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Corrosion inhibition effect of Aloe Vera gel: Gravimetric and electrochemical study

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ABSTRACT

Effect of Aloe Vera gel on mild steel corrosion in 1 M HCl medium has been studied using weight loss, electrochemical impedance spectroscopy, and Tafel polarization. These results were supplemented by atomic force microscopy (AFM) and scanning electron microscopy (SEM). This extract is selected for this study in view of its rich source of organic molecules. Tafel polarization studies reveal that Aloe Vera gel extract acts as mixed inhibitor. The activation parameters showed that the inhibitor is adsorbed by both physisorption and chemisorption. The inhibitor showed >90% inhibition efficiency and lowest corrosion rate at optimum concentration of 200 ppm.

Introduction

The corrosion of mild steels has received a considerable amount of attention as a result of its industrial concern. The study of corrosion inhibition of mild steel (MS) using inhibitor in acidic media is one of the challenging topics of current research in various industries involving chemical cleaning, descaling, pickling, acid oil-well acidizing, etc. A number of organic compounds have been reported as effective corrosion inhibitors [1–5]. But, most of them are highly toxic to both human being and environment. Thus, it remains an important objective to find low-cost and ecofriendly inhibitors. In this direction, exploration of drugs for their corrosion inhibition properties seems to be a viable concept. The toxic effects of these inhibitors have led to the use of naturally occurring products as corrosion inhibitors [6,7]. Though, drugs are nontoxic but economically they are less viable as compared to plant extracts because plant extracts are inexpensive, nontoxic and renewable source of wide range of organic chemicals of industrial significance. A high inhibition efficiency of the plant's extracts is acknowledged due to adsorption of the organic moieties (present in the extract) on the surfaces of the metals, which effectively reduced the exposed surface area [8,9] of the metals in corrosive solutions.

The plant extracts of *Lawsonia inermis* [10], *Justicia gendarussa* [11], *Argemone Mexicana* [12], *Isertia cocccinea* [13] and *Palicourea guianensis* [14] have been tested as corrosion inhibitors for steel in HCl medium. These plant extracts are low cost, nontoxic, readily available, and ecofriendly substances. Therefore finding naturally occurring substances as corrosion inhibitors is a subject of great practical significance [15–17].

In the present research, we have worked on the problem of mild steel protection in hydrochloric acid medium. Mild steel is one of the most utilized iron alloys for numerous engineering and industrial applications due to its cost effectiveness and excellent functional properties. So, we have carried out corrosion inhibition studies on the mild steel. On the basis of our finding, we reported aqueous extract of Aloe Vera gel as green corrosion inhibitor for mild steel in hydrochloric acid medium. *Aloe Vera* gel consists primarily of water and polysaccharides (pectins, hemicelluloses, glucomannan, acemannan, and mannose derivatives). It also contains amino acids, lipids, sterols (lupeol, campesterol, and β-sitosterol), tannins, β-carotene, Vitamin B_{12}, Vitamin E (α-tocopherol) and enzymes. Mannose 6-phosphate is a major sugar component. The structures of different constituents are presented in Fig. 1. This fact attracted our attention towards corrosion studies using an extract this gel. To the best of our knowledge, this extract has not been used for the purpose of corrosion inhibition studies for mild steel so far. We have demonstrated the anticorrosion potential of this extract using weight loss, Tafel polarization, and electrochemical impedance spectroscopy. We have also studied the effect of immersion time (up to 7 days), temperature (308–338 K), and acid concentration (0.5–2.0 M HCl) on inhibition effect of the extract using weight loss method.

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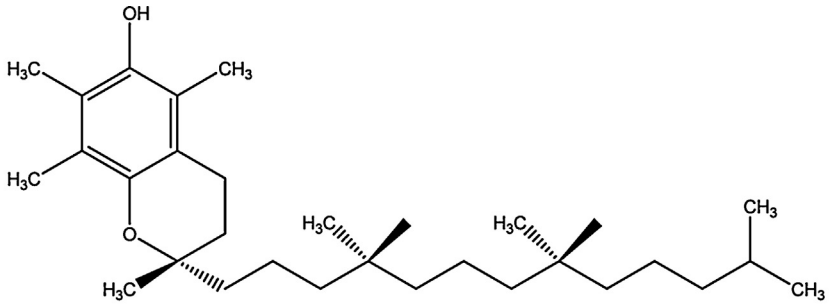
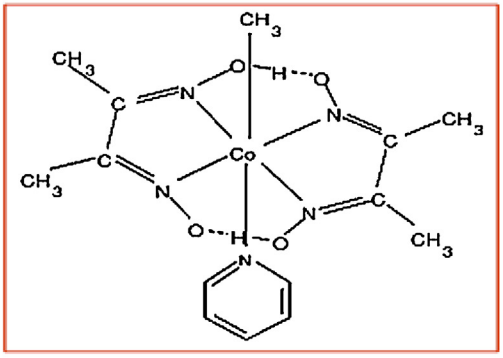
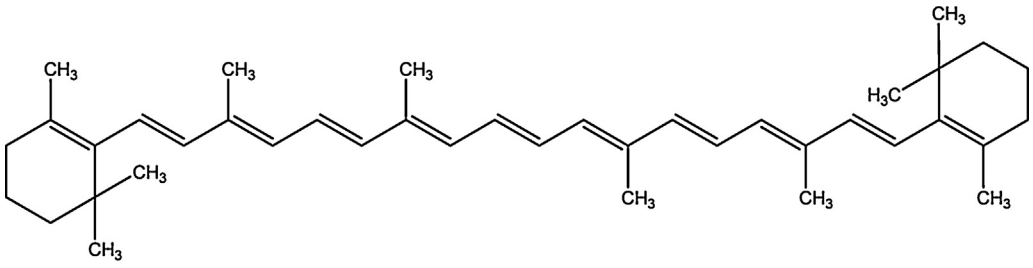


Vitamin E (α-tocopherol)



Vitamin B_{12}



β-carotene

Fig. 1. Structure of different constituents of Aloe Vera gel.

We have used Aloe Vera extract in this study because it is similar effective to inhibit corrosion of mild steel solution at lower concentration compared to some earlier studied inhibitors [12,18–20,6,21]. The supremacy of Aloe Vera extract compared to some earlier studied inhibitors can be viewed in Table 1.

Experimental

Extraction procedure

The leaves of *Aloe Vera* plant were collected from the field, and the extract was prepared according to the method used earlier [22] and used for the corrosion study without any further purification. The Aloe Vera gel is 200:1 soluble in water [23].

Materials

The following composition of the mild steel was used for all of the experiments (wt.%) C = 0.17, Mn = 0.46, Si = 0.26, S = 0.017, P = 0.019 and balance Fe were used for weight loss as well as electrochemical studies. Weight loss and electrochemical studies were performed on mild steel coupons of dimensions 2.5 cm × 2 cm × 0.025 cm and 1 cm × 1 cm × 0.03 cm, respectively. For preparation, test coupons were abraded successively with