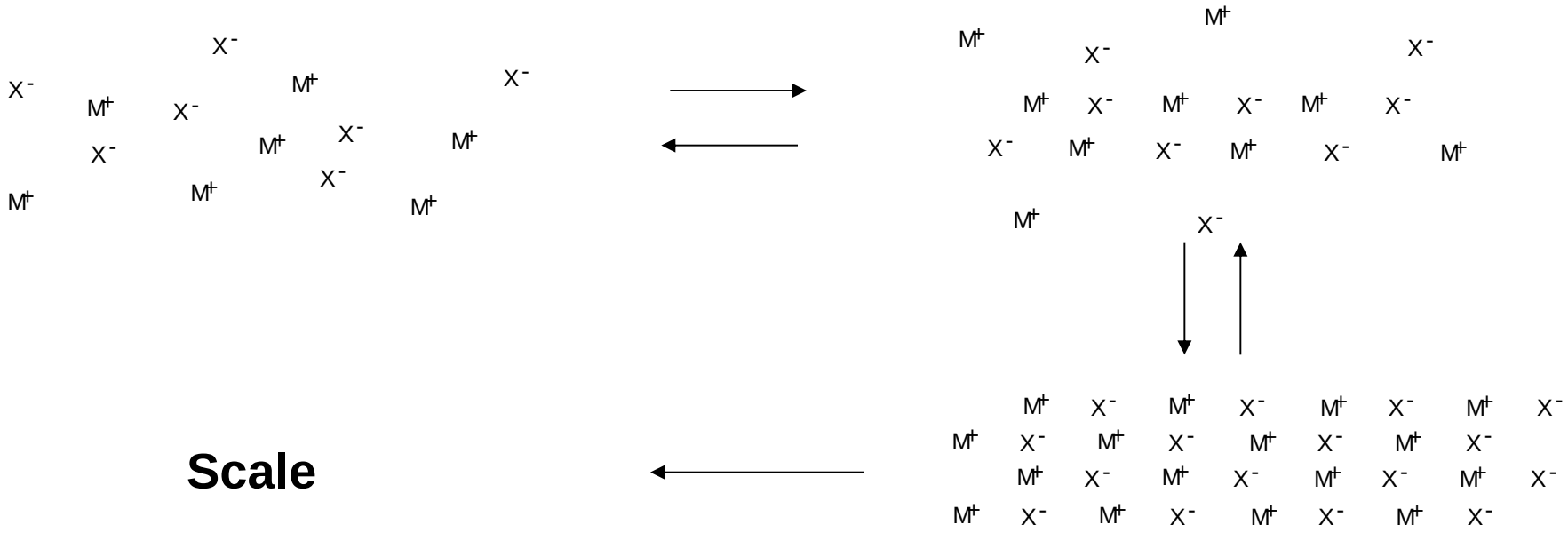
Definition of Scale

- **Deposition of sparingly soluble minerals onto metal or other surfaces in contact with water.**
- **Common scales**
  - **Calcium carbonate**
  - **Calcium sulfate**
  - **Barium sulfate**

Precipitation of Scale



Scale Formation Process

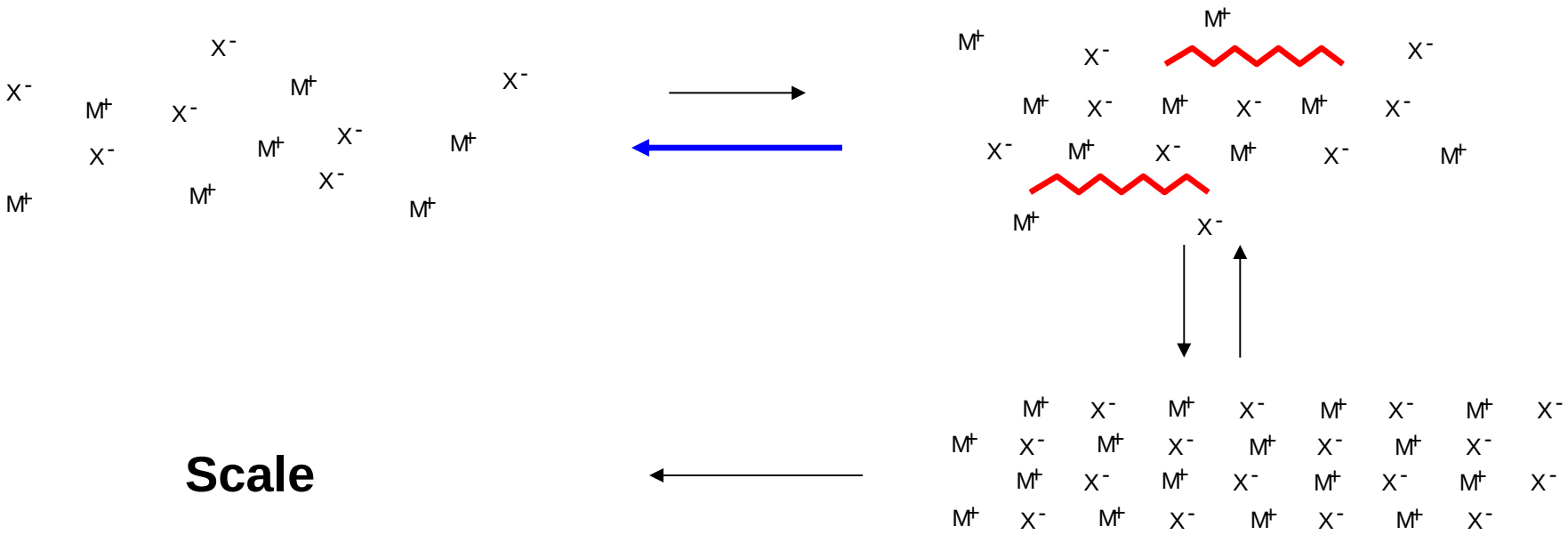


M^+ Cation

X^- Anion

Scale Inhibition Mechanisms

Threshold Effect



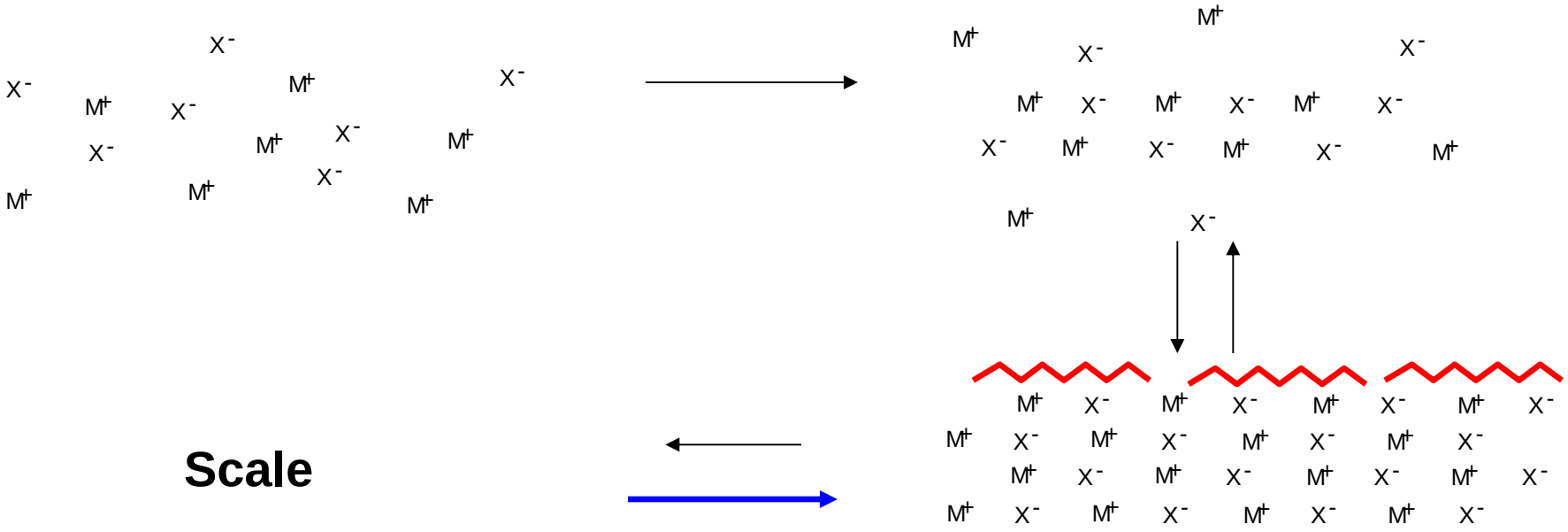
M^+ Cation

X^- Anion

Polymeric Additive

Scale Inhibition Mechanisms

Crystal Growth Inhibition



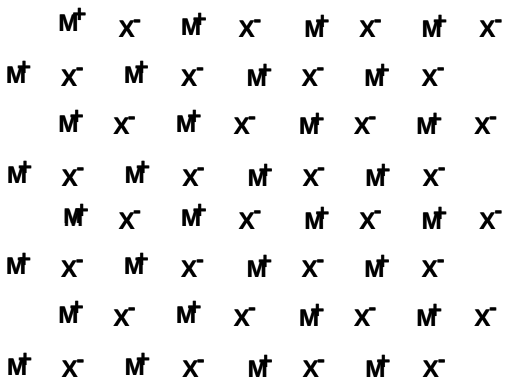
M^+ Cation

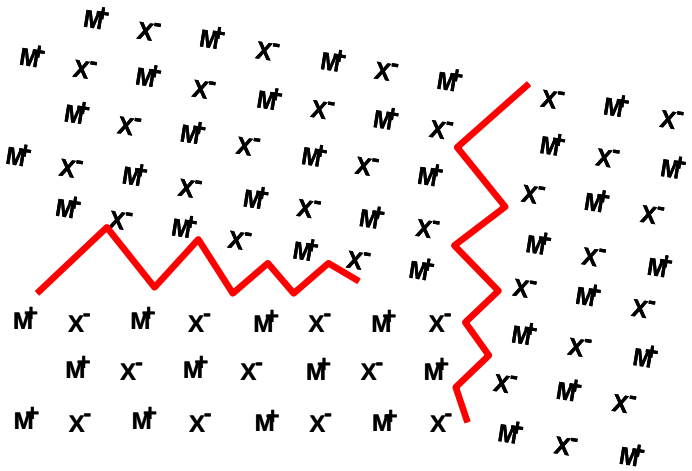
X^- Anion

Polymeric Additive

Scale Inhibition Mechanisms

Crystal Distortion





(i) Crystal Lattice

Hard scale

Good adherence to surfaces

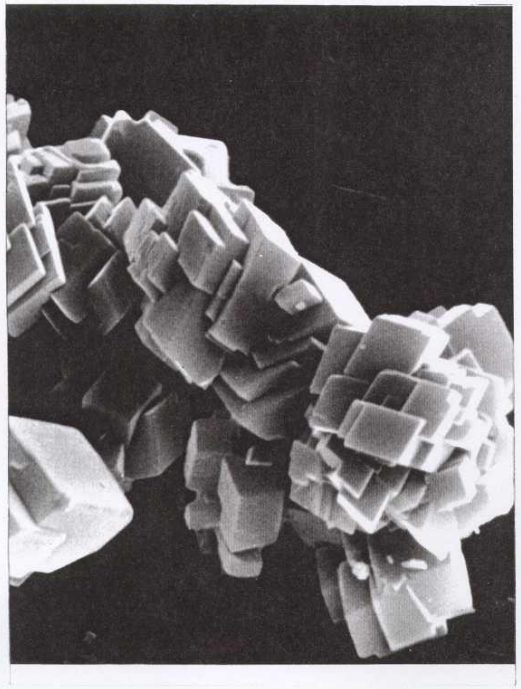
(ii) Distorted Crystal Lattice

Soft scale

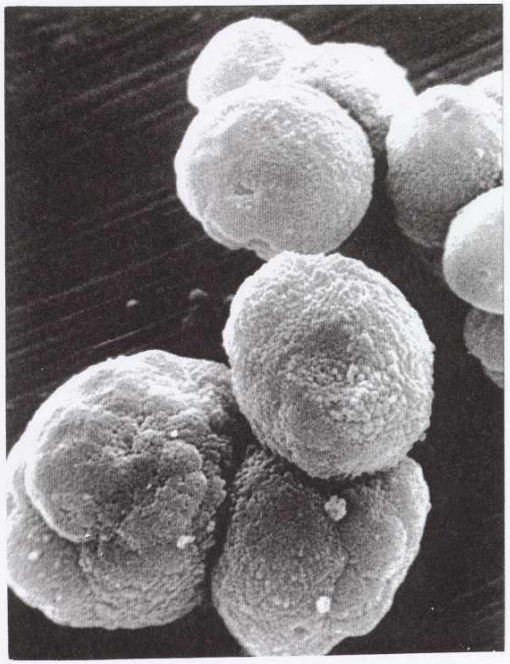
Less adherent to surfaces

Scale Inhibition Mechanisms

Crystal Distortion



No additive (magnification x 7500)

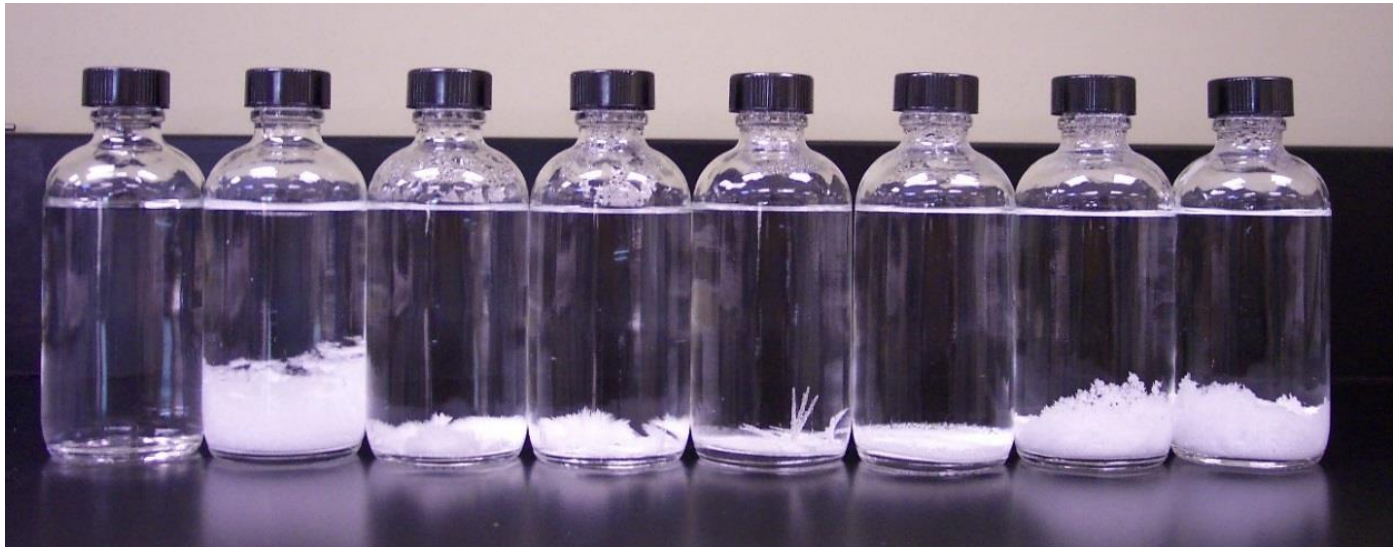


10 mg/l polymaleic acid (magnification x 7500)

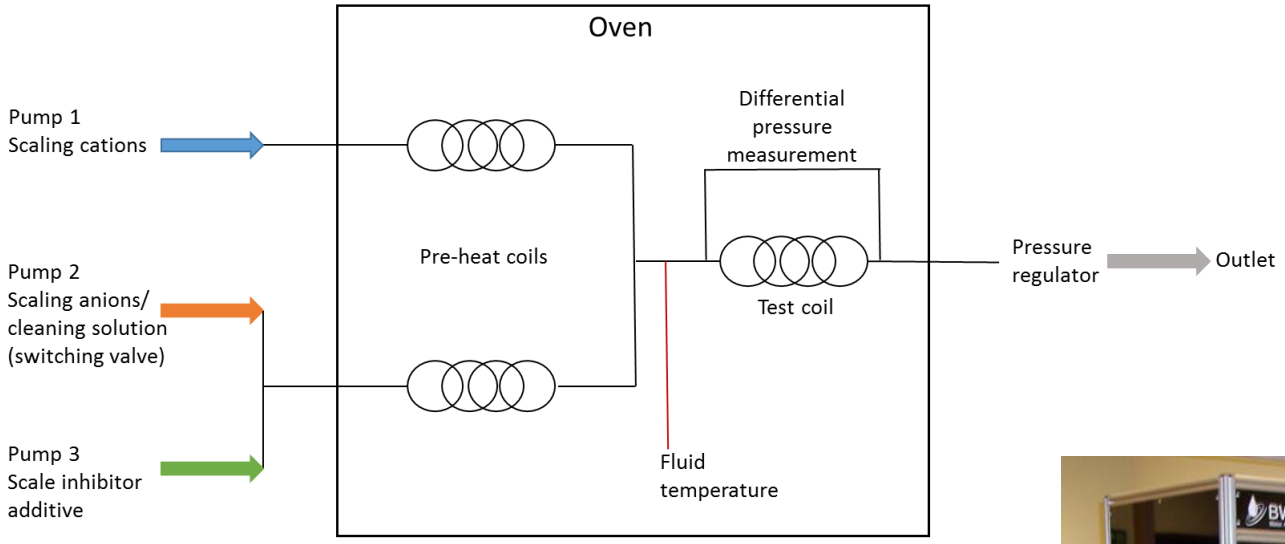
SCALE INHIBITOR TEST METHODS

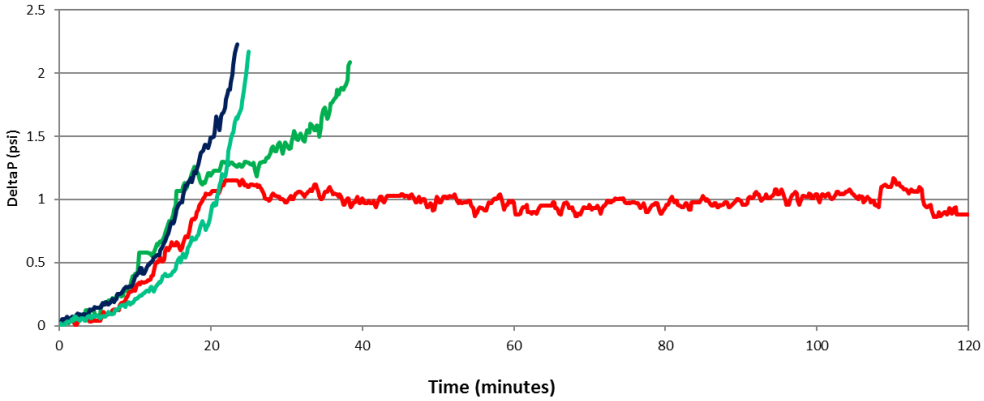
Bottle Testing

- Relatively simple and easy test
- Only assesses threshold inhibition mechanism so doesn't give a complete picture of an additive's performance



Dynamic Testing





Dynamic Testing

- **Requires sophisticated equipment**
- **More comprehensive test since it assesses all scale inhibition mechanisms - threshold inhibition, crystal growth inhibition, and crystal distortion**

Bottle vs Dynamic Testing

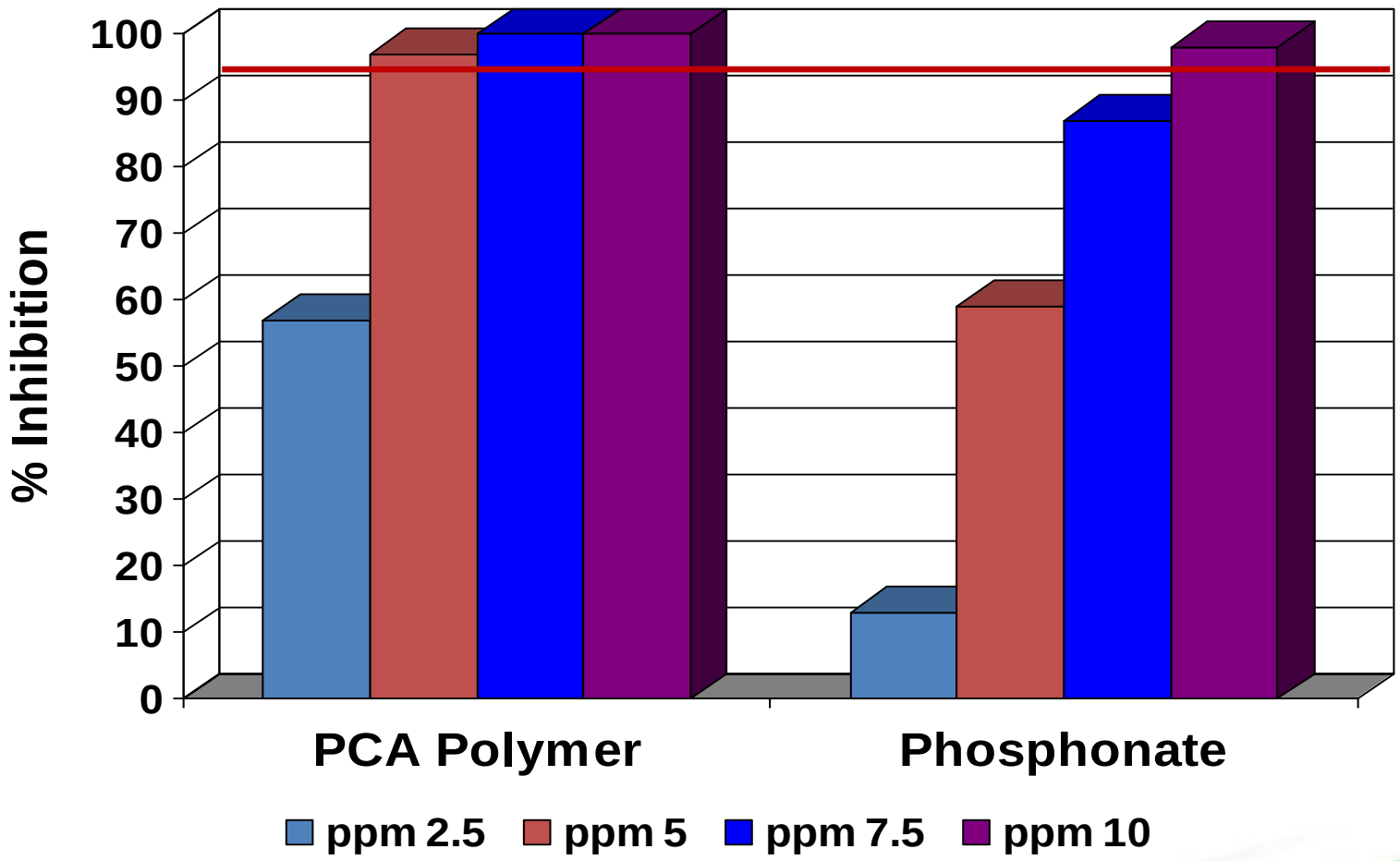
Bottle Test - Threshold Inhibition)

- Disrupt clusters before reaching critical size for nucleation prior to crystallization
- Low dose levels, typically phosphonates & some low molecular weight polymers
- Fail drastically once crystal formed

Dynamic Test - Crystal Growth Blocking

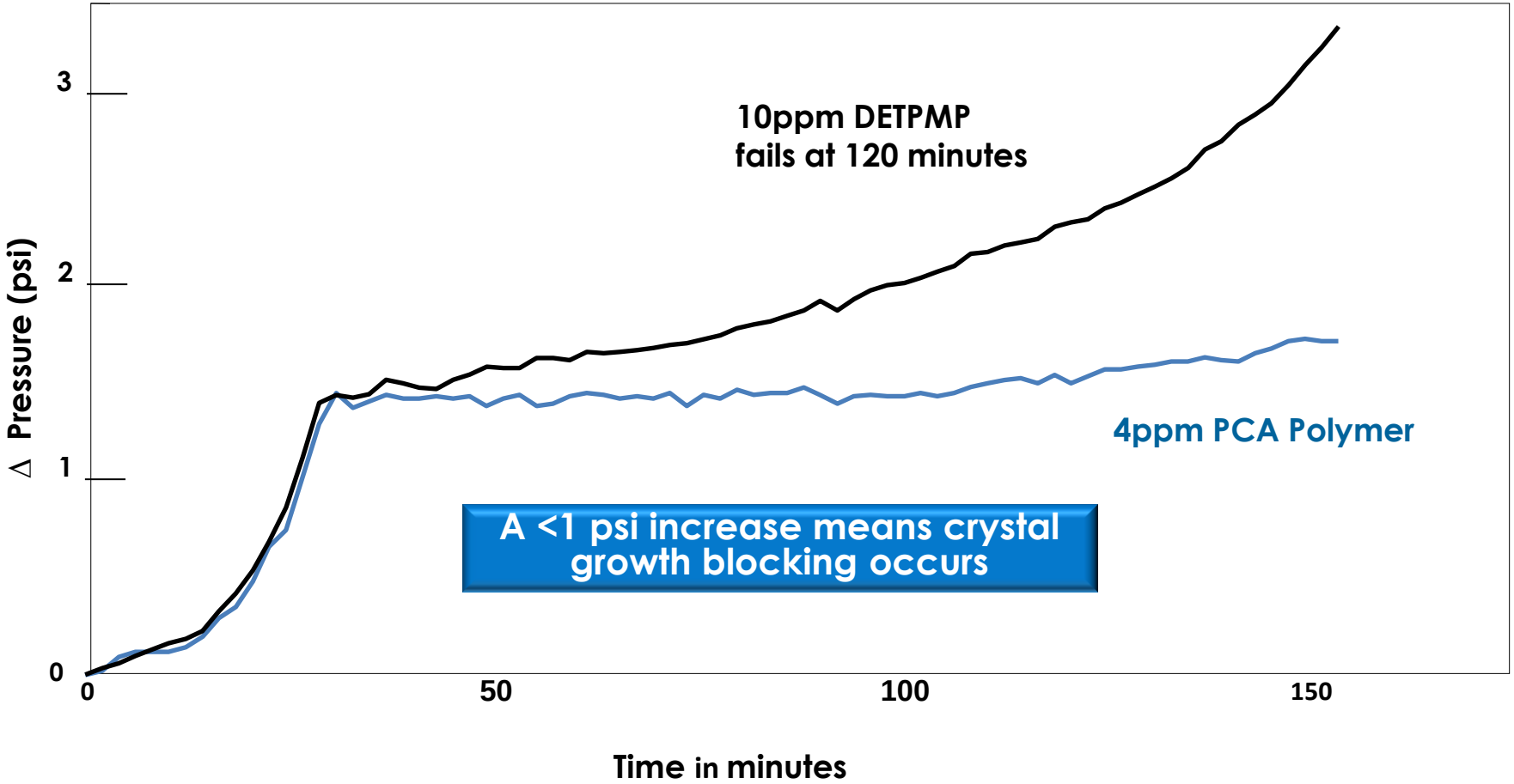
- Blocks further growth at crystal faces
- Inhibition of growth at crystal face leads to distortion to non-adherent form
- Specialty carboxylic polymers found to be above industry standards

Threshold Inhibition Example*



* Barium Sulfate Inhibition

Crystal Growth Blocking Example*



PCA polymer outperforms phosphonate as a crystal growth blocker

*Barium sulfate inhibition

PREDICTIVE SCALE MODELING

Modeling Starts with a Water Chemistry

- Very high sulfate concentration in the fresh water
- High barium and strontium concentration in produced water

	'Fresh' water source mg/L	Produced water mg/L
Na^+	1171	38,829
Ca^{2+}	460	16,893
Mg^{2+}	85	1734
K^+	0	566
Ba^{2+}	5.0	836
Sr^{2+}	0	2727
Fe^{2+}	0	143
SO_4^{2-}	2083	5.0
HCO_3^-	404	0
Cl^-	1100	101,269
TDS	5500	162,394
pH	6.40	5.90

Blending these waters is likely to cause severe sulfate scale issues

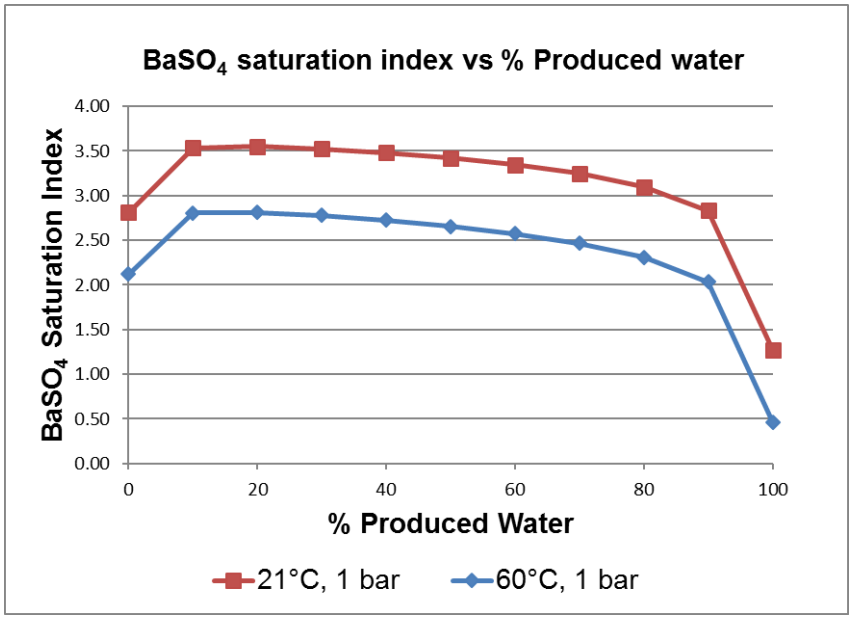
What Modelling Can Tell Us

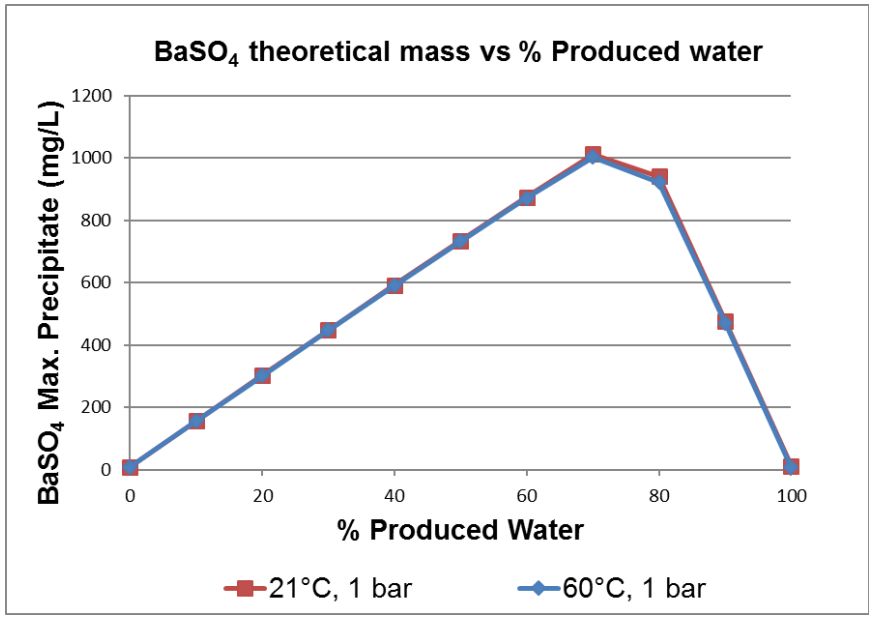
- What is the scaling risk with an 80:20 Fresh:Produced water mix?
- How does the scaling risk change with produced water?
- Are there any inhibitors that can reduce or eliminate scale formation?

- Scale modelling performed using ScaleSoftPitzer™
  - Saturation index
  - Amount of precipitate expected

Saturation Index		
Negative	Under-saturated	No scale precipitation
0	At equilibrium	No scale precipitation
Positive	Supersaturated	Potential for scale to precipitate

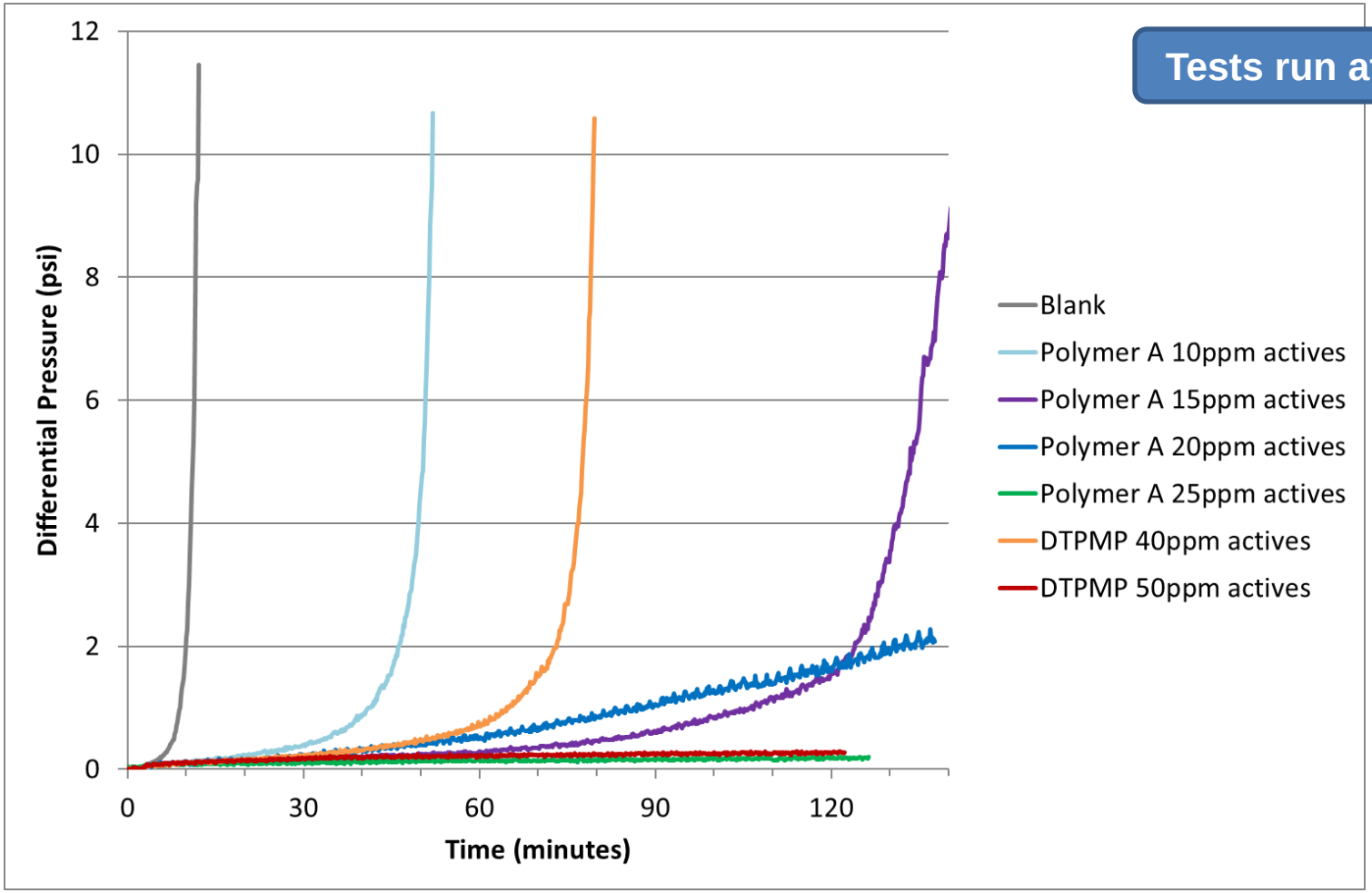
Modelling Results





- High severity $BaSO_4$
- Modelling helps you understand where you can operate
- 20% produced water feasible to treat but needs a high performing scale inhibitor.

Scale Inhibitor Performance



Polymer A = Sulfonated phosphinocarboxylic acid

Summary

- Scale inhibitors work by different mechanisms:
  - Phosphonates – threshold inhibition
  - Polymers - threshold inhibition, crystal growth inhibition, and crystal distortion
- Dynamic scale inhibitor testing is more comprehensive and a better predictor of field performance
- Predictive scale modeling can highlight scaling issues when using recycled water

Thank you

Questions?