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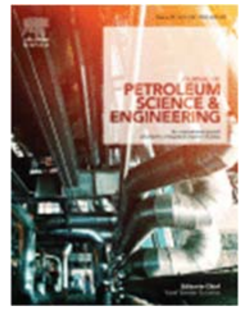

Effect of akyl chain length, flow, and temperature on the corrosion inhibition of carbon steel in a simulated acidizing environment by an imidazoline-based inhibitor

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Highlights

- • 2-heptadecyl-1-[2-(octadecanoylamino)ethyl]-2- imidazoline (QSI) has been synthesized.

- QSI fairly protects low carbon steel in 15% HCl solution.
- Corrosion inhibition performance of QSI is better under hydrodynamic than static condition.
- Addition of KI synergistically enhanced inhibition performance of QSI.
- Temperature and chain length of pendant hydrocarbon affect inhibition efficiency.

Abstract

An imidazoline, 2-heptadecyl-1-[2-(octadecanoylamino)ethyl]-2-imidazoline (QSI) with -$C_{17}H_{35}$ as the tail chain length was synthesized, characterized, and studied as corrosion inhibitor for low carbon steel in 15% HCl solution under static and hydrodynamic conditions. Influence of addition of KI, temperature, and chain length of pendant hydrocarbon on inhibition efficiency (η) was also examined. It is found that, QSI exhibits a mixed type behavior but fairly inhibited the corrosion of low carbon steel in the studied medium. The maximum concentration studied (400 mg/L) afforded η of <50%. Addition of KI to QSI synergistically enhanced the corrosion inhibition performance of QSI, upgrading the η to approximately 90%. Increase in the system temperature increases the η of both QSI and QSI + KI. From the variation of η with temperature and the calculated corrosion kinetic parameters, chemical adsorption is proposed as the adsorption mechanism of the additives. QSI performs better under hydrodynamic condition than static condition. However, the corrosion resistance of the metal decreases at rotation speed higher than 1000 rpm. Inhibition efficiency of imidazoline decreases as the length of the hydrocarbon pendant chain increases. Imidazoline compounds with -$C_{13}H_{27}$ and -$C_{15}H_{31}$ as the length of the pendant group hydrocarbon perform better than QSI with -$C_{17}H_{35}$.

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Keywords

Corrosion
Inhibition
Imidazoline
Synergism
Pendant group chain

1. Introduction

The oil and gas exploration and production industry is one of the sectors currently driving the global economy, with a total revenue of 2 trillion USD (IBISWorld and Report, 2018). It is forecasted by the Organization of Petroleum Exporting Countries (OPEC), that by 2040, crude oil and natural gas will remain the fuels with the largest shares of over 27% and 25%, respectively, (Organization of Petroleum Exporting Countries, 2018). The sector uses various techniques to stimulate production and one of such is acid treatments (Jiawei et al., 2020; Zou et al., 2013, 2011). The utilization of acids in well stimulation stemmed from their ability to dissolve layer minerals and foreign materials, such as drilling mud (Ituen et al., 2019; Zou et al., 2011). It involves pumping concentrated acid solutions into wells to increase formation permeability and porosity in the near wellbore region (Gandossi, 2013; Kalfayan, 2008). Hydrochloric acid (HCl) or HCl/HF mixture is commonly used. Acid selection depends largely on the type of formation and the process normally last between 2 and 24 h (Brondel et al., 1994) as longer exposure time aggravates corrosion.

Corrosion of pipeline and facility, usually low carbon steels (Zhang et al., 2018) is a serious problem during well acidizing (Ituen et al., 2019; Jiawei et al., 2020; Zou et al., 2013, 2011). An effective and low cost corrosion mitigation approach is corrosion inhibitor technology (Ituen et al., 2019; Zou et al., 2013), whereby effective corrosion inhibitors are added to the acidizing solution to avoid severe corrosion during the process (Annand and Woodson, 1976; Quinlan, 1980).

A review on acidizing corrosion inhibitors identified the imidazolines as one of the effective acidizing inhibitors (Singh and Quraishi, 2015). They are nitrogen-containing heterocycles derived from imidazoles, which have found application in the medical field (Shetnev et al., 2019; Trulli et al., 2018). The high inhibiting effect of imidazolines is associated with the ease of feedback coordinate covalent bonding between the imidazoline ring and substrate surface during chemical adsorption process (Mousavi et al., 2011; Solomon et al., 2019a). Specifically, 0.5% imidazoline quaternary inhibitor synthesized from oleic acid and diethylene triamine in the ratio of 1:1.2 inhibited carbon steel corrosion in 15% HCl at 80 °C by 99.12% (Zhou et al., 2018). Zhang et al. (2015) reported that, 300 mg/L of an imidazoline derivative, 2-methyl-4-phenyl-1-tosyl-4, 5-dihydro-1H-imidazole protected a P110 carbon steel surface in 1.0 M HCl solution by 94.60%.

The hydrophobic tail and the pendant group have been found to have huge influence on the corrosion inhibition performance of imidazoline (Blair et al., 1949; Meyer, 2001; Ramachandran et al., 1996). The length of the hydrophobic tail and pendant group is key to inhibition performance. According to Ramachandran et al. (1996), imidazoline compound with hydrophobic tail chain length less than 12 carbon atoms behave poorly as corrosion inhibitor. Blair et al. (1949) held that, imidazoline compounds with long chain hydrophobic compound anchored on one of the ring N-atoms or on a relatively small organic radical attached to one of the N-atoms are the most effective as corrosion inhibitor. In our previous reports (Solomon et al., 2019a, 2019b), we synthesized two similar imidazoline compounds, N-(2-(2-tridecyl-4,5-dihydro-1H-imidazol-1-yl)ethyl)tetradecanamide and N-(2-(2-pentadecyl-4,5-dihydro-1H-imidazol-1-yl)ethyl)palmitamide that differ only on the length of the tail ($–C_{13}H_{27}$ and $–C_{15}H_{31}$, respectively) and studied their corrosion inhibition performance for low carbon steel in 15% HCl solution. They were highly effective and exhibited corrosion inhibition efficiency of >90%. To understand the influence of hydrophobic tail chain length on the corrosion inhibition of imidazoline in acidizing environment, we, in the present study,

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