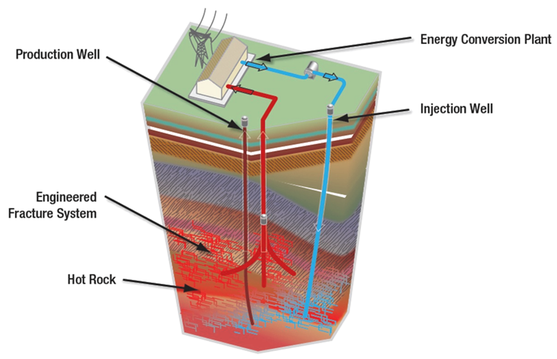
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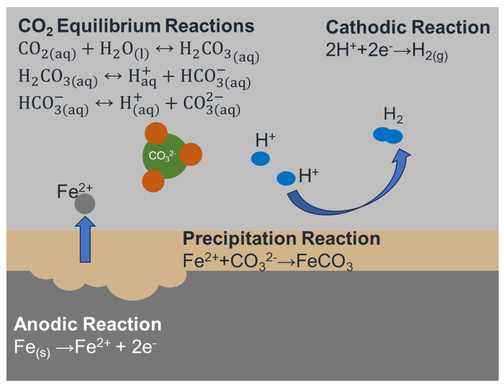
Challenges for Green Inhibitor Development for Geothermal Applications

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INTRODUCTION

- Objective 1: Investigate the effects of NaCl concentration on corrosion product formation and characteristics
- Objective 2: Investigate the impact NaCl concentration has on corrosion inhibitor performance using two commercial inhibitors with one having a greener chemistry
- Geothermal District Heating systems (GDH) can have a wide range of operating conditions, making the understanding of the corrosion mechanisms and inhibitor performance heavily specialised to one site
- One corrosion product that can be formed in these systems is iron carbonate, $FeCO_3$





METHODS

Apparatus:
1L Glass Bubble Cell with condenser

Combined Ag/AgCl and Platinum Electrode

Test Run Time 24 hours to allow for initial screening before long term tests

Inhibitor A: a combination of a quaternary amine surfactant and an ethoxylated amine salt



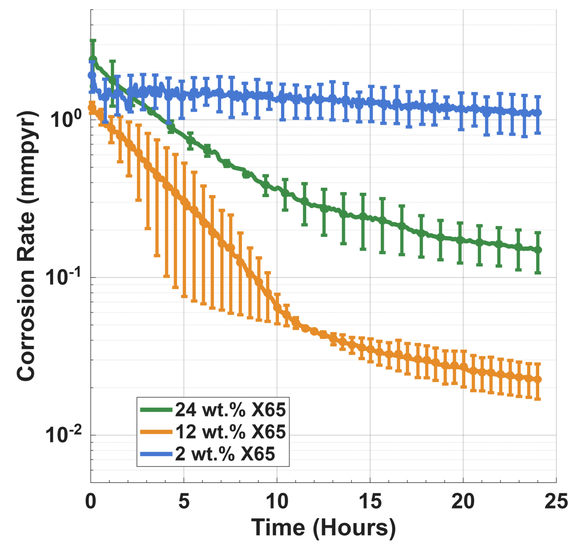
Brine Solution:
2 wt.%, 12 wt.% and 24 wt.% NaCl, CO_2 Saturated

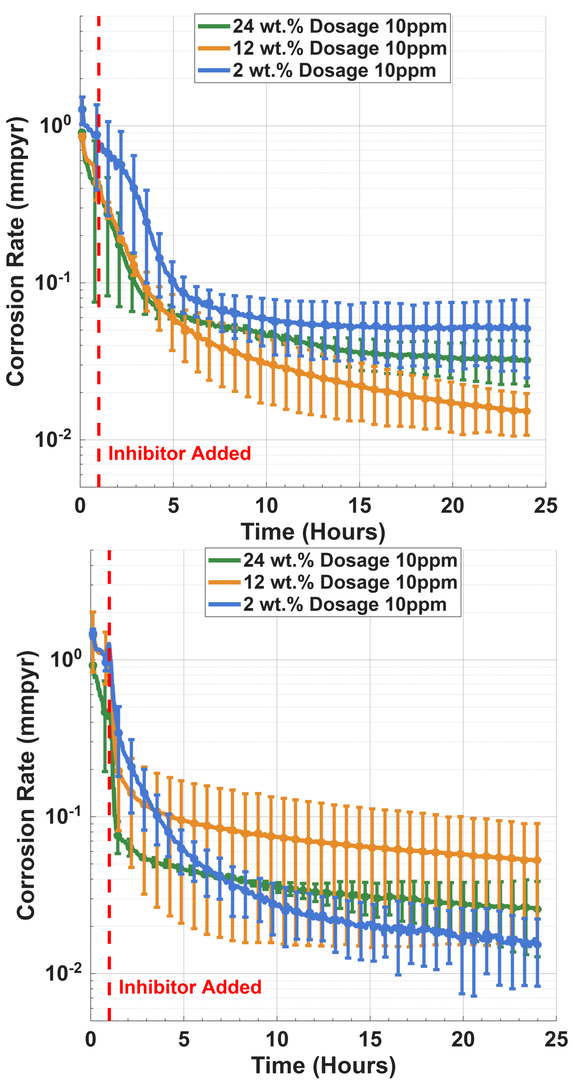
Test Conditions:
80 °C, pH 6.2

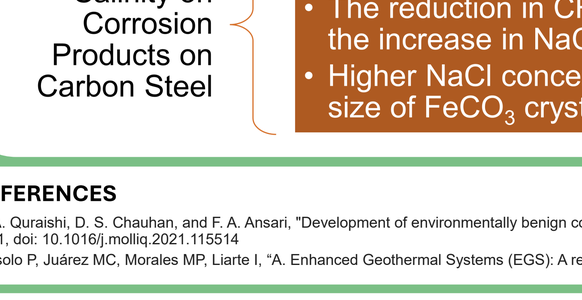
Test Material:
X65 Carbon steel

Inhibitor B: a combination of a quaternary amine surfactant and an amino amine polymer

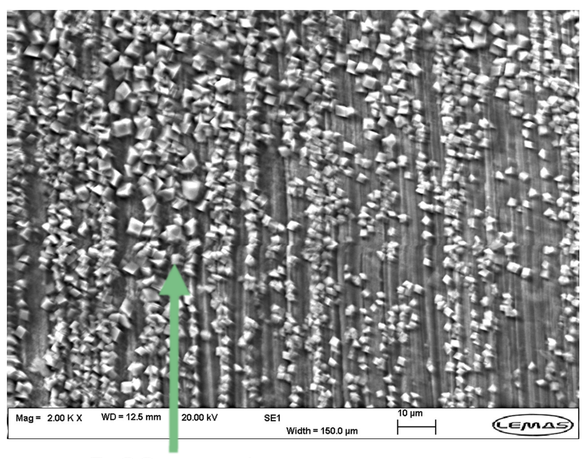
RESULTS





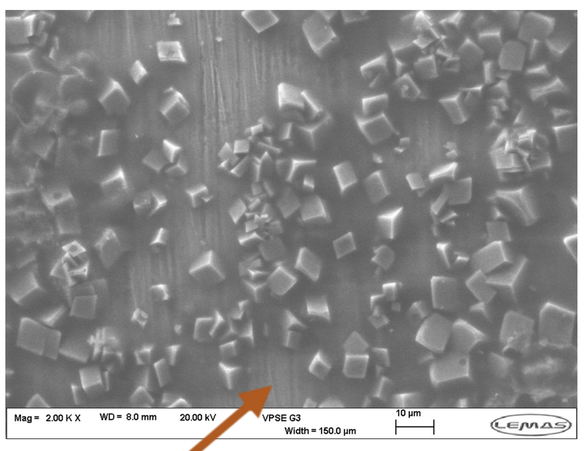


12 wt.% NaCl

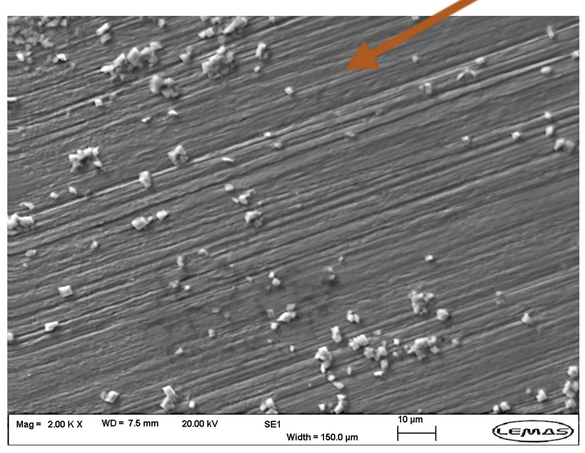


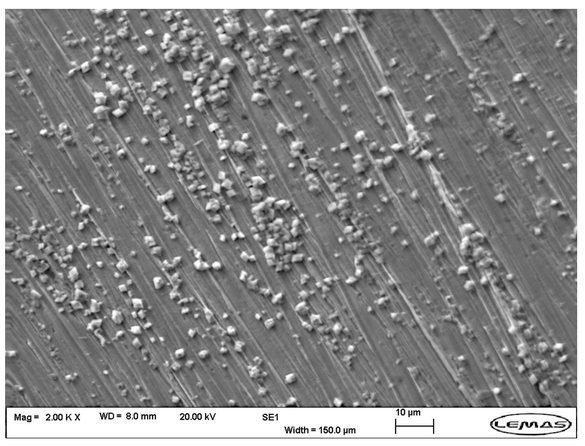
$FeCO_3$ crystals

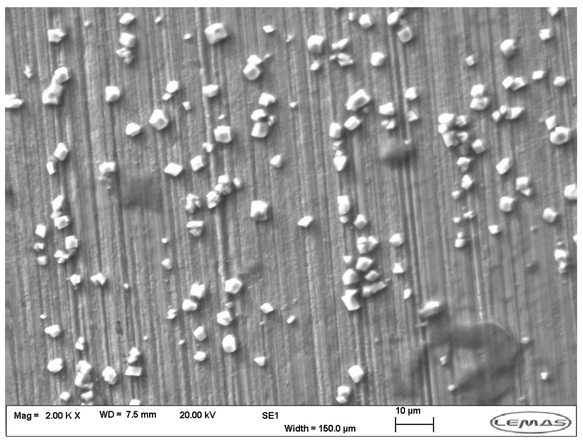
24 wt.% NaCl

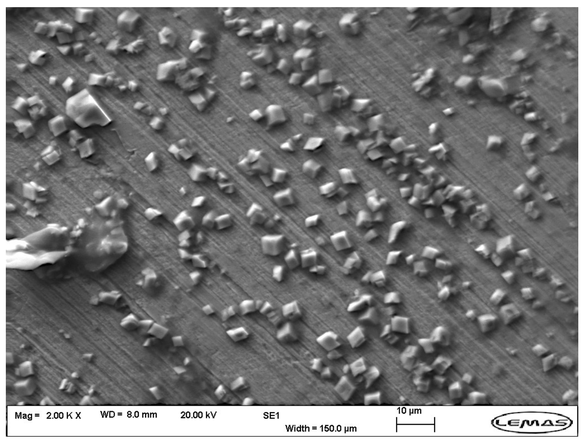


Bare Carbon Steel









Uninhibited Brine

- 2 wt.% CR remains largely unchanged, indicating that there is no $FeCO_3$ forming
- Formation of $FeCO_3$ present at 12 and 24 wt.% brines as the CR decreases
- 12 wt.% - small $FeCO_3$ crystals formed on the grind marks
- 24 wt.% - larger $FeCO_3$ crystals that aren't formed in neat formations and have varying sizes

Inhibitor A

- CR decreases across all salinities as the CI forms a protective layer
- Trend of NaCl conc. and CR same as that in the uninhibited tests
- 12 wt.% - small $FeCO_3$ crystals present with large areas of bare steel
- 24 wt.% - more crystals present suggesting that the NaCl concentration allows for $FeCO_3$ to form for longer before CI blocks the sites

Inhibitor B

- CR drops dramatically after the inhibitor is introduced
- Lower NaCl concentration has the greater reduction in CR with the trend of inhibitor A reversed
- FeCO3 crystals appear the same size across the 12 wt.% and 24 wt.%
- Greater number of $FeCO_3$ crystals on the 24 wt.%

CONCLUSION

Effect of Salinity on Corrosion Products on Carbon Steel

- The concentration of NaCl has an impact on the rate of formation of corrosion products
- The reduction in CR does not appear to be linear to the increase in NaCl concentration
- Higher NaCl concentrations appear to reduce the size of $FeCO_3$ crystals

Effect of Salinity on Chemical Inhibitor Performance

- Increasing NaCl can impact the final CR value depending on the inhibitor composition
- Higher NaCl concentrations can result in similar performance across different chemical inhibitors
- Some chemical inhibitors can in certain environments provide less protection than naturally forming layers

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