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The inhibition of mild steel corrosion by papaya and neem extracts

ABSTRACT

This study examined earlier research on using papaya and neem extracts as inhibitors to minimize the corrosion of mild steel in a variety of corrosive situations. The potential inhibitory characteristics of plant extracts to potentially replace the hitherto used, well-known inhibitors that are harmful to the people handling them as well as the environment, inspired several scholars to conduct corrosion inhibition tests on metals using plant extracts. The findings of earlier research demonstrated that the maximal inhibitory efficiency provided by neem leaf extract to prevent the degradation of carbon steel in a hydrochloric acid (1 M) medium was 97%, while 86% was observed for the protection in H_2SO_4 (1 M) solution. The extract from Carica papaya leaves was shown to have up to 83% maximum inhibitory efficacy for preventing mild steel corrosion in HCl (1 M). It has been revealed that when extract concentration increased, the rate of steel corrosion reduced. Additionally, papaya leaves' corrosion-inhibiting mechanism was said to occur mostly in the cathodic area. Both plant-leaf extracts (Papaya and Neem) have been reported to have adsorption qualities that, for the most part, agreed with the Langmuir adsorption isotherm model.

***Keywords**: corrosion inhibition, papaya, neem, plant extracts, mild steel.*

1. INTRODUCTION

The more frequently used building component material is carbon steel owing to its inexpensive and satisfactory mechanical characteristics [1]. The exposure of alloys of steel to acidic environments can lead to significant corrosion damage [2]. When metals or alloys interact chemically or electro-chemically with their surroundings, a more stable state is created and corrosion occurs [1,3,4]. Metal corrosion is a serious issue that has to be addressed for reasons of safety, the environment, and the economy [5]. One of the most useful strategies for corrosion prevention in acid solutions is the employment of inhibitors [6]. Corrosion inhibitors are a crucial component of materials protection against corrosion-related material degradation [7] and can function when added in minute concentrations to the degrading environment [8]. Invaluable steel structures like boilers, heat exchangers, and containers that store oil can be well shielded against corrosion by these corrosion inhibitors [2].

Many years back, effective corrosion inhibitors like chromates and synthetic phosphates had been used to efficiently deter the corrosion of steel in various acidic media, but currently, the use of chromates and other synthetic substances for corrosion inhibition is generally discontinued because of their toxicity, high cost, and environmentally unfriendly nature. This development has made researchers to seek other sets of inhibitors that are not only effective but globally affable [9]. Making use of natural materials as inhibitors for the corrosion of alloys has found expression in research undertakings by many scholars [10]. From to several reports, natural compounds originating from seeds and leaves, for instance, can be employed as corrosion inhibitors [11].

According to earlier studies, the plants Azadirachta indica and Carica papaya are genuine eco-friendly green materials that may prevent mild steel from corroding in acidic environments. By using a weight-loss corrosion study technique, the leaf extracts of neem and pawpaw trees were employed to prevent the deterioration of mild steel in a sulphuric acid solution [12]. When the extracts

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were added to the corrosive medium, the rate at which the mild steel corroded decreased compared to the unfettered media. When it comes to preventing mild steel from corroding in a sulphuric acid solution, neem has been found to outperform pawpaw extract [12].

The current study seeks to critically analyze past research on the application of plant leaf extracts of papaya and neem to prevent carbon steel corrosion in diverse corrosive environments. Efforts would be intensified to discover knowledge gaps and what might be done to remedy them.

2. GREEN INHIBITORS

2.1. Effectiveness of green inhibitors against metal corrosion

The gross demand for and use of corrosion inhibitors that are less harmful and biodegradable than conventional formulations is now increasing exponentially. As a result, corrosion inhibitors with the "green" designation are receiving unprecedented worldwide interest [13]. According to Khaled [14], the use of materials, and approaches that reduce or eliminate the formation of biomasses, and raw materials that are harmful to human health or the environment is what is meant by a "green approach to degradation remediation." Plant extracts have been demonstrated over time to be the ideal candidates to replace existing toxic corrosion inhibitors owing to their competitive advantage of the reduction in environmental threat, widespread availability, lower cost, and greater inhibitive potency [15]. Even though organic green corrosion inhibitors can be obtained from a variety of sources, such as surfactants, ionic liquids, amino acids, plant extracts, and biopolymers, plant extracts have been shown over time to be the best at averting corrosion [16].

Green corrosion inhibitors are devoid of heavy metals and other harmful compounds, and they are biodegradable. Some research outcomes have shown the effective usage of naturally occurring compounds to stop metals from corroding in both acidic [17-23] and alkaline environments [24]. Various natural sources provide green corrosion inhibitors. They are abundant in organic compounds, include many polar atoms, and have bonds with many electrons. Their molecules adsorb on the surface of the metal or alloy during the inhibition process and create a barrier [25]. They may create coordinate bonds by donating an electron to the iron or metal atoms' unoccupied d-orbitals throughout the process [26].

When corrosion happens, metal ions enter the solution at the anode and move the metal's electrons to the cathode. For the cathodic process to work, electron acceptors such as oxygen, oxidizing agents, or hydrogen ions are required. By stopping or delaying anodic or cathodic processes, corrosion can be minimized. Adsorbed inhibitors form a defence barrier on the metal surface, thereby protecting the anodic, cathodic, or both sites to minimize the corrosive processes of oxidation, reduction, or both [26].

2.2. Azadirachta indica

Azadirachta indica (AZI) is a widely used multifunctional tree that serves as both a pesticide and a food source [27]. AZI also referred to as neem or margosa, is a fast-growing shrub in the Meliaceae family of mahogany that is renowned for its medicinal properties, ability to produce natural insecticides, and lumber. The Indian subcontinent and other arid regions of South Asia are likely the neem's original habitats. In addition to being utilized in cosmetics and organic farming, the plant is used in Ayurvedic and traditional medicine [28].

Figure 1. Azadirachta indica leaves [28,29]

Slika 1. Listovi Azadirachta indica [28,29]

Neem trees have appealing rounded tops, thick furrowed bark, and a height range of 15 to 30 meters (49 to 98 ft). The complex leaves are normally evergreen and feature serrated leaflets (as shown in Fig. 1), although they can drop off during extremely dry spells. Bunches of the tiny, fragrant, white male or staminate (bisexual) blossoms are produced in the leaf axils [28]. Structures made of carbon steel-reinforced concrete have been protected against corrosion by neem leaf extracts. After 102 days, 95% of the corrosion was prevented, according to the observation [30].

Neem's botanical name, Azadirachta indica (AZI), is also claimed to have medicinal properties [31]. According to reports, AZI outperformed an established and successful inhibitor known as 1, 2, 3 - benzotriazole (I.E. = 85%) in terms of its inhibitory behaviour to prevent the corrosion of steel in the sulphuric acid medium by achieving an inhibition efficiency (I. E.) of 92.7% [32]. As a result, it was discovered that the gum exudates of AZI at an 80-ppm concentration prevented mild steel corrosion in HCl (1 M) while adhering to the Langmuir adsorption isotherm model.

2.3. Carica papaya

Although the papaya plant may grow up to 8 meters (26 feet) tall and resembles a palm, it is not as woody as the name might suggest. The plant is topped with deeply lobed leaves (as seen in Fig. 2) that may reach a width of 60 cm (2 ft) and are carried on hollow 60 cm long petioles (leaf stalks).

Figure 2. Carica papaya leaves [35]

Slika 2. Listovi Carica papaya [35]

Hermaphrodite varieties of the species are known, and there are many inconsistencies in the distribution of the sexes that are prevalent. The species is typically dioecious, with male and female flowers being produced on distinct plants [33]. The papaya plant, Carica, is an evergreen herb that resembles a tree and grows 2–10m tall. It is typically unbranched but may become branched after being injured. All of its sections contain white latex. The stem is hollow, cylinder-shaped, 10-30 cm in diameter, and covered with spongy-fibrous tissue with distinct leaf scars. The plant has a broad rooting structure [34].

2.4. Models of the adsorption isotherm

The adsorption of the inhibitor onto the metal's surface enables the corrosion inhibition process [36]. The electrochemical potential at the interface between the solution and the metal, the chemical makeup of the solution, the physical characteristics of the metal surface, and temperature all affect the rate of adsorption [37].

The interaction between the metal and the inhibitor is well understood according to the adsorption isotherm models [38].

2.4.1. Isotherm of Langmuir adsorption

A monolayer of the inhibitor is present on the surface of the material that is protected from corrosion according to the Langmuir adsorption isotherm model [39]. To keep the energies of adsorption on the metal surface uniform, the ions that occur between the liquid and solid phases are evenly distributed [38,40]. The following equation (1) represents the Langmuir adsorption isotherm:

$$\frac{C_m}{\theta_{Cor}} = C_{In} + \frac{1}{K_{ad/de}} \quad (1)$$

where,

θ_{Cor} = surface coverage fraction.

C_{In} = concentration of the inhibitor.

$K_{ad/de}$ = the constant (equilibrium) for the desorption/adsorption process.

2.4.2. Freundlich adsorption isotherm

An exponential distribution of energy that surrounds a heterogeneous surface is described by the Freundlich adsorption isotherm [40]. It provides a clear explanation of how the inhibitor concentration on a metal's surface and the inhibitor concentration in a liquid is in contact with relation to one another [41]. The mathematical expression for the Freundlich adsorption isotherm model is stated thus:

$$\theta_{Cor} = K_{fed} C_{ad}^{1/n_{int}} \quad (2)$$

where,

θ_{Cor} = at equilibrium, the amount of metal absorbed per gram of the adsorbent.

K_{fed} = constant of Freundlich isotherm (mg/g).

n_{int} = the intensity of adsorption.

C_{ad} = equilibrium adsorbate concentration (mg/L).

2.4.3. Temkin adsorption isotherm

Temkin's adsorption isotherm [40] illustrates linearity in the decrease of adsorption heat with surface coverage. The model serves as an illustration of the uniform distribution of binding energies that takes into consideration the interactions between the adsorbent and adsorbate. The Temkin adsorption model stands out from other isotherms because it describes the interactions that take place in the adsorbed layer [42]. It is expressed mathematically as:

$$\theta_{Cor} = B_{Sorp}\, InA_{Tem} + B_{Sorp}\, InC_{in} \quad (3)$$

$$B_{Sorp} = \frac{RT}{b_{Tem}} \quad (4)$$

where,

θ_{Cor} = the surface coverage fraction.

B_{Sorp} = heat of sorption constant (J/mol).2

A_{Tem} = equilibrium binding constant of Temkin isotherm (l/g).

C_{in} = Inhibitor concentration.

R = universal gas constant (8.314J/mol/K).

T = absolute temperature.

b_{Tem} = Temkin isotherm constant.

3. AN OVERVIEW OF PREVIOUS STUDIES ON CORROSION INHIBITION OF CARBON STEEL USING THE AZADIRACHTA INDICA AND PAPAYA EXTRACTS

The recent literature on corrosion inhibition properties of Azadirachta indica and papaya extracts is being reviewed in this section. Attention will be given to the mechanisms of inhibition of plain carbon steel using Azadirachta indica and papaya extracts. The authors will appraise the existing literature and draw meaningful deductions which will further elucidate the inhibition characteristics of Azadirachta indica and papaya extracts.

The summary of the observations in recent literature on the corrosion inhibition of carbon steel in various corrosive media by the leaf extracts of Azadirachta indica and papaya plants is presented in Table 1. It can be observed from the results as presented in Table 1, that Azadirachta indica extract is more effective compared to Papaya extract in inhibiting the corrosion of plain carbon steel in an acid medium.

Table 1. A summary of corrosion inhibition of carbon steel using the plant extracts of Azadirachta indica and Carica papaya

Tabela 1. Rezime inhibicije korozije ugljeničnog čelika korišćenjem biljnih ekstrakata Azadirachta indica i Carica papaje

Inhibited alloy	Corrosive Environment	Method (s) of study	Part (s) of Plant used	Maximum inhibition efficiency, (%)	Adsorption isotherm model	Ref.
Azadirachta Indica Plant						
MS	HCl (0.1 M)	WL, PDP, EIS	Leaf	93.24	Langmuir, Temkin	[43]
MS	HCl (1.0M)	WL, PDP, EIS	Leaf	97%	-	[44]
MS	HCl (5 M)	WL, EIS, EIS	Leaf	89.25	Freundlich, Langmuir	[45]
MS	HCl (0.25 M)	WL	Leaf	94.22	Langmuir	[46]
			Stem	83.2		
			Seed	86.3		
MS	NaCl (0.5 wt%), Ca $(OH)_2$ (1 wt%)	WL, EIS	Leaf	86	-	[47]
CS	HCl (1.0 M)	WL	Leaf	87	Temkin	[48]
MS	H_2SO_4 (1.0 M)	WL	Leaf	86	-	[49]
MS	H_2SO_4 (1.0 M)	WL	Leaf	86	-	[50]
Carica Papaya Plant						
MS	Crude oil water	WL, PDP	Peel extract	99.2	Langmuir, Temkin, Freundlich	[51]
MS (as received, annealed, and cold worked)	HCl (0.5 M), NaOH (0.5 M)	WL	Leaf	54.1 (as received) 42 (cold worked) 23.1 (Annealed)	-	[52]
MS	HCl (2.2 M)	WL	Leaf	88.4	-	[53]
A36 MS	H_2SO_4 (1.0 M)	WL	Seed	92	Langmuir	[54]
A304 SS	HCl (1.0 M)	PDP	Leaf	97	-	[55]
MS	H_2SO_4 (0.5M)	WL	Fluid	89.9	Langmuir	[56]
MS	HCl (1.0 M)	WL	Leaf	83	Temkin, Langmuir	[57]
MS	Nitric acid (2.5 M)	WL	Leaf	96	Langmuir	[58]

3.1. Inhibition characteristics of Azadirachta indica extract

Many authors have recently studied the effect of Azadirachta indica extract as a corrosion inhibitor on plain carbon steel in various acid media. Okewale et al. [43] studied the influence of Azadirachta indica leaf extract as a corrosion inhibitor on mild steel in 0.1M HCl solution using the weight loss method. It was observed that the Azadirachta indica leaf extract inhibited the corrosion of steel in an 0.1M HCl solution. A reduction in corrosion rate from 0.001 mpy to 0.0002 mpy was observed with the increase in the concentration of the inhibitor over an extended duration (up to 5 days). The highest inhibition efficiency of 93.24% was reported whilst the adsorption behaviour of the Azadirachta indica extracts agreed with the Temkin and Langmuir adsorption isotherm models. In a related study, Abro et al. [44] employed weight loss, electro-potential measurements, potentiodynamic polarization and impedance spectroscopy methods to investigate the corrosion inhibition of Azadirachta indica leaves extract in 1.0M HCl solution. The inhibition efficiency of Azadirachta indica leaf extract was observed to increase with exposure time. The study concluded that Azadirachta indica leaves inhibited the corrosion of mild steel with an efficiency of about 97% within 72 h.

Kumar et al. [45] employed the extract of Azadirachta indica leaves to inhibit the corrosion of mild steel in a hydrochloric acid (5 M) medium. It was observed that the optimum adsorption of the extract on the surface of mild steel adhered to the Langmuir and Freundlich adsorption isotherm models. The Azadirachta indica leaf extract was observed to inhibit the corrosion of mild steel with a maximum efficiency of 89.25 %. Some parts of the Azadirachta indica tree including the stem, seed, and leaves have been studied by Ogundana et al. [46] to determine their corrosion-inhibitory properties on mild steel in HCl (0.25 M) solution. The efficiency of the inhibitors obtained from the Azadirachta indica plant was observed to be sensitive to the concentration of the plant extract. It was reported that the inhibitor from Azadirachta indica leaves extract attained an inhibition efficiency of 94.22% followed by the Azadirachta indica stem extract (86.3%) and Azadirachta indica seed extract (83.2%) after about nine days of exposure at a concentration of 1 g respectively. The inhibition mechanism of every examined extract was found to agree with the Langmuir adsorption isotherm.

Baitule et al. [47] studied the corrosion-inhibitory influence of Azadirachta indica leaf extract on mild steel in an alkaline solution having chloride ions. It was observed that inhibition efficiency increased with a corresponding increase in the concentration of the Azadirachta indica leaf extract. The study noted that a concentration of 600 ppm of Azadirachta indica leaf extract yielded an inhibition efficiency of 86%. Nahle et al. [48] studied the influence of Azadirachta Indica aqueous extract on corrosion inhibition of low carbon steel in 1.0M HCl solution at temperatures in the range from 303 to 343K using electrochemical and weight loss methods. It was observed that the inhibition efficiency of Azadirachta Indica's aqueous extract increased with the concentration of the extract. At 2.0 g/L concentration of the extract, the inhibition efficiencies at test temperatures of 303 K and 343 K were reported to be 87% and 80% respectively, signifying a decrease in efficiency as the temperature increases. The adsorption behaviour of the extract was found to be consistent with the Temkin adsorption mechanism. However, it was explained that the observed decrease in the inhibition efficiency with the increase in test temperature of the corrosive medium indicates that the degradation of the steel is aggravated by the temperature rise.

Okpara et. al. [49] studied the influence of Azadirachta indica leaf extract on the corrosion behaviour of medium carbon steel in H_2S0_4 medium. It was observed that the corrosion rate of the steel decreased with increase in the concentration of the inhibitor (Azadirachta indica leaf extract). This result agrees with the findings of Waidi et. al. [50], which reported a maximum inhibition efficiency of 86 % at an inhibitor concentration of 0.5 g/L of the Azadirachta indica leaf extract in 1 M of H_2S0_4 solution. It can therefore be deduced from these studies that the inhibition efficiency of Azadirachta indica extract increases with the inhibitor concentration. In addition, these studies show that the corrosion inhibition properties of Azadirachta indica extracts are more effective in HCl media compared to the H_2S0_4 solutions. It can also be inferred that the corrosion inhibition properties of Azadirachta indica extract diminish with a significant temperature rise of the corrosive medium.

3.2. Inhibition characteristics of papaya extract

The use of Carica papaya peels among other biocidal-green inhibitors for corrosion inhibition of steel in a crude oil-water environment has been studied by Agarry et al. [51]. It was observed that the presence of 4000 mg/L of the peel extract of papaya in 35 days yielded an inhibition efficiency of 99.2% in protecting the mild steel from corrosion in the crude oil-water environment. It was reported that the papaya peel extract inhibits corrosion by adsorption mechanism which was consistent with Langmuir, Temkin and Freundlich isotherm adsorption models. Nwigwe et al. [52] studied the inhibition of Carica papaya leaves extract on the corrosion of cold worked and annealed mild steel in 0.5M solutions of HCl and NaOH media using the weight loss method. It was observed that the maximum inhibition efficiencies for protecting the steel samples in 0.5M HCl solution were 42% (cold worked), 54.1% (as received), and 23.1% (annealed) respectively. Also, it was reported that Carica papaya leaf-extracts inhibited the corrosion of the steel samples in 0.5M NaOH solution with inhibition efficiencies of 33.3%, 51.4% and 53.8% for the annealed, cold worked and as-received samples respectively. It can be deduced from this result that Carica papaya leaves extract inhibits corrosion more effectively in NaOH solution medium than the HCl solution. Also, annealed steels are less responsive to inhibition by Carica papaya leaves extract compared to cold-worked steel samples.

Benedict et al. [53] investigated the potency of the papaya leaf extract in inhibiting the corrosion of mild steel in HCl (2.2M). The maximum inhibition efficiency of 96.4% was attained. Ayoola et al. [54] studied the adsorption influence on the corrosion inhibition properties of papaya seed on A36 mild steel in 1 M H_2SO_4 solution. It was observed that the thermodynamic impact on the inhibitive behaviour of the papaya seed was temperature sensitive as the inhibition efficiency of the papaya seed increased with a reduction in test temperature from 318.15K to 278.15K. The adsorption behaviour of papaya seed was found to agree with the Langmuir isotherm model. An inhibition concentration of 4 g/L was reported to yield a maximum inhibition efficiency of 92 %. Nugroho et al. [55] investigated the inhibition mechanism of papaya leaf when added to hydrochloric acid (1 M) solution where mild steel had been immersed. The study observed that papaya leaf extract was a cathodic inhibitor as the inhibitor decreased the rate of corrosion by reacting with the corrosion solution. Papaya leaf extract was noted to yield a maximum inhibition efficiency of 97 %. In a related study, Ayoola et al. [56] utilized the fluid obtained from the over-ripped papaya fruit to inhibit the corrosion of mild steel (A315) in 0.5M H_2SO_4. A maximum inhibition efficiency of 89% was reported at a concentration of 10% vol/vol papaya extract and the inhibition behaviour of the extract agreed with the Langmuir isotherm adsorption model.

Omotioma et al. [57] used the pawpaw leaf extract at 1g/L concentration to inhibit the corrosion of mild steel in 1M HCl. It was observed that the adsorption characteristics of the papaya leaf extract agreed with the Temkin and Langmuir adsorption isotherm models with maximum inhibition efficiency of 80.29%. In another study, Oki et al. [58] employed papaya leaf extract to inhibit the corrosion of mild steel in nitric acid (2.5 M). A maximum inhibition efficiency of 96% was attained and the adsorption behaviour of the extract aligned with the Langmuir isotherm model. These studies suggest that Azadirachta indica and Papaya extracts are effective green inhibitors for protecting carbon steels against corrosion in acid and alkaline media at room temperature. It can also be deduced that the inhibitive properties of Azadirachta indica and Papaya extracts diminish with temperature rise.

4. IDENTIFIED GAPS IN KNOWLEDGE

Previous studies have extensively investigated corrosion rates and inhibition efficiencies resulting from the use of the extracts of neem and papaya to protect against the corrosion of mild steel in different acidic concentrations but the following gaps in knowledge have been spotted.

1. There is limited knowledge about identifying the specific phytochemicals in the plant extracts that were active behind the inhibitive process. It is recommended that future studies be conducted to identify and separate the inherent active inhibitive constituents of the extracts of plants under review to make for optimum and efficient corrosion inhibition disposition.
2. Predictive models are rarely available to predict the corrosion rates of steel in the presence and absence of papaya and neem leaf extracts in various acidic solutions. It is advised that future research make use of various prediction methods to forecast the rates at which mild steel would corrode in the aforementioned corrosive conditions.
3. Most previous research works focused on the corrosion inhibition of mild steel in acidic media using Carica papaya and Azadirachta indica leaf extracts. There is a scarcity of literature on saline media and crude oil water as corrosive media. Future studies should be channelled in this direction.
4. Computational studies correlating the binding energies $E_{homo,}$ E_{lumo} and other structural features of the phytochemical constituents of Carica papaya and Azadirachta indica with their corrosion inhibition efficiency have not been given sufficient attention by previous researchers. Futher studies are recommended in this direction.

5. CONCLUSIONS

From a review of earlier research on the use of papaya and neem leaf extracts to inhibit mild steel from corroding in various corrosive conditions, these conclusions may be drawn:

- The maximum recorded inhibitory effectiveness provided by neem leaf extract to prevent mild steel degradation in the presence of hydro-chloric acid (1M) was reported to be 97%, whereas 86% was observed for the protection in sulphuric acid solution (1M). According to reports, the degradation rate of steel increased in an acidic medium as the concentration of the extract decreased.

- The Carica papaya leaf extract's highest recorded inhibitory efficiency for preventing mild steel corrosion in HCl (1 M) was 83%.
- According to reports, papaya leaves' corrosion-inhibiting mechanism primarily occurs in the cathodic area.
- It was discovered that when the temperature decreased, papaya and neem leaf extracts were more successful in inhibiting corrosion under acidic environments.
- The model as postulated by Langmuir was mostly supported by the reported adsorption characteristics of both plant-leaf extracts (Papaya and Neem).

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IZVOD

INHIBICIJA KOROZIJE MEKOG ČELIKA EKSTRAKTOM PAPAJE I NIMA

Ova studija je ispitala ranija istraživanja o korišćenju ekstrakta papaje i nima kao inhibitora da bi se smanjila korozija mekog čelika u različitim korozivnim situacijama. Potencijalne inhibitorne karakteristike biljnih ekstrakata da potencijalno zamene do sada korišćene, dobro poznate inhibitore koji su štetni za ljude koji njima rukuju, kao i za životnu sredinu, inspirisali su nekoliko naučnika da sprovedu testove inhibicije korozije na metalima koristeći biljne ekstrakte. Nalazi ranijih istraživanja su pokazali da je maksimalna inhibitorna efikasnost koju je obezbedio ekstrakt lista nima za sprečavanje razgradnje ugljeničnog čelika u medijumu sa hlorovodoničnom kiselinom (1 M) bila 97%, dok je 86% primećeno za zaštitu u H_2SO_4 (1 M) rešenje. Pokazalo se da ekstrakt iz listova papaje Carica ima do 83% maksimalne inhibitorne efikasnosti za sprečavanje blage korozije čelika u HCl (1 M). Otkriveno je da kada se koncentracija ekstrakta poveća, stopa korozije čelika se smanjuje. Pored toga, rečeno je da se mehanizam koji sprečava koroziju korišćenjem listova papaje javlja uglavnom u katodnoj oblasti. Prijavljeno je da oba ekstrakta listova biljaka (papaja i nima) imaju adsorpcione kvalitete koje se, uglavnom, slažu sa modelom izoterme adsorpcije Langmuir.

Ključne reči: *inhibicija korozije, papaja, nim, biljni ekstrakti, meki čelik.*

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