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The isoxazolidines: the effects of steric factor and hydrophobic chain length on the corrosion inhibition of mild steel in acidic medium

S.A. Ali [a,*], A.M. El-Shareef [b], R.F. Al-Ghamdi [b], M.T. Saeed [a]

[a] *Chemistry Department, King Fahd University of Petroleum and Minerals, Dhahran 31261, Saudi Arabia*
[b] *Chemistry Department, Dammam Girl's College, Dammam 31113, Saudi Arabia*

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Abstract

Several new isoxazolidines having varying degree of steric environment and hydrophobic chain length, prepared efficiently using single-step nitrone cycloaddition reactions, are tested for corrosion inhibition of mild steel in 1 M and 5 M HCl at 50–70 °C range by gravimetric and electrochemical methods. All compounds have shown very good corrosion inhibition efficiency (IE%) in acidic solution. Steric crowding around the nitrogen centres and hydrophobic chain lengths as well as increase in temperature (in the presence of the inhibitor in the higher concentration range 100–400 ppm) are found to increase the inhibition efficiency of the isoxazolidines. Thermodynamic parameters (ΔG°_{ads}, ΔH°_{ads}, ΔS°_{ads}) for the adsorption process and kinetic parameters for the metal dissolution (or hydrogen evolution) reaction in the presence of one of the isoxazolidines were determined. Experimental results agree with the Temkin adsorption isotherm. The inhibition of corrosion in 1 M HCl, influenced by both physi- and chemisorption, was found to be under mixed control, but predominantly under cathodic control.

* Corresponding author. Tel.: +966 3 860 3830; fax: +966 3 860 4277.
E-mail address: shaikh@kfupm.edu.sa (S.A. Ali).

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1. Introduction

The study of corrosion of mild steel and iron is of both theoretical and practical concern [1,2]. Corrosion inhibitors—especially the organic compounds containing oxygen, sulfur and nitrogen—are widely used in industrial acid cleaning, acid descaling, acid pickling, and oil well acidizing in order to restrain the corrosion attack on metallic materials [3–8]. The corrosion inhibition of metal may involve either physisorption or chemisorption of the inhibitors to the metal surface and subsequent interference with either cathodic or anodic or both reactions occurring at the adsorption sites. The electrostatic attraction between the charged hydrophilic groups and the charge active centres on the metal surface leads to physisorption. The existing data show that most organic inhibitors adsorb on the metal surface by displacing water molecules on the surface and forming a compact barrier film [9]. Availability of nonbonded- (lone pair) and π-electrons in alkenes, alkynes and aromatic rings in inhibitor molecules may involve in chemisorption; the strength of the coordinate covalent bond thus formed depends upon the electron density and polarizability of the donor atom of the functional group [10]. In the case of alkynes it has been proposed that the alkynes undergoes polymerization to form a protective film (coating) on the metal surface [11] and the film prevents mass transport and results in inhibition of corrosion [12].

It is the 'functional groups' in the organic molecules that render their important services in the inhibition of corrosion; inhibitory actions of a plethora of functional groups are described in the corrosion literature [2]. Even though isoxazolidines are known for many decades [13–15], it was only recently a preliminary investigation introduced the organic functionality to the corrosion literature for the first time [16]. Isoxazolidines, an important class of compounds, are extensively used in the synthesis of a great many natural products of biological interest [17]. In the present work, we have synthesized several new isoxazolidines with varying degree of steric crowding around the nitrogen and the hydrophobic chain length, and studied their effects on the corrosion inhibition of mild steel in HCl using gravimetric measurements and potentiodynamic polarization curves.

2. Experimental details

2.1. Materials

N-Methylhydroxylamine hydrochloride, 1-octene, paraformaldehyde (Fluka Chemie AG) and 1-tetraadecene (Merck-Schuchardt) were used as received. Isopropylhydroxylamine (lit. mp 87 °C) and ^{t}butylhydroxylamine (lit. mp 64–65 °C) are