Evaluation of Corrosion in a Glycerin-Based Fluid System

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The challenges in oil exploration and production in increasingly deep reservoirs require the development of technologies capable of overcoming harsh environmental conditions, such as high temperatures and pressures. A necessary stage before financial investments in new technologies is the execution of laboratory-scale tests to simulate the operational conditions to which systems will be subjected. In this context, this work aims to evaluate the inhibitory power of a glycerin-based fluid system. The results obtained so far show a corrosion rate of 0.038 mm/year for the fluid without glycerin and 0.0019 mm/year with glycerin. Therefore, glycerin contributes to a lower corrosion rate, making it favorable for use in such systems.
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Currently, many onshore and offshore oil and gas resources around the world are found in high-temperature and high-pressure reservoirs, which pose a significant challenge for oil exploration. Fluids are among the primary resources used in drilling and completion operations, although their characteristics may vary depending on the stage of the process.

The challenges of oil exploration and production in deep reservoirs demand the development of technologies that can withstand these extreme environments. Before any financial investment in a new technology, laboratory-scale tests are required to approximate the experimental conditions to those expected during actual operations.

In this context, the composition of the fluid used is of utmost importance, requiring careful control of several parameters, such as cost-effectiveness, component availability, environmental and reservoir compatibility, stability, low crystallization point, high density, suitable pH, low damage potential, and low corrosion rate. Generally, fluids used in well intervention operations are saline solutions, which give them a corrosive character.

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Globally, the cost of corrosion amounts to approximately 2.5 trillion dollars annually, corresponding to about 3.4% of the world's GDP [1]. In the oil and gas industry alone, approximately US$1372 billion is spent annually due to corrosion-related problems [1]. An effective way to mitigate corrosion is through the use of inhibitors. Organic and inorganic molecules with active functional groups, such as N, O, and S, are widely employed to prevent corrosion issues [1].

The effectiveness of a corrosion inhibitor depends on various parameters, including temperature, pressure, stress severity, and the concentration of dissolved solids [2]. Chemical inhibitors play an essential role in controlling corrosion in tubular steels. In oil and gas production, different types of steel are used to manufacture materials such as pipelines, casings, and tubing. Among them, X80 steel is one of the most widely applied. Therefore, selecting an appropriate inhibitor requires a comprehensive understanding of the treatment conditions, including temperature, pressure, fluid properties, pH, and flow characteristics [3].

The Production Development Laboratory (LDP) is an ongoing project at SENAI CIMATEC Park, in partnership with Petrobras, Shell, and ANP. It will support research in the oil and gas sector, aiming to simulate the operational conditions of Brazil's pre-salt reservoirs. The LDP will include the construction of a 300-meter well drilled in a single phase, equipped with different casing strings and components subjected to specific test conditions. Within this healthy environment, the fluid will be exposed to defined pressure and temperature conditions to evaluate its performance. The objective of this work, therefore, is to assess the inhibitory effect of a glycerin-based fluid system to ensure the long-term integrity of these tubular materials.

Materials and Methods

Sample Preparation

Corrosion studies were carried out on carbon steel API 5L X80. Each specimen had an exposed area of 1.95 cm² and was embedded in acrylic resin with electrical contact through a copper wire. The specimens were polished with sandpapers (600, 800, and 1200 grit) to achieve a uniform texture, then washed with isopropyl alcohol and distilled water to remove organic residues (oils and debris) before being immediately immersed in the test fluid for electrochemical testing.

Electrochemical Testing

The electrochemical test followed the methodology described by Macedo (2011), using a conventional three-electrode electrochemical cell composed of a working electrode (API 5L X80 steel), a reference electrode (Ag/AgCl), and a counter electrode (Pt). The tests were conducted using a Metrohm PGSTAT128N potentiostat/galvanostat at room temperature (~25 °C).

The test commenced with a 60-minute open-circuit potential (OCP) stabilization period, followed by the acquisition of a polarization curve at a scan rate of 0.01 mV/s over a potential range of –1.5 V to +1.5 V relative to the OCP.

Test Fluids

Fluid A (Raw Water): Water from an artesian well (intended as the water source for the LDP facilities), collected on 25/02/2025, with pH 5, conductivity 92 µS/cm, and temperature 23.7 °C.

Fluid B (70:30 fluid): 400 mL prepared in a 70:30 ratio, composed of 300 mL raw water and 100 mL glycerin (Biobrotas, 99% purity). The solution exhibited an electrical conductivity of 44 µS and a pH of 6.

Results and Discussion

Figure 1 shows the polarization curves obtained with the API 5L X80 steel electrode in artesian well water and in the 70:30 water–glycerin mixture, at a scan rate of 1 mV/s.The addition of glycerin caused a shift in the corrosion potential, indicating its inhibitory potential against chloride-induced corrosion.

The corrosion potential of raw water was –889 mV, and with the addition of 30% glycerin, it shifted to –817 mV. Using Tafel extrapolation, the electrochemical parameters (current density and corrosion rate) were determined, as shown in Table 1.

The data indicate a reduction in corrosion rate with the addition of glycerin to the system. The corrosion current also decreased, suggesting the formation of a protective layer that limits ion permeation through the electrical double layer to the metallic surface.Thus, glycerin acts as an effective corrosion inhibitor.

The inhibition efficiency (IE) of glycerin was estimated using the Equation 1 [4]:

$$\mathcal{E}\,(\%) = \theta * 100 = \frac{T_S - T_C}{T_S} * 100 \qquad \text{Eq. 1}$$

where Ts is the corrosion rate without glycerin, and Tc is the corrosion rate with glycerin. This calculation indicates an inhibition efficiency of approximately 50%. However, a higher inhibition level is desirable. Therefore, additional polarization and mass-loss tests are being conducted with the addition of an imidazoline-based corrosion inhibitor.

Conclusion

We concluded that glycerin significantly reduces the corrosion rate of the system, making it a viable

Figure 1. Polarization curves obtained with the API 5L X80 steel electrode in artesian well water and in a 70:30 water–glycerin fluid at 25 °C. ν = 1 mV/s.

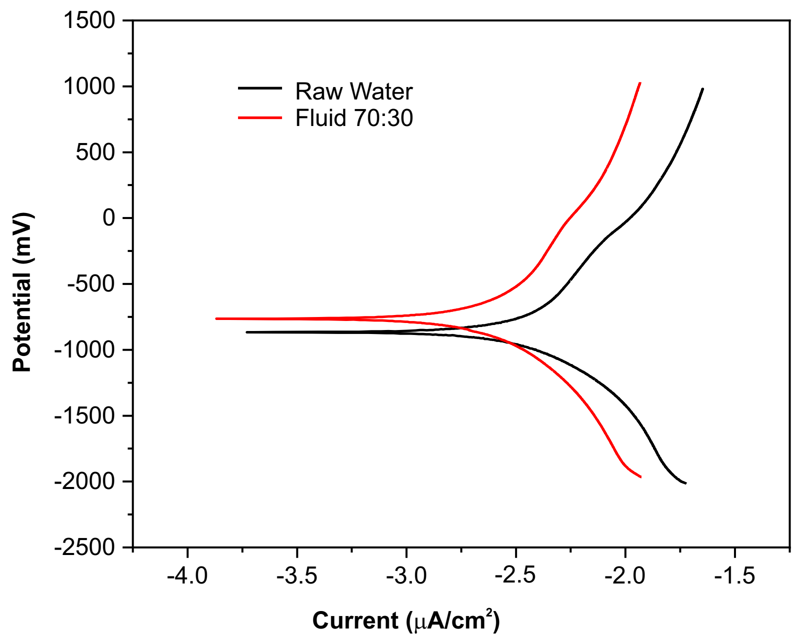

Table 1. Electrochemical parameters obtained from Tafel extrapolation for API 5L X80 steel processes in the presence of glycerin at 25 °C.

Fluid	E_{corr} (mV)	I_{corr} (μA/cm²)	CR (mm/year)
Raw Water	–865	3.32	0.038
Fluid 70:30	–817	1.83	0.019

component in healthy intervention fluids. Although the system achieved an inhibition efficiency of 50%, higher efficiency is desirable to ensure metallic stability over an estimated 20-year operational lifetime. Therefore, immersion and mass-loss tests are currently in progress using imidazoline-based inhibitors to achieve an inhibition efficiency greater than 70%.

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