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Corrosion Consequences of Nitrate/Nitrite Additions to Oilfield Brines

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Abstract

Because nitrate ions are sometimes added to oilfield brines for bacterial control, a laboratory study was conducted to determine the possible influence of nitrate and nitrite ions on steel corrosion. Corrosion consequences were suspected due to the oxidizing potential of these ions and some oxidizing agents are known to promote accelerated corrosion.

Results of this study indicated that nitrate ions did not influence corrosion or its inhibition. However, nitrite ions sometimes enter these systems and they can be influential. Nitrite ions caused sour (contains H₂S) oilfield brines to become more corrosive and compromised corrosion inhibitor effectiveness in both sweet (no significant H₂S) and sour systems.

Introduction

Certain bacteria in oil patch brines can produce operational problems.¹⁻³ A procedure sometimes employed to control these bacteria is the addition of nitrate or nitrite ions.⁴⁻¹¹ Several papers show this procedure to be effective in both laboratory and field conditions. Some bacteria present in oilfield waters cause at least a portion of the nitrate to convert to nitrite.^{4,6,11} Sometimes nitrite is added directly.⁶⁻¹⁰

In the past, work has shown that the addition of some oxidizing agents – particularly oxygen – into oilfield corrosion systems increases corrosion rates and compromises the effect of many corrosion inhibitors.^{12,13} The concern of the possible corrosion consequences of nitrate addition has been raised.^{6,10,16} The purpose of this paper is to present results of a laboratory study on the influence of nitrate and nitrite on steel corrosion and on corrosion inhibitor effectiveness in brines which simulate oilfield conditions.

Experimental Procedure

All tests were conducted at laboratory temperatures and at atmospheric pressure. Two liter glass resin kettles were fitted with gas inlet/exhaust tubes and electrode holders. Three steel electrodes (0.25 in. diameter and 1.75 in. long) were exposed to brines made with 3% NaCl and 0.3% CaCl₂; the electrodes were monitored by linear polarization resistance instrumentation. Most electrodes were carbon steel; a few were type 316 stainless steel.

For single-gas tests, the appropriate gas was continuously sparged into the kettles. For example, sweet tests used only CO₂ for sparging. Tests of sour conditions were first saturated with CO₂; then Na₂S added to provide a mixture of dissolved CO₂, H₂S and HCO₃⁻ at a pH of 5.5; then the kettle sealed. Test brines were stirred magnetically. Several laboratory - to-field comparisons have shown that this type of testing can predict corrosion behavior in many medium temperature, medium flow rate oilfield conditions.^{12,14}

Electrodes were added after the brines were equilibrated and appropriate corrosion inhibitors added at that time. A.R. salts of NaNO₃ or NaNO₂ were added at the beginning of gas sparging. Both uninhibited and inhibited corrosion rates were constantly monitored but all tabulated rates were taken 6 hours after test start. A variety of typical oilfield corrosion inhibitor types was examined, usually at 200 ppm of formulated inhibitor.

A few tests used weighed electrodes for comparison of integrated electrochemical rates with weight loss data. These tests usually ran for 24 hours.

Results and Discussion

Nitrate addition to CO₂ saturated brines lowered the corrosivity slightly. Corrosivity versus nitrate appears to go through a minimum but at most concentrations, lower corrosivity results (Figure 1). Corrosivity in sour brine (CO₂ + H₂S) is essentially uninfluenced by nitrate (also seen in Figure 1).