Influence of Viscosifying Polymers on Carbon Steel for EOR Application - EIS Analysis

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ABSTRACT

Polymer flooding is an Enhanced Oil Recovery (EOR) technique that allows extraction of 15 to 20% more crude oil during oilfield exploitation. The viscosification of the brine with polymer leads to the enhancement. SAV10 is an Acrylamide Tertiary Butyl Sulfonic (ATBS) based polymer that can be injected in high salinity brines and at high temperature conditions. In such conditions, corrosion control is key to ensure integrity of the facilities. The influence of SAV10 on the corrosion of carbon steel (main alloy used in oil and gas exploitation) has been studied by electrochemical techniques. Electrochemical Impedance Spectroscopy - EIS - was used to propose mechanisms according to chloride concentration of the brine. SAV10 shows a slight inhibiting effect ensuring a safe deployment of the polymer technology.

KEY WORDS: Steel; EOR; Corrosion; ATBS; SAV10; EIS

INTRODUCTION

Acrylamide is the most common range of viscosifying polymer used in chemical Enhanced Oil Recovery (EOR) applications and Acrylamide Tertiary Butyl Sulfonic acid (ATBS) is an innovative specific polymer for this application. The effect of this kind of additive on the corrosion behavior of metals and alloys used in waters and brines piping materials is of increasing concern to Oil & Gas companies. However, only a few papers (Martin and Braga, 1986 ; Hilliard, 1984 ; Jia, Yang, Bin Abd Rahman and Gu, 2017) have evaluated the effect of polymers on corrosion of carbon steel, using mainly WL (Weight Loss) of coupons, LPR (Linear Polarization Resistance) technique, LSV (Linear Sweep Voltammetry) curves plotting and Electrochemical Impedance Spectroscopy (EIS). Inhibitive effect of classical polyacrylamide has been found in concentrated phosphoric acid (Jadaa, Abd and Khadom 2021), in ground water, (Manimaran and Rajendran, 2018) or in brines (Bonnier, Martin, Rivas 2020). The aim of the present study is to evaluate the change in uniform corrosion of carbon steel linked with the use of this polymer. The literature on polymer along with corrosion topics is rather rare to date. Most of the time, corrosion is a concern in studies on corrosion inhibitors, and viscosifying polymer is a concern in studies of performance of polymer flooding.

THEORY AND PARAMETERS OF INTEREST

Corrosion corresponds to a modification of a material by changing its oxidation state. In the present case, oxidation of cast iron may be represented by Eq. 1.

$$Fe \rightarrow Fe^{2+} + 2e^-$$ (1)

Dissolution of iron occurs only in acidic medium. Near neutral solution, other corrosion products, such as hematite in aerated solution or magnetite in deaerated one, may be formed on the surface, leading to more or less porous surface. At higher pH, hydroxide Fe(OH)$_3$ in deaerated or Fe(OH)$_2$ in aerated solution can be formed (Pourbaix, 1974).

Electrons produced during iron oxidation need to be consumed locally by a reduction reaction. In sea water, two reactions can be considered, oxygen reduction or hydronium ion reduction, respectively Eqs. 2–3.

$$2H_2O + O_{2,dissout} + 4e^- \rightarrow 4OH^-$$ (2)

$$2H^+ + 2e^- \rightarrow H_2$$ (3)

The flow of electrons between anodic and cathodic sites corresponds to a specific current called the corrosion current. By convention, positive current corresponds to a global anodic reactivity and the negative one to a global cathodic reactivity. However, the measured current corresponds always to the sum of all currents (anodic and cathodic).

Corrosion potential – $E_{corr}$ is one of the parameters to measure. It represents the potential spontaneously taken by the metal in a given solution without any solicitation. It corresponds to the potential at which anodic and cathodic current are equal due to the fact that electrons cannot be in excess.

Corrosion current density – $J_{corr}$ corresponds to the flux of electrons produced during oxidation and consumed during reduction per surface unit. This current cannot be directly measured due to the local oxidoreduction process. In order to obtain this value, considering that