New developments in scale and corrosion inhibitors for geothermal applications

Davide Parravicini – Alessandro Guidetti

Introduction

- Scale and corrosion affect basically all the geothermal plants, impacting their efficiency
- Scale is formed due to temperature, pressure and pH changes
- Most common scales are: Calcite, Barite (NORMs), Silica, Stibnite
- Several methodologies such as mechanical cleaning, pipeline heating and use of acids or alkaline chemicals have been developed and used
- However, use of corrosion and scale inhibitor seems to be the most cost-effective methodology

Mechanical clean-out is quite expensive: $0.5 to $2.0M/y for a major operation

Introduction

Corrosion is mainly related to:

- High temperature
- Chlorides
- Salinity
- H_2S
- CO_2
- pH modification to minimize silica scaling

Development of Scale and Corrosion inhibitors

Challenges

- High temperature affecting thermal stability
- Compatibility with brine
- Compatibility with materials and/or other chemicals

Degradation by-products or Ca-inhibitor adduct can precipitate and create a deposit that can affect the efficiency of the plant

Development of Scale and Corrosion inhibitors

How to develop a new scale or corrosion inhibitor

- Software simulations/scale analysis to define the issue
- Static and Dynamic performance test
- Thermal aging test
- Compatibility with brine, materials and other chemicals

Example n°1 – New Thermally Stable Corrosion Inhibitor

Objective: develop a novel film-forming corrosion inhibitor effective at high temperature

Weight loss coupon test used to screen > 30 new chemistries

Testing conditions:

- Temperature: 170°C / 80°C
- Time: 6h / 24h
- Material: C1018
- No stirring
- Saturated with nitrogen
- No pre-filming step
- Brine: Geothermal brine
- Presence of 10ppm of scale inhibitor
- Dosage: 50ppm as product

Geothermal brine (ppm)	
Na^+	27957
K^+	3893
Mg^{2+}	111
Ca^{2+}	7450
Sr^{2+}	492
Ba^{2+}	19.3
Cl^-	65027
SO_4^{2-}	76
HCO_3^-	173
SiO_2	170
pH	5.0-5.5

Example n°1 – New Thermally Stable Corrosion Inhibitor

	Test n°1 (mpy)	Test n°2 (mpy)	Avg. (mpy)
Blank	31.1	29.77	30.435
Benchmark 1	29.24	30.04	29.64
TOFA-DETA imidazoline	32.43	31.9	32.165
Oleylamine	34.29	33.76	34.025
Experimental 1	20.47	27.11	23.79
Experimental 2	22.06	23.13	22.595
Experimental 3	24.99	30.57	27.78
Experimental 4	17.81	18.61	18.21
Experimental 5	30.31	23.39	26.85
Experimental 6	23.92	24.46	24.19
Experimental 7	24.73	24.46	24.60
Experimental 8	26.59	25.26	25.93
Experimental 9	26.85	26.85	26.85
Experimental 10	34.03	28.71	31.37
Experimental 11	29.78	29.78	29.78

Blank

Exp.4

Exp. 4 outperforms all the other technologies tested. 40% reduction in the corrosion rate compared to blank

Italmatch Chemicals
ADVANCED WATER SOLUTIONS

Example n°1 – New Thermally Stable Corrosion Inhibitor

Additional tests on Exp. 4

- Weight loss coupon test at lower temperature/longer residence time

  → *confirmed superior performance*

- Compatibility with scale inhibitor

  → *both scale and corrosion performance not affected*

- Field trials

  → *positive results obtained from different plants*

Example n°2 – Novel NORMs Inhibitor

Objective: develop a new NORMs inhibitor for high salinity geothermal brine

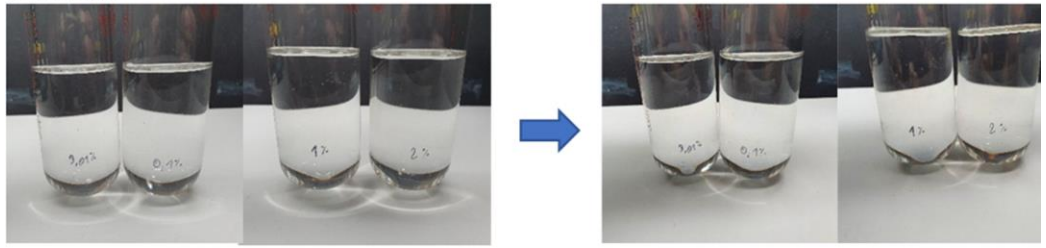
Development work includes:

- Static test vs Barite
- Static test vs PbS
- Compatibility with brine at high T
- Compatibility with corrosion inhibitor

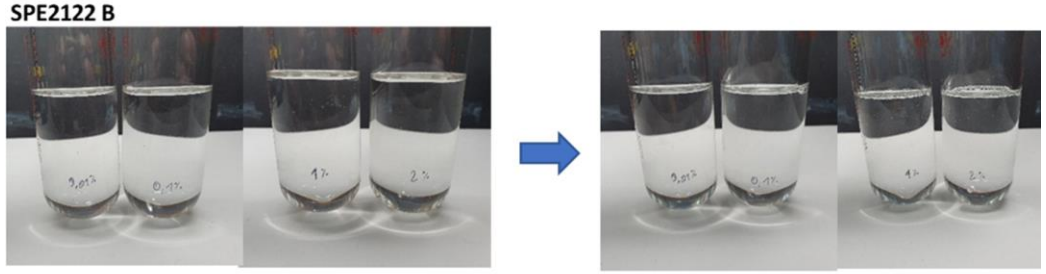
Example n°2 – Novel NORMs Inhibitor

Brine compatibility test

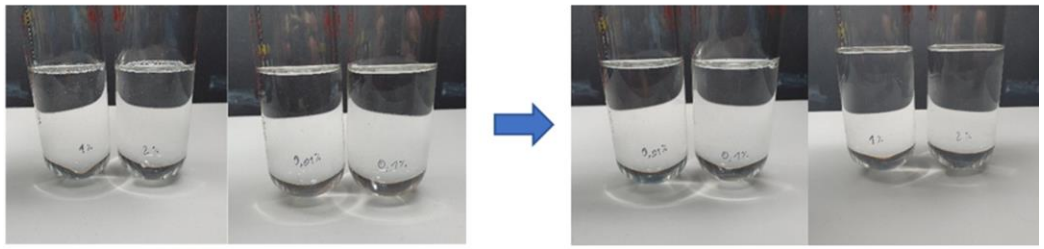
SPE2122 A



SPE2122 B



SPE2122 C



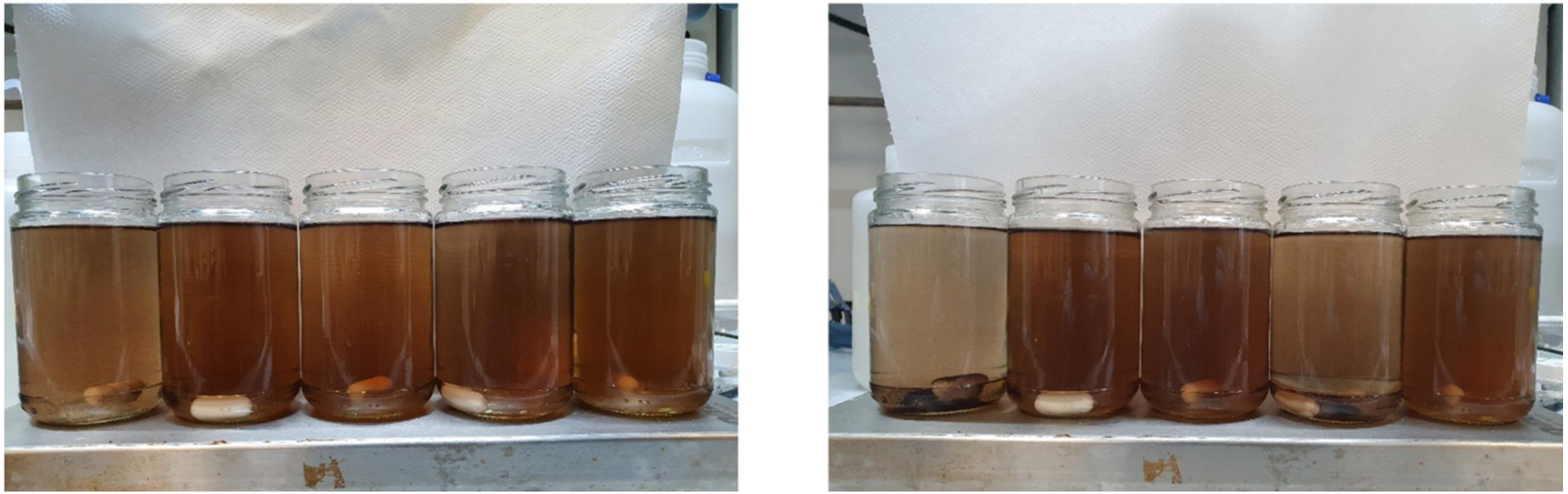
Compatibility with synthetic geothermal brine. On the left compatibility (0.01%, 0.1%, 1% and 2% respectively) at t=0, on the right compatibility after 24h.

All the three technologies developed are fully compatible with the brine at high temperature

Italmatch Chemicals
ADVANCED WATER SOLUTIONS

Example n°2 – Novel NORMs Inhibitor

PbS static test

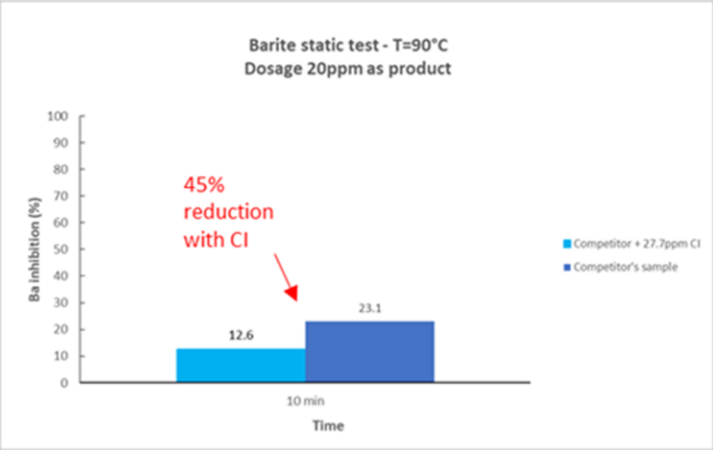


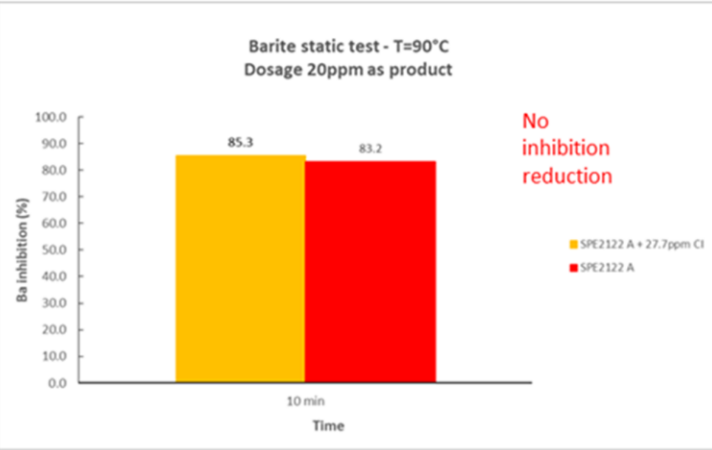
PbS test (t=0 and t=2h respectively). From left to right: Blank, Competitor, SPE2122 A, SPE2122 B, SPE2122 C

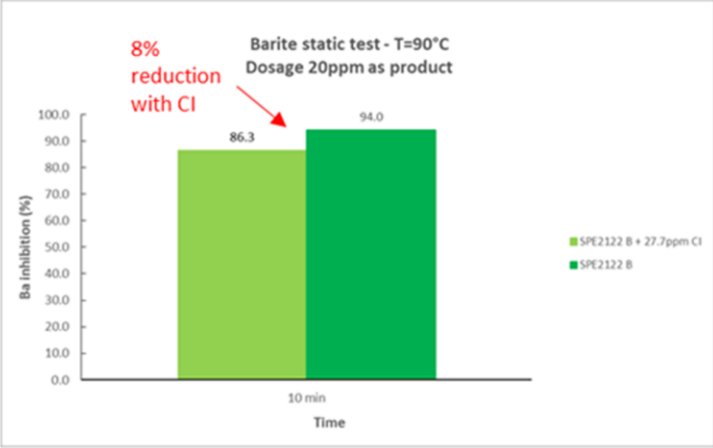
Competitor's sample, SPE2122 A and SPE2122 C provided best performance, keeping turbidity stable over the two hours of test which means that most of PbS particles remained well dispersed in solution.

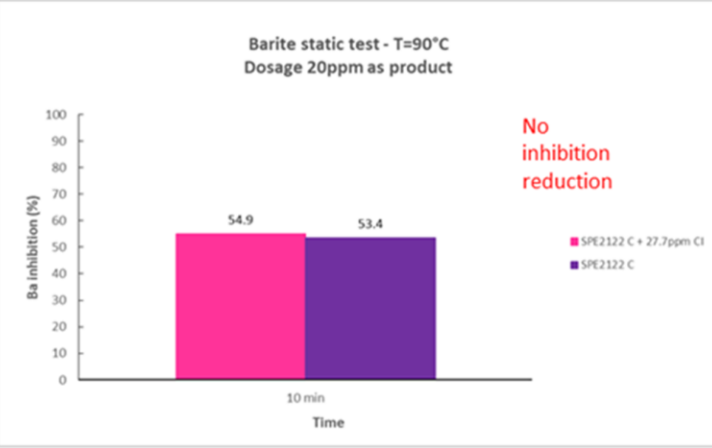
Example n°2 – Novel NORMs Inhibitor

Barite static test









SPE2122 A provides better performance and it is not affected by corrosion inhibitor

Italmatch Chemicals
ADVANCED WATER SOLUTIONS

Conclusion

- Corrosion and scale are critical issues for geothermal plants
- To develop a new inhibitor, an extensive lab work is needed, keeping in mind all the required properties and the challenges related to the geothermal environment
- This work showed two successful examples of recent developments:
  - Corrosion inhibitor
  - NORMs inhibitor

Italmatch Chemicals
ADVANCED WATER SOLUTIONS

Thank you