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Title: A corrosion control concept by scale engineering: A novel green inhibitor applied for high temperature and pressure aqueous supercritical CO2 systems

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A corrosion control concept by scale engineering: A novel green inhibitor applied to high temperature and pressure aqueous supercritical CO_2 systems

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Abstract: Traditional corrosion inhibitors are bio-toxic chemicals with organic components that bond to the fresh metal surface and thus isolate them from corrosive environments. The shortcoming of these inhibitors is that they are less effective in high-temperature and high-pressure environments, and where corrosion scale is formed or particulates are deposited. In this paper, we describe a novel green inorganic inhibitor made of environmentally friendly and cost-effective geo-material that was developed for high-temperature and high-pressure environments, particularly under scale-forming conditions. It inhibits corrosion by enhancing the protectiveness of corrosion scale.

In contrast to traditional corrosion inhibitors which are efficient for bare surface corrosion but not effective with scale, the novel inhibitor has no effect on bare surface corrosion but greatly improves corrosion inhibition under scale-formation conditions. This is because a homogeneous scale doped with inhibitor component forms. This enhanced corrosion scale demonstrated excellent protection against corrosion. In high-pressure CO_2 systems (pCO_2=10 Mpa, T=50 °C and [NaCl]=1 wt%) without inhibitor, the bare-surface corrosion rate decreases from ca. 10 mm/y to 0.3 mm/year due to formation of scale. Application of a six hundred ppm solution of the new inorganic inhibitor reduced the corrosion rate to 0.01 mm/year, an additional factor of 30. The current inhibitor product was designed for application to CO_2 systems that form corrosion scale, including but not limited to oil and gas wells, offshore production of oil and gas, CO_2 sequestration and enhanced geothermal production involving CO_2.

Keywords: corrosion inhibitor, supercritical CO_2, electrochemistry

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Outline

- Background Introduction
- Experiments
- Results
- Conclusions

Background

- **Challenges to high pressure and high temperature CO_2 corrosion control**
  - Low efficiency (<50%)
    - Decompose
    - Scale
  - Environmental hazard
  - Biotoxic

Background

- **New thoughts on inorganic corrosion inhibitor**
  - Stable: naturally grown
  - Low cost: Geo-material
  - Environmentally friend
  - High corrosion efficiency (>90%)

Objectives

- **Develop a novel green corrosion inhibitor high CO2 pressure environment through scale engineering Stable**
  - Use $FeCO_3$ as base materials
  - Change scale property by doping $FeCO_3$ with inorganic component
    - Improve stability at HP HT conditions (to reduce scale crack thus localized corrosion)
    - Improve corrosion inhibition (e.g. to achieve 10 time protectivity than $FeCO_3$)

Experiments

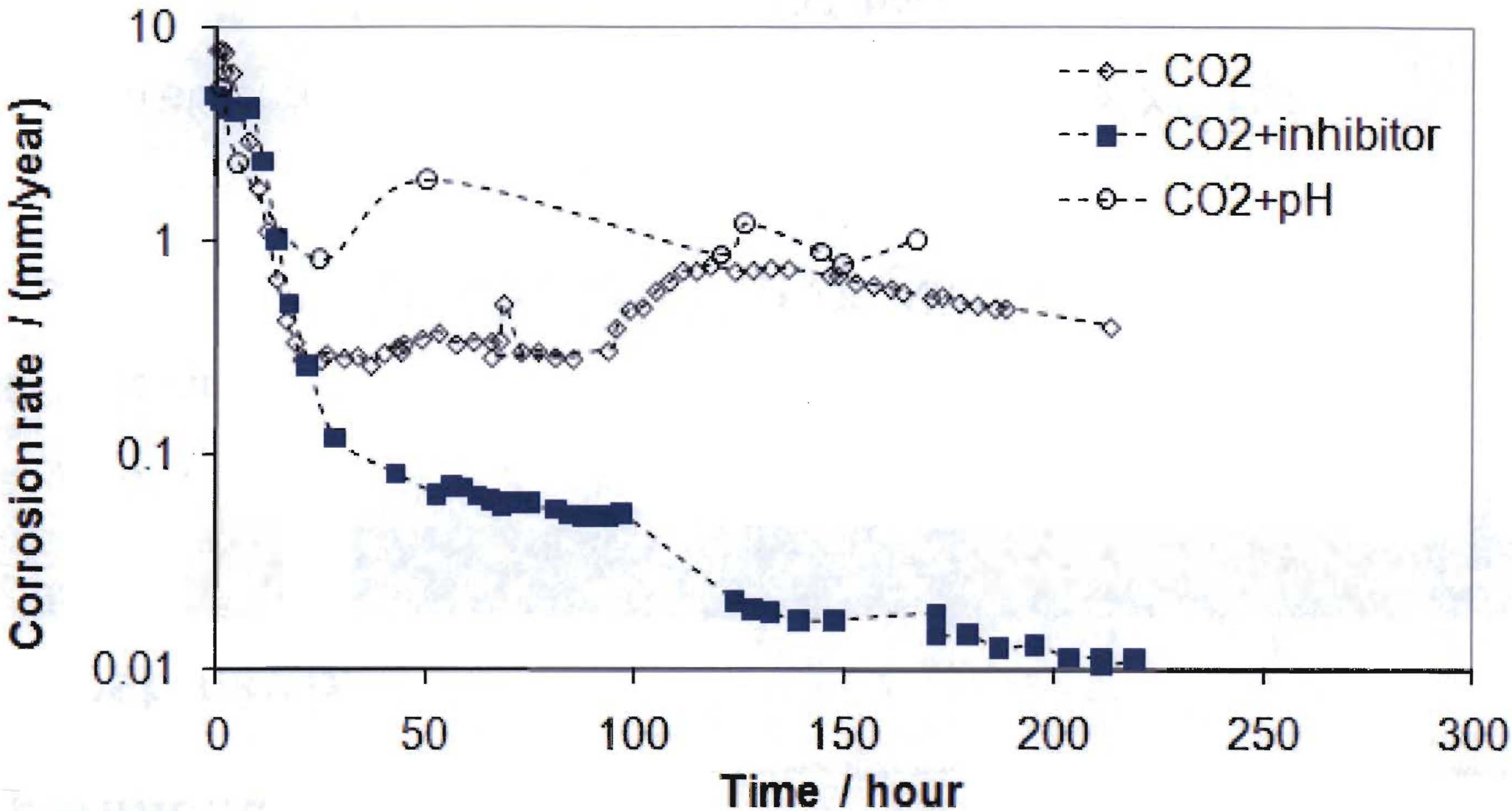
- **High pressure autoclave cell with three electrode systems**
  - Working electrode: J55 carbon steel coupon
  - Reference electrode: Titanium rod
  - Counter electrode: Autoclave body
- **Measurements**
  - Electrochemical: LPR, EIS
  - Surface analysis: SEM, EDX, XRD

Experiments

- **Test matrix**

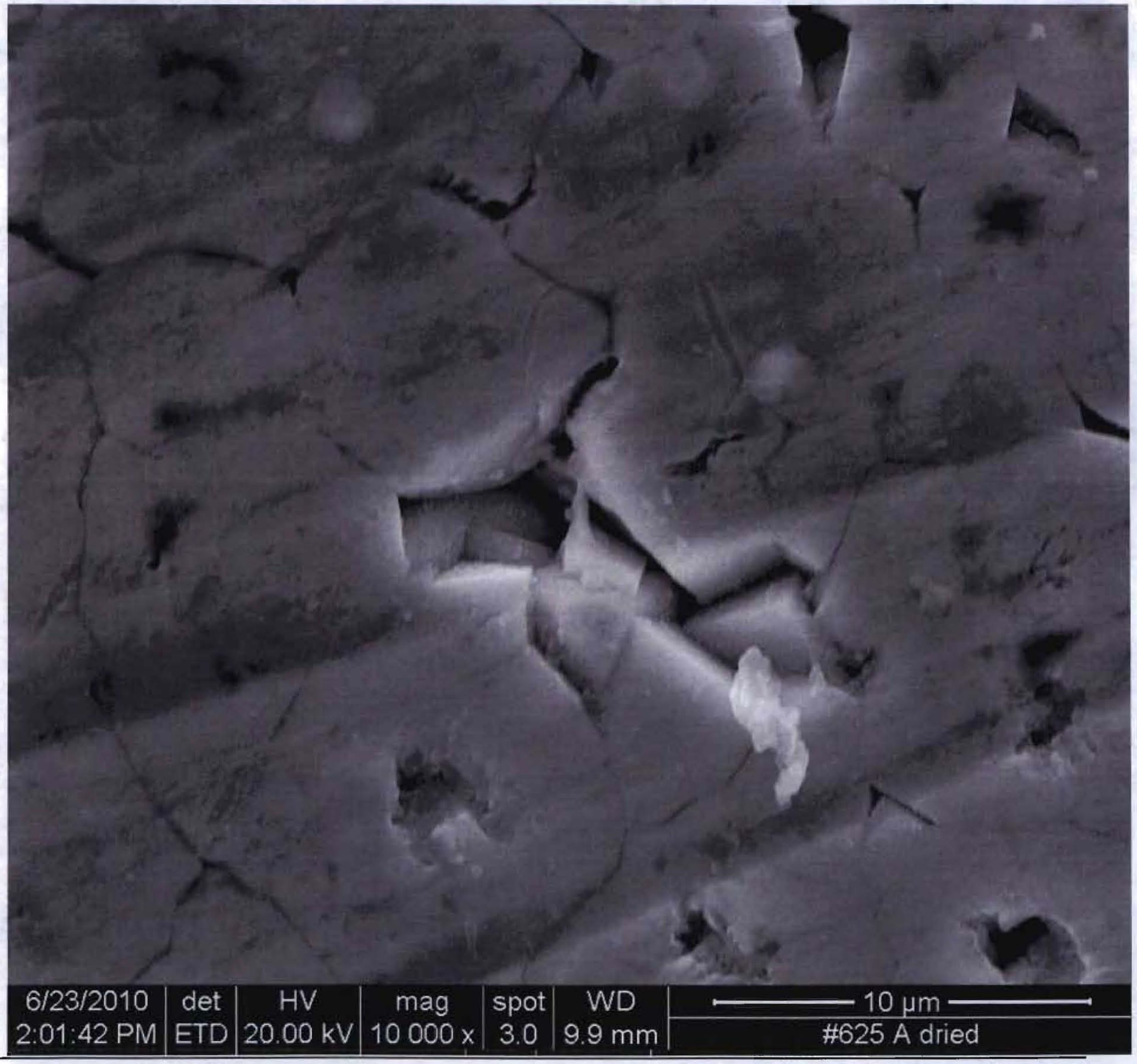
Temperature	50 °C
CO_2 pressure	100 bar
Electrolyte	1 wt% NaCl
	CO_2 brine
Inhibition effect comparison	CO_2 brine inhibitor X
	CO_2 brine +pH adjustment

Results: Corrosion inhibition effect



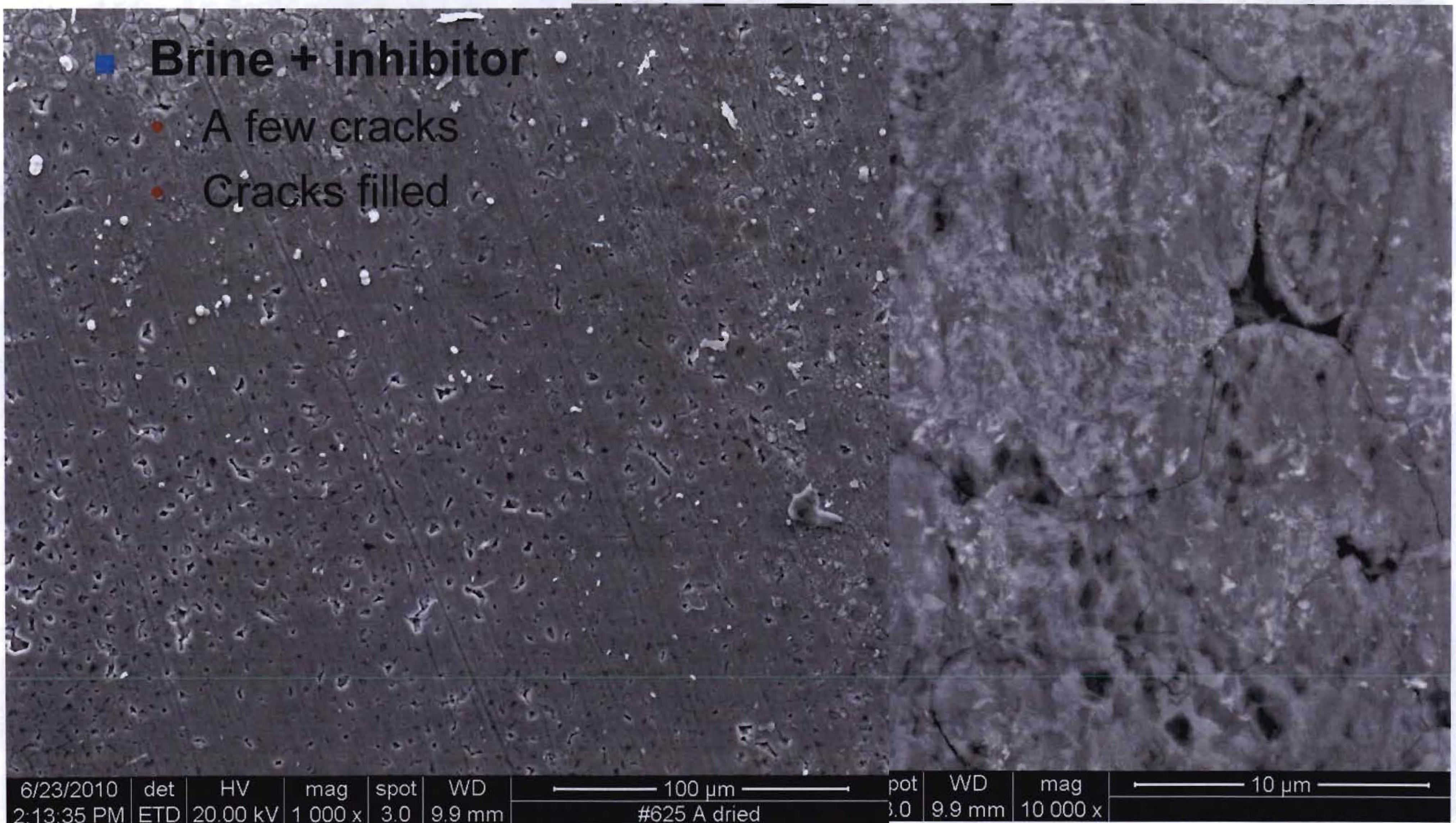
Results: Scale topography

- **CO_2 brine**
  - Many cracks
  - Cracks filled



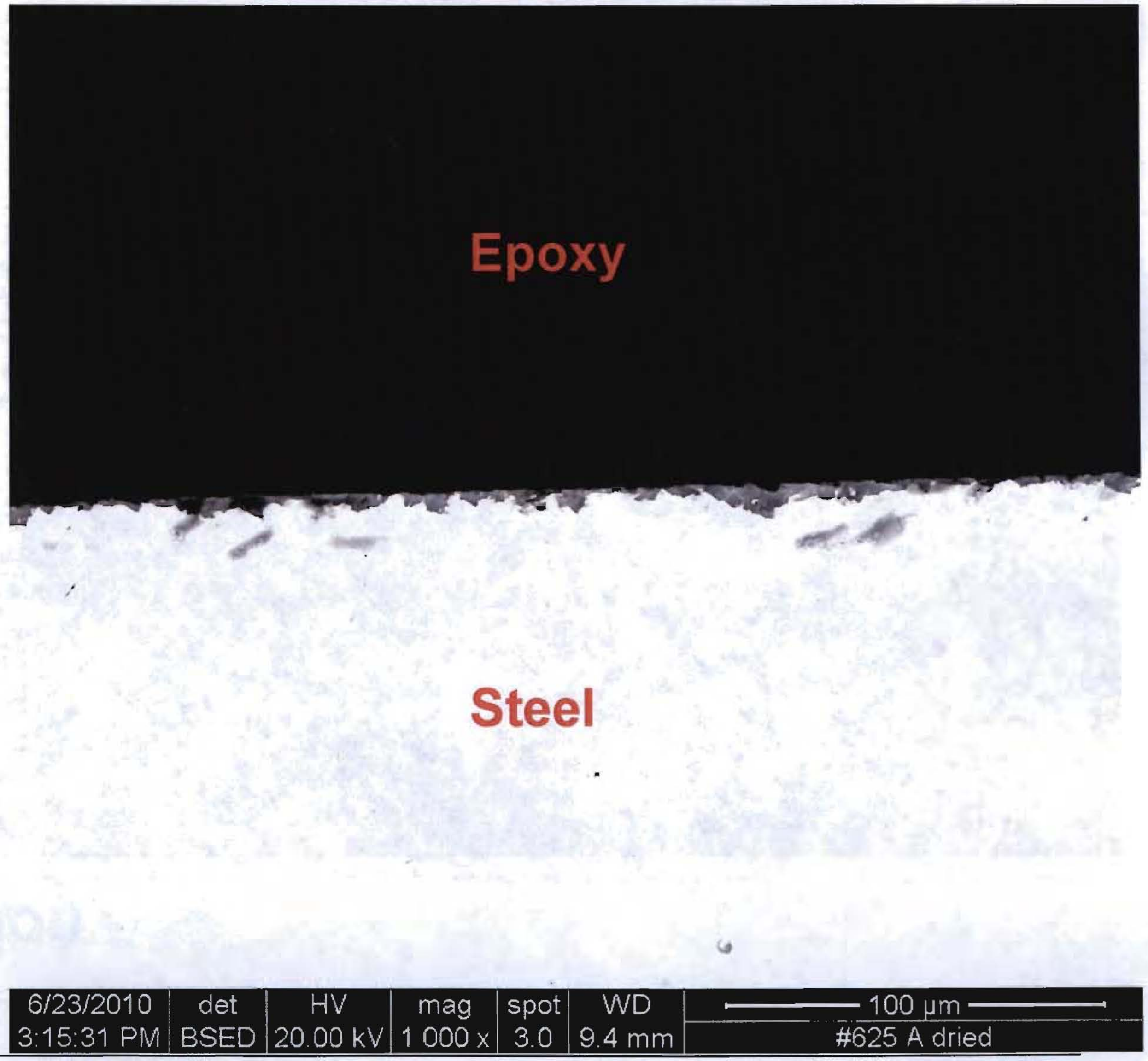
Results: Scale topography

- **Brine + inhibitor**
  - A few cracks
  - Cracks filled



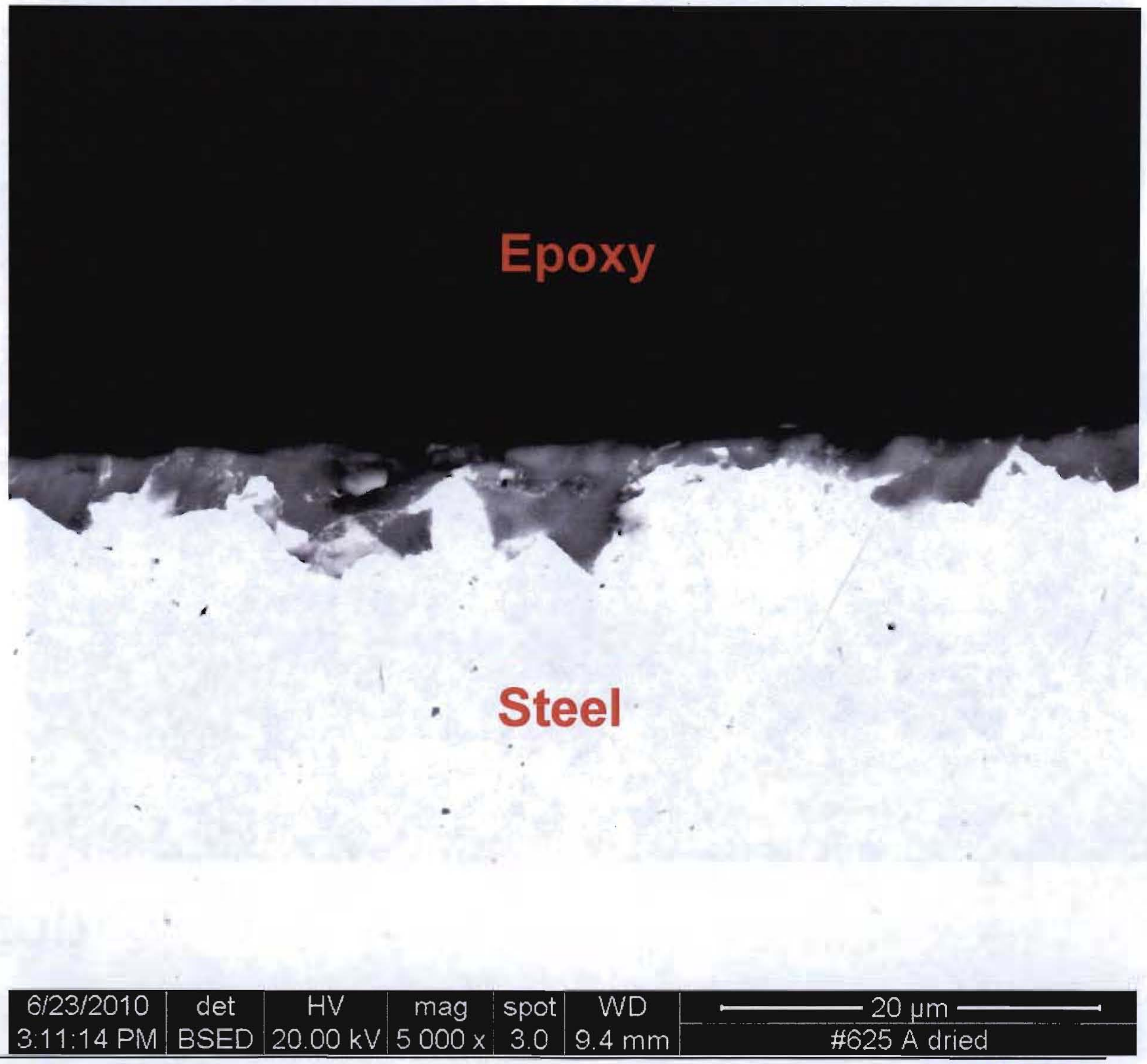
Results: Cross section

- **Brine + inhibitor**
  - Rough surface



Results: Cross section

- **Brine + inhibitor**
  - Pitting factor<5



Conclusions

- **A new inorganic corrosion inhibitor was identified**
  - Advantage:
    - Abundant: Geo-material
    - Low cost
    - High temperature stable
  - Excellent corrosion inhibition efficiency
    - Inhibit corrosion 1000 time vs. fresh surface corrosion
    - Inhibitor corrosion ~100 times vs. $FeCO_3$ scale
    - Localized corrosion is minimum (pitting factor <5)
    - Less scale cracks

Acknowledgements

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  - LANL-Carbon program

Question and comments?

Thank you!