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Corrosion and inhibition of carbon steel XC38 in a standardized reconstituted geothermal water (SRGW) at 100°C and 120 bars of pressure in the absence or presence of biosourced inhibitors

Chahinez HELALI^{1,2}, Stéphanie BETELU¹, Romain VALENTIN², Sophie THIEBAUD-ROUX² and Ioannis IGNATIADIS¹, ¹BRGM, ORLEANS/FRANCE; ²INPT, TOULOUSE/FRANCE²

In the Paris Basin (France), corrosion and iron sulfide scale are encountered as a problematic of the geothermal energy, sanctioning it by economical prejudice and industrial and technological challenges. The vector of corrosion is the presence in the water of corrosive agents such as Cl^- , HCO_3^- , SO_4^{2-} , HS^- and gases H_2S and CO_2 . In these waters, sulfide concentration is between 1 to several decades of mg/L depending on the place, but also on the microbiological activities and water flow rate. In a previous study, a focus was made on experiments in the absence and in the presence of Biosourced Inhibitors (BI) at 70°C and 1 bars of pressure.

The analytical protocol proposed in this present study on liquid phase allows also highlighting that the corrosion and anticorrosion behavior differ according to hydrothermal conditions including hydrostatic pressure. In this work, we are going further by integrating the role of hydrothermal conditions, including hydrostatic pressure, in the kinetic rate and mechanisms by using High Pressure of 120 bars and High Temperature of 100°C in a Hydro-Pressurized Hydro-Thermo Reactor (HPHTR). The stainless steel HPHTR, provided by Autoclave Parr Instruments, is controlled by a proportional-integral-derivative controller (or PID) controller), which manage the agitator, the heating temperature and the pressure inside the HPHTR. The useful reactor volume is of 550 mL (total volume 1 L) is fulfilled with standardized reconstituted geothermal water (SRGW).

The HPHTR is pressurized with a gas mixture of N_2 (79.2%) CO_2 (20%) and H_2S (0.8%). Holes permit the insertion of a ZrO_2 -based pH electrode, temperature and pressure sensors as well as one Ag/AgCl reference electrode, one Ag_2S sulfide electrode and two XC38 electrodes. Between the two later ones, one is used without external electrochemical disturbance while the second one electrode is dedicated to electrochemical sensing during the experiments, using a Potentiostat-galvanostat impedancemeter. The experimental setup is able to follow every 10 s the autoclave parameters: temperature, pressure, pH, redox potential and sulfide concentration and

stirring rate using a Keithley data logger managed by with Xlink software. The calibration of the pH ZrO_2 electrode (temperature range from 90 to 230°C) versus Ag/AgCl reference electrode needs the measurement of a difference of potential (ΔE) at 100°C for two buffer solutions having a known pH at this temperature. The objective is to obtain the correlation line (ΔE vs $f(\text{pH})$) and thus convert ΔE values in pH values. The experiments performed in this study follow a step-by-step approach:

1. Calibration of pH electrode with two pH buffers (4 and 7) at temperature of 100°C.
2. Stabilisation of temperature at 100°C and pressure at 120 bars of the 550 mL of SRGW with the gas mixture with simultaneous continuous measurement of pH and redox potential of the SRGW as well as the open circuit potential (OCP) of the immersed CS-XC38 electrode until stabilization. This stabilized solution is called SRGW100C120B for 100°C and 120 bars.
3. After 1+2, starting of the electrochemical methods for corrosion measurement (three basic methods, several loops). This experiment is the “without inhibitor” experiment of CS-XC38 immersed in SRGW100C120B.
4. After 1+2, starting an injection of biosourced inhibitor (BI) formulation A at concentration of x ppm. Starting of the electrochemical methods for corrosion measurement as in point 3. This experiment is the “with inhibitor A at x ppm ” experiment of CS-XC38 immersed in SRGW100C120B
5. After 1+2, starting an injection of biosourced inhibitor formulation B at concentration of y ppm. Starting of the electrochemical methods for corrosion measurement as in point 3. This experiment is the “with inhibitor B at y ppm ” experiment of CS-XC38 immersed in SRGW100C120B.
6. After 1+2, starting an injection of biosourced inhibitor formulation C at a concentration of z ppm. Starting of the electrochemical methods for corrosion measurement. This experiment is the “with inhibitor C at z ppm ” experiment of CS-XC38 immersed in SRGW100C120B.
7. Exploitation of all the physical, chemical and electrochemical results for the three experiments with BI and one experiment without inhibitor.

Experiments are under implementation and the data are being thoroughly processed for calculating the corrosion current densities as a function of time and for evaluating and paralleling the impact hydrothermal conditions, including hydrostatic pressure and biosourced inhibitors nature on corrosion-scale phenomena. The results will be exposed at the conference.