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Anti-corrosive propensity of naturally occurring aldehydes and 1-(3-aminopropyl)imidazole condensed Schiff bases: Comparison on the effect of extended conjugation over electron donating substituents

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ABSTRACT

Schiff bases prepared by condensation of 1-(3-aminopropyl)imidazole and three different naturally occurring aldehydes, namely salicylaldehyde, vanillin and cinnamaldehyde (ISSB, IVSB and ICSB, respectively) are tested as corrosion inhibitors for mild steel in 1 M HCl. Comparative effects of extended conjugation and +R effect bestowed by the electron donating group are explored towards the extent of corrosion protection of mild steel. ICSB, having extended conjugation, stands out to be the most efficient one. At 1 mM concentration, it imparts nearly 99% inhibition efficiency at 40 °C after 48 h of exposure of mild steel in 1 M HCl. DFTB+ study reveals the active centers of inhibitor molecules responsible for bi-directional electron transfer with metal surface. Irreversibility test with ICSB layer formed after exposure in 1 M HCl for 24 h having 1 mM ICSB, provides 78% inhibition efficiency to mild steel when exposed to the uninhibited 1 M HCl for 3 h. From detailed temperature dependence study, thermodynamics and kinetic parameters are obtained, which are instrumental to ascertain the nature of adsorption of the studied inhibitors.

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1. Introduction

A variety of Schiff bases have been investigated for their potential anti-corrosive activities both for ferrous and non-ferrous metals and alloys in recent past [1–14]. Schiff bases possess several characteristics conducive for corrosion mitigation. However, in many cases the reported inhibition efficiencies are not very high. In some instances, the inhibitory effect does not last long, particularly at elevated temperature. These shortcomings are associated with the insolubility of Schiff bases, as well as instability of the inhibitor layer in highly acidic medium under prolonged exposure or at higher temperature. In addition, report on the irreversibility test for corrosion inhibitors, *i.e.*, how long the inhibitor layer can sustain in the aggressive uninhibited acid solution, is really scarce [15]. This is an important aspect in regard to applicability of inhibitors in real situation. Most of the works involving Schiff bases as corrosion inhibitors focus on the effect of multiple imine bonds, presence of electron donating/withdrawing groups, aromatic moieties, heteroatoms, aliphatic chain length etc. [1–14]. Some studies have pointed out better performance of the Schiff bases having extended conjugation, which results into higher electron density on the imine group [3,16–18]. In the present work, we intend to present a comparative study between the effect of extended conjugation and that of electron donating substituents. For this, we have used structurally comparable inhibitor molecules and took mild steel as the test material and 1 M aqueous HCl as the corrosive medium. Mild steel is one of the most widely used structural materials because of its strength, malleability, ductility, weldability, machinability, and most-importantly cost effectiveness [19] As it is very prone towards corrosion, protecting mild steel, particularly from mineral acid environment like HCl is still a challenge [19]. There are diversified uses of mineral acids like HCl. These include chemical processing, pickling, acid de-scaling, oil-well acidifying processes and many others [20]. During these processes, as well as during transportation and storage of acid, application of suitable corrosion retardant is a pre-requisite.

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