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Eco-friendly 2-Thiobarbituric acid as a corrosion inhibitor for API 5L X60 steel in simulated sweet oilfield environment: Electrochemical and surface analysis studies

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Abstract

The corrosion inhibition efficiency of 2-Thiobarbituric acid (TBA) for metal substrate (API X60 steel) in 3.5% NaCl solution saturated with CO2 gas was probed using various techniques namely, LPR (linear polarization resistance), EIS (electrochemical impedance spectroscopy), and PDP (potentiodynamic polarization). The effects of TBA concentration (25–100 ppm), solution pH (4 and 6), temperature (25–80 °C), and immersion time (2–72 h) on the inhibition efficiency were examined. SEM (scanning electron microscopy) and XPS (X–ray photoelectron spectroscopy) were deployed to explore the corrosion retardation mechanism. TBA exhibited protection efficiencies exceeding 90% for all experimental conditions considered. The excellent anticorrosion performance by TBA was retained up to 72 hours of immersion time. PDP results exhibited that TBA behaved as a mixed type inhibitor. Results from kinetics and thermodynamics analyses indicate that TBA chemically adsorbed on the steel surface following Langmuir isotherm model. The composition of the adsorbed TBA film has been analyzed by XPS.

Introduction

CO_2 corrosion is a serious challenge faced in the oil and gas industries. Crude oil wells contain varying amounts of CO_2 as an associate gas. CO_2 gas readily dissolves in the formation water and forms a weak carbonic acid which leads to severe corrosion attack. Beside the general corrosion, CO_2 also causes localized corrosion and as it is known, this type of corrosion is difficult to predict, detect, and protect against1. It is ranked as the topmost type of attack encountered in the production and transportation of crude oil1,2. In oilfields, 60% of failures are believed to be caused by corrosion and CO_2 corrosion is the major contributor3.

The use of corrosion inhibitors is the most practical and less expensive approach widely employed to control corrosion in the oil and gas industries4,5,6,7,8. Hitherto, arsenates, chromates, ferrocyanide, and metavandate were the choice corrosion inhibitors for the oilfield corrosion but have long lost patronage on the basis of their high toxicity. As replacement, organic adsorption inhibitors such as imidazolines and their derivatives are used7. Another category of organic inhibitors in use in industrial formulations are products formed from the condensation reactions of organic compounds with amino, carbonyl, and hydroxyl functional groups8. The π-electrons and heteroatoms like N, O, P, and S present in the structures of organic compounds serve as adsorption centers and facilitate adsorption on substrate surface6,7,9. Nevertheless, some of these synthetic compounds are only effective at high concentrations and also possess toxicity that is inimical to the environment. The research focus of the present is on developing effective ecological friendly inhibitors – the so called green corrosion inhibitors that could take the place of organic and inorganic inhibitors10. The targeted class of compounds include natural polymers, plant extracts, amino acids, expired drugs, and medicinal products11,12.