International Journal of Multidisciplinary Research and Growth Evaluation.

The Potential of Kapok Leaves as a Corrosion Inhibitor with Optimal Protection in Acidic Media

Syarif Hidayatullah [1*], Suteja [2], Ahmad Akromul Huda [3]
[1-3] Mechanical Engineering Department, Faculty of Engineering, University of Mataram, Indonesia

* Corresponding Author: **Syarif Hidayatullah**

Article Info

ISSN (Online): 2582-7138
Impact Factor (RSIF): 7.98
Volume: 06
Issue: 06
November - December 2025
Received: 03-08-2025
Accepted: 05-10-2025
Published: 29-10-2025
Page No: 48-53

Abstract
The pickling process conducted in acidic environments presents notable environmental concerns, largely attributed to the utilization of synthetic organic compounds as corrosion inhibitors for the protection of carbon steel surfaces. To mitigate these environmental impacts and suppress corrosion rates, the advancement of eco-friendly, naturally derived inhibitors has garnered increasing attention. In the present work, an extract obtained from *Ceiba pentandra* (kapok) leaves was investigated as a potential corrosion inhibitor for carbon steel in 1 M HCl solution. The inhibitory behavior was examined using Tafel polarization and Electrochemical Impedance Spectroscopy (EIS) at varying extract concentrations. Findings revealed that the kapok leaf extract developed a dense and uniform protective layer on the steel surface, effectively diminishing the corrosion rate. At the optimum concentration of 3000 mg/L, the inhibition efficiency achieved 80.31%. EIS measurements further indicated a pronounced enhancement in polarization resistance, confirming the establishment of a stable inhibitor film. These results highlight that kapok leaf extract exhibits considerable potential as a green and sustainable corrosion inhibitor in acidic conditions, offering a promising alternative to conventional synthetic inhibitors for industrial applications.

DOI: https://doi.org/10.54660/.IJMRGE.2025.6.6.48-53

Keywords: Corrosion Inhibition, Carbon Steel, Natural Extract, Green Inhibitor

1. Introduction

Corrosion of metals constitutes a major challenge across diverse industrial sectors, particularly within metal processing, chemical, petrochemical, and oil and gas industries (Makhlouf *et al.*, 2018) [13]. The occurrence of corrosion results in the progressive deterioration of materials, loss of mechanical integrity, and escalated maintenance and replacement expenses. Globally, the economic impact of corrosion is estimated to reach trillions of US dollars each year, underscoring its significance as a key factor influencing operational efficiency and industrial sustainability (Jalab *et al.*, 2022) [10]. Among various corrosion control strategies, the incorporation of corrosion inhibitors especially under acidic conditions such as during pickling and descaling processes remains one of the most effective approaches (Deyab, 2020) [5]. These inhibitors operate by adsorbing onto the metal surface and forming a protective barrier that restricts direct interaction between the metal and the corrosive medium, thereby retarding the overall corrosion reaction rate.

The application of acidic solutions such as hydrochloric acid (HCl) for metal surface cleaning is common in steel and light metal industries because of their high efficiency in removing oxides and surface scales (Goyal *et al.*, 2018; Yildiz *et al.*, 2021) [8, 19]. Nevertheless, the aggressive nature of these acids accelerates the corrosion of base metals, thus necessitating the use of efficient inhibitors to preserve material integrity. Conventional inhibitors, primarily composed of synthetic organic or inorganic compounds such as amine-, phosphate-, or heavy metal-based formulations have proven effective but are increasingly scrutinized due to their environmental and toxicological implications.

These include potential risks of toxicity, bioaccumulation, and contamination of soil and aquatic systems. Consequently, the exploration of environmentally benign, naturally sourced corrosion inhibitors has emerged as a vital research direction over recent decades (Verma *et al*., 2021).

Green or natural corrosion inhibitors offer multiple advantages, including widespread availability, biodegradability, minimal toxicity, and promising scalability for industrial applications (Zomorodian & Behnood, 2023) [22]. Numerous investigations have confirmed the corrosion-inhibiting potential of various plant extracts such as those derived from tobacco leaves, banana peels, papaya leaves, and black cumin seeds which are rich in bioactive constituents including alkaloids, flavonoids, tannins, and saponins (R. Holla *et al*., 2024) [15]. These phytochemicals contain functional groups capable of interacting with metallic surfaces through physical or chemical adsorption, resulting in the formation of a protective layer that mitigates corrosion activity. However, the inhibitory performance of such natural extracts is strongly influenced by their chemical composition, concentration, and environmental parameters, necessitating individual assessments for each potential botanical source (Dehghani *et al*., 2024) [4].

The kapok tree (*Ceiba pentandra*), a tropical species widely distributed across Southeast Asia including Indonesia possesses leaves rich in polyphenols, flavonoids, and tannins, which are recognized for their antioxidant and corrosion-inhibiting capabilities (Ardyn *et al*., 2023) [1]. Despite numerous reports on the efficacy of other plant-based inhibitors under various pH conditions, studies focusing on the corrosion inhibition behavior of kapok leaf extract remain scarce particularly in acidic media such as hydrochloric acid solutions commonly employed in industrial operations. This gap highlights the importance of investigating kapok leaf extract as a potential green inhibitor that aligns with the growing demand for environmentally compatible and locally available corrosion protection agents.

Accordingly, the present study aims to assess the inhibitory performance of *Ceiba pentandra* leaf extract on carbon steel corrosion in 1 M HCl solution. Electrochemical techniques namely Tafel polarization and Electrochemical Impedance Spectroscopy (EIS) were employed to quantitatively evaluate corrosion rates and elucidate the protective mechanisms involved. In addition to determining inhibition efficiency at different extract concentrations, the research also characterizes the nature of the protective film formed on the metal surface and compares the findings with those of conventional synthetic inhibitors. The outcomes of this work are anticipated to contribute valuable insights toward the development of sustainable, bio-based corrosion inhibitors derived from local natural resources, providing a viable and eco-conscious alternative for industrial applications.

2. Method

2.1. Preparation of Kapok Leaf Extract

Fresh kapok (*Ceiba pentandra*) leaves were thoroughly washed, air-dried, and ground into a fine powder. The extraction process was conducted using 96% ethanol as the solvent through maceration for 48 hours. The resulting mixture was filtered, and the solvent was subsequently removed using a rotary evaporator to obtain a concentrated viscous extract.

2.2. Preparation of Specimens and Test Solutions

Carbon steel specimens (Q325 grade) were cut to dimensions of 3.5 cm × 1.0 cm × 0.5 cm. The surfaces were sequentially polished with 1500-grit emery paper, then ultrasonically cleaned in acetone and ethanol, and finally dried under ambient air conditions. The corrosive medium consisted of a 1 M HCl solution, to which varying concentrations of kapok leaf extract (0, 1000, 2000, and 3000 mg/L) were added to prepare the test solutions. The chemical composition of carbon steel Q325 is as follows (Wang *et al*., 2019) [18]: C 0.167%, Cr 0.019%, Cu 0.004%, Mn 0.284%, Mau 0.001%, Ini 0.004%, P 0.021%, S 0.010%, Si 0.162%, V 0.001%, and Fe Balance.

2.3. Electrochemical Measurements

Electrochemical analyses were conducted using a conventional three-electrode configuration comprising carbon steel as the working electrode, a platinum wire as the counter electrode, and a saturated KCl (3M) reference electrode (Gapsari *et al*., 2022) [7]. Prior to each measurement, the specimens were immersed in the test solution for 30 minutes to ensure stabilization of the open-circuit potential.

Tafel polarization curves were obtained by sweeping the potential at a scan rate of 10 $mV \cdot s^{-1}$ within the potential window of −0.8 to 0.0 V relative to the reference electrode. Electrochemical Impedance Spectroscopy (EIS) measurements were recorded in the frequency domain ranging from 10^{-1} to 10^{5} Hz with an applied AC perturbation amplitude of 5 mV. The acquired impedance spectra were analyzed by fitting the data to an equivalent electrical circuit represented by the R(QR) model.

The inhibition efficiency (η) was calculated using the following equation (Hidayatullah *et al*., 2024; Syarif Hidayatullah *et al*., 2025) [9, 17]:

$$IE(\%) = \frac{I^{0}_{corr} \times I'_{corr}}{I^{0}_{corr}} \times 100 \tag{1}$$

$$IE\ (\%) = \frac{R_p - R_p{}^{0}}{R_p} \times 100 \tag{2}$$

3. Results and Discussion

3.1. Potentiodynamic Polarization (PDP)

The corrosion inhibition behavior of *Ceiba pentandra* (kapok) leaf extract on carbon steel in 1 M HCl solution was systematically evaluated through potentiodynamic polarization measurements. The corresponding Tafel polarization curves (Figure 1) revealed a pronounced reduction in corrosion current density (icorr) with increasing inhibitor concentration, indicating the effective adsorption and protective action of the kapok leaf extract on the metal surface. This observed trend confirms the extract's strong potential as a sustainable, plant-derived corrosion inhibitor.

In the uninhibited system, the carbon steel specimen exhibited a corrosion current density (Icorr) of 0.000303 $A.cm^{-2}$, confirming the high susceptibility of the material to rapid corrosion in the acidic environment (Zheng *et al*., 2023) [21]. The introduction of *Ceiba pentandra* (kapok) leaf extract at progressive concentrations of 1000, 2000, and 3000 $mg \cdot L^{-1}$ resulted in a pronounced decline in Icorrr, with corresponding values of 0.000125, 0.000091, and 0.000059 $A.cm^{-2}$, respectively (Table 1). This substantial reduction in corrosion current density signifies the extract's capability to effectively mitigate both anodic metal dissolution and the cathodic hydrogen evolution reaction (Li *et al.*, 2025) [11].

The inhibition efficiency (IE%) was computed according to Equations (1) and (2). At the optimal concentration of 3000 mg·L⁻¹, the extract achieved a maximum inhibition efficiency of 80.31%, demonstrating the formation of a compact and adherent protective film over the steel surface. The observed efficiency is comparable to those reported for other plant-derived corrosion inhibitors, emphasizing the promising performance of kapok leaf extract as a green alternative.

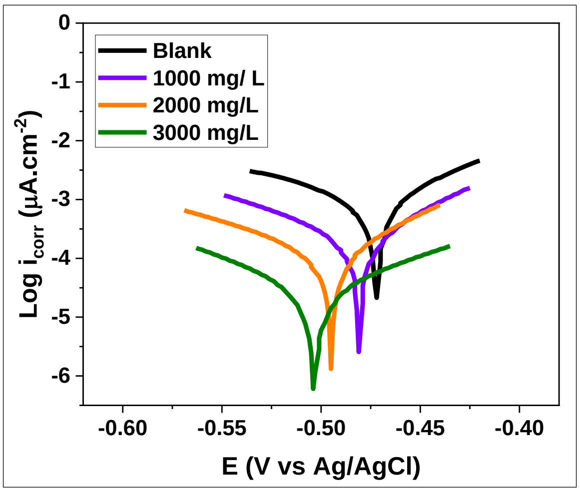

Fig 1: Tafel Polarization Curves (PDP)

A slight displacement in corrosion potential (Ecorr) was observed, shifting from −0.487 V in the blank solution to −0.512 V at 3000 mg·L⁻¹. This marginal change (<0.085 V) suggests that the inhibitor functions as a mixed-type inhibitor, simultaneously affecting both anodic and cathodic reactions (Dehghani *et al.*, 2019) [3]. The limited potential shift further supports the dual inhibition mechanism proposed for the extract's protective action.

The anodic and cathodic Tafel slopes (β_a and βc) provide critical insights into the underlying inhibition mechanism. At lower concentrations of *Ceiba pentandra* extract, both slope values remained nearly constant, indicating that the fundamental electrochemical reactions governing corrosion were not substantially modified by the presence of the inhibitor. Conversely, at higher concentrations, a noticeable reduction in the anodic Tafel slope was recorded, signifying a more pronounced influence of the inhibitor on the anodic metal dissolution process. In contrast, only minor variations were observed in the cathodic slope, implying that while the extract partially suppresses the hydrogen evolution reaction, its dominant effect arises from the inhibition of anodic iron oxidation. This behavior is in close agreement with previous findings for other phytochemical-based corrosion inhibitors (Dehghani *et al.*, 2019) [3].

The polarization resistance (R_p), determined through the Stern–Geary relationship (Feliu *et al.*, 1989) [6], exhibited a substantial increase with rising concentrations of the kapok leaf extract. The highest R_p value was achieved at 3000 mg·L⁻¹, corroborating the enhanced protective capacity of the natural inhibitor. This progressive increase in R_p corresponds directly to the observed decrease in corrosion rate, as a higher polarization resistance reflects a slower electrochemical degradation process. These results further validate the reliability of electrochemical analyses in assessing inhibitor performance.

The Tafel polarization curves (Figure 1) visually confirm this trend, showing a systematic decline in corrosion current density as the inhibitor concentration increases, while maintaining the typical Tafel behavior. This observation suggests that the kapok leaf extract primarily inhibits corrosion through surface adsorption and blockage of active corrosion sites, rather than by altering the intrinsic electrochemical mechanism of steel dissolution (Ma *et al.*, 2022) [12].

Table 1: Tafel Curve Parameters of the Inhibitor

C	β_a (V/dec)	β_c (V/dec)	E_{corr} (V)	i_{corr} (A/cm²)	Corrosion rate (mm/year)	Rp	IE (%)
blank	0.15	0.14	-0.487	0.000303	1.5143	10.34	
1000	0.18	0.15	-0.495	0.000125	0.6231	28.41	59.15
2000	0.19	0.16	-0.505	0.000091	0.4576	41.08	70.02
3000	0.21	0.17	-0.512	0.000059	0.30	68.14	80.31

3.2. Electrochemical Impedance Spectroscopy (EIS)

The Electrochemical Impedance Spectroscopy (EIS) technique was utilized to gain deeper insight into the protective performance of the *Ceiba pentandra* (kapok) leaf extract. The corresponding Nyquist plots (Figure 2) for carbon steel in 1 M HCl, recorded in the presence and absence of the inhibitor, exhibit well-defined capacitive semicircles whose diameters expand progressively with increasing extract concentration. This enlargement of the semicircle diameter reflects a marked rise in the charge transfer resistance (R_p), signifying the development of a denser and more adherent inhibitor film on the metal surface. Such behavior confirms the enhanced barrier properties imparted by the kapok leaf extract, consistent with the improved corrosion protection efficiency observed in the polarization results (Negi *et al.*, 2024) [14].

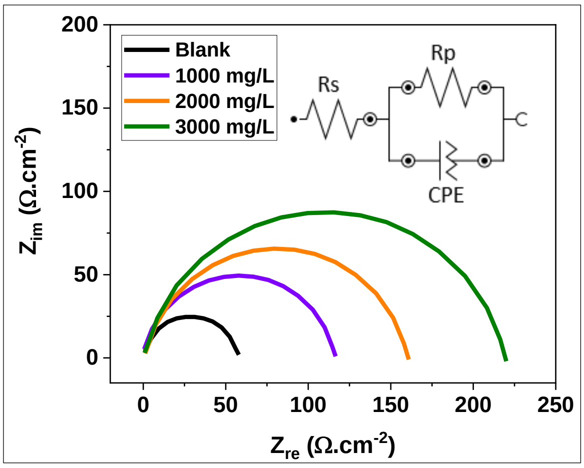

Fig 2: Nyquist Plots from EIS Analysis

Under uninhibited conditions, the charge transfer resistance (R_p) was measured at 60.63 Ω.cm². Upon incorporation of *Ceiba pentandra* (kapok) leaf extract at concentrations of 1000, 2000, and 3000 mg·L⁻¹, the R_p values increased substantially to 120.12, 159.82, and 222.19 Ω.cm², respectively (Table 2). This pronounced enhancement in R_p reflects the progressive improvement in surface protection and the reduction in corrosion kinetics with increasing inhibitor concentration.

Simultaneously, a marked decrease in the constant phase element (CPE) values was observed, suggesting a reduction in interfacial capacitance as a result of the formation of a thicker and more compact inhibitor film. Furthermore, the exponent (N) values, which approached unity at higher extract concentrations, indicate that the inhibitor film behaves nearly as an ideal capacitor characteristic of a homogeneous, well-organized, and strongly adherent protective layer on the steel surface (Singh *et al.*, 2020) [16].

Table 2: EIS Test Parameters for the Inhibitor

C	CPE (μF.cm²)	R_p (Ω.cm²)	R_s (Ω.cm²)	N	IE (%)
Blank	119.210	60.63	0.47	0.98	-
1000	99.89	120.12	0.13	0.99	49.52
2000	90.21	159.82	0.19	0.99	62.06
3000	79.27	222.19	0.43	0.99	72.71

The Nyquist plots (Figure 2) reveal that the incorporation of *Ceiba pentandra* (kapok) leaf extract not only enlarges the diameter of the capacitive semicircle but also alters the interfacial electrochemical characteristics by impeding charge transfer across the electrode/solution boundary. The substantial rise in charge transfer resistance (R_p), accompanied by a concurrent reduction in constant phase element (CPE) values at elevated inhibitor concentrations, provides clear evidence of the extract's ability to establish a compact, adherent, and highly resistive film on the steel surface. This protective barrier effectively limits the penetration of aggressive chloride ions, thereby mitigating corrosion progression within the acidic medium (Negi *et al.*, 2024) [14].

The EIS derived inhibition efficiency (IE%) exhibited a consistent trend with the Tafel polarization results, attaining a maximum value of 72.71% at an inhibitor concentration of 3000 mg·L⁻¹. This strong correlation further verifies the high protective performance of the *Ceiba pentandra* (kapok) leaf extract as an effective corrosion inhibitor for carbon steel in acidic media.

The experimental impedance data were accurately fitted using an equivalent electrical circuit composed of solution resistance (R_s), charge transfer resistance (R_p), and a constant phase element (CPE). The excellent agreement between the simulated and experimental Nyquist plots confirms the suitability of the selected circuit model and reinforces the reliability of the electrochemical measurements.

3.3. Isothermal Adsorption

As illustrated in Figure 4, isothermal adsorption models were employed to elucidate the interaction between inhibitor molecules from the *Ceiba pentandra* (kapok) leaf extract and the carbon steel surface. The EIS data were utilized to interpret the adsorption behavior and evaluate the suitability of different isotherm models. In general, the accuracy of the adsorption model is considered high when the linear correlation coefficient (R^2) approaches unity. Among the two evaluated models, the Freundlich isotherm exhibited the highest R^2 value, indicating that it provides the best representation of the adsorption characteristics of the kapok leaf extract on the metal surface.

The adsorption of the kapok leaf extract inhibitor follows a mixed adsorption mechanism, encompassing both chemisorption and physisorption processes. This dual nature is supported by the obtained adsorption equilibrium constant (K_{ads}) of 1891.21 L·mol⁻¹ and the standard free energy of adsorption (ΔG_{ads}) value of −27.13 kJ·mol⁻¹, as calculated from the Freundlich isotherm equation (Zhang *et al.*, 2020) [20]. These values suggest that the adsorption involves both physical and chemical interactions, leading to the formation of a stable and protective inhibitor film on the steel surface.

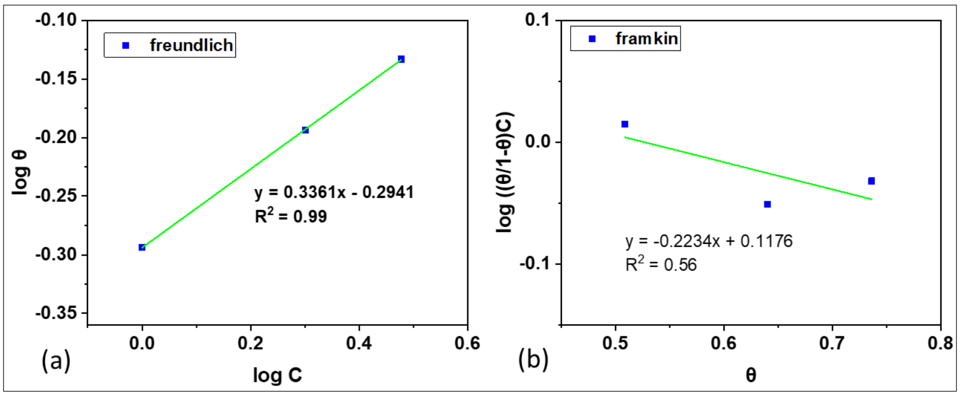

Fig 4: Isothermal Adsorption Curves: (a) Freundlich and (b) Frumkin

3.4. Surface Protection

The remarkable corrosion inhibition efficiency of the *Ceiba pentandra* (kapok) leaf extract can be ascribed to the adsorption of its bioactive phytochemical constituents primarily phenolics, flavonoids, saponins, and tannins onto the carbon steel surface. These compounds contain electron-rich functional groups such as hydroxyl (–OH) and carboxyl (–COOH), together with conjugated π-systems, which exhibit a strong affinity toward the metallic surface through both physical and chemical adsorption processes (Ardyn *et al*., 2023; R. Holla *et al*., 2024) [1, 15].

The observed enhancement in inhibition efficiency with increasing extract concentration, accompanied by stable *n* values and the emergence of a single time constant in the EIS spectra, supports the applicability of the Freundlich adsorption isotherm. This behavior suggests the formation of a uniform, monolayered coverage of inhibitor molecules on the steel surface, thereby producing a compact and impermeable barrier that effectively restricts the ingress of aggressive chloride ions (Negi *et al*., 2024) [14]. Such adsorption characteristics are consistent with those reported for other plant-derived corrosion inhibitors.

The protective film formed by the kapok leaf extract suppresses corrosion by obstructing the active anodic and cathodic sites on the steel surface. Specifically, it inhibits both anodic iron dissolution and the cathodic hydrogen evolution reaction, resulting in a substantial decrease in the overall corrosion rate (Avdeev *et al*., 2024) [2]. The findings obtained from Tafel polarization and EIS analyses exhibit excellent agreement, confirming that the extract functions as a mixed-type inhibitor with a dominant influence on the anodic process. The close correspondence between polarization resistance values from both techniques further validates the robustness and reproducibility of the electrochemical evaluation.

Moreover, the formation of a stable and adherent protective layer is substantiated by the pronounced reduction in corrosion current density, the marked increase in polarization resistance, and the improvement in interfacial capacitive properties at the metal/electrolyte boundary. The synergistic interactions among the multiple phytochemical constituents in the extract contribute to the durability and compactness of the adsorbed film, ensuring sustained protection even at moderate concentrations. Consequently, *Ceiba pentandra* leaf extract exhibits strong potential as a green, cost-effective, and industrially viable corrosion inhibitor for acidic environments.

4. Conclusion

In summary, the *Ceiba pentandra* (kapok) leaf extract has been effectively demonstrated to function as a green corrosion inhibitor for carbon steel in a 1 M HCl environment. Electrochemical investigations, including Tafel polarization and Electrochemical Impedance Spectroscopy (EIS), revealed that the incorporation of the extract markedly decreased the corrosion rate while significantly enhancing the polarization resistance of the steel surface. At the optimal concentration of 3000 $mg \cdot L^{-1}$, a maximum inhibition efficiency of 80.29% was achieved, corresponding to the formation of a dense, uniform, and adherent protective film on the metal surface. Furthermore, the EIS analysis exhibited a substantial rise in impedance magnitude with increasing inhibitor concentration, confirming the establishment of a highly resistive barrier that effectively mitigates electrochemical degradation. Collectively, these results affirm that the *Ceiba pentandra* leaf extract exhibits strong potential as an environmentally benign and sustainable corrosion inhibitor, providing a viable green alternative to conventional synthetic inhibitors for industrial-scale protection in acidic media.

5. References

1. Ardyn K, Andayani S, Suprastyani H. Penggunaan ekstrak kasar daun kapuk randu (Ceiba pentandra (L.) Gaertn) untuk menghambat bakteri Pseudomonas fluorescens secara *in vitro*. JFMR-Journal of Fisheries and Marine Research. 2023;7(3). doi:10.21776/ub.jfmr.2023.007.03.1
2. Avdeev YG, Nenasheva TA, Luchkin AY, Marshakov AI, Kuznetsov YI. Effect of organic corrosion inhibitors on the kinetics of the cathodic hydrogen evolution reaction on steel in a sulfuric acid solution. Russian Journal of Physical Chemistry B. 2024;18(1):111-24. doi:10.1134/S1990793124010044
3. Dehghani A, Bahlakeh G, Ramezanzadeh B. Green Eucalyptus leaf extract: a potent source of bio-active corrosion inhibitors for mild steel. Bioelectrochemistry. 2019;130:107339. doi:10.1016/j.bioelechem.2019.107339
4. Dehghani A, Ghahremani P, Mostafatabar AH, Ramezanzadeh B. Plant extracts: probable alternatives for traditional inhibitors for controlling alloys corrosion against acidic media—a review. Biomass Conversion and Biorefinery. 2024;14(6):7467-86. doi:10.1007/s13399-022-02893-4
5. Deyab MA. Understanding the anti-corrosion mechanism and performance of ionic liquids in desalination, petroleum, pickling, de-scaling, and acid cleaning applications. Journal of Molecular Liquids. 2020;309:113107. doi:10.1016/j.molliq.2020.113107
6. Feliu S, González JA, Andrade MC, Feliu V. Determining polarization resistance in reinforced concrete slabs. Corrosion Science. 1989;29(1):105-13. doi:10.1016/0010-938X(89)90083-8
7. Gapsari F, Hidayatullah S, Hadi Setyarini P, Madurani KA, Hermawan H. Effectiveness of a fish scales-derived chitosan coating for corrosion protection of carbon steel. Egyptian Journal of Petroleum. 2022;31(1):25-31. doi:10.1016/j.ejpe.2022.02.001
8. Goyal M, Kumar S, Bahadur I, Verma C, Ebenso EE. Organic corrosion inhibitors for industrial cleaning of ferrous and non-ferrous metals in acidic solutions: a review. Journal of Molecular Liquids. 2018;256:565-73. doi:10.1016/j.molliq.2018.02.045
9. Hidayatullah S, Sulaiman AM, Iftitah EN. Durio zibethinus extract performance as corrosion inhibitor in simulated seawater. Mechanics Exploration and Material Innovation. 2024;1(1):27-34. doi:10.21776/ub.memi.2024.001.01.4
10. Jalab R, Saad MA, Sliem MH, Abdullah AM, Hussein IA. An eco-friendly quaternary ammonium salt as a corrosion inhibitor for carbon steel in 5 M HCl solution: theoretical and experimental investigation. Molecules. 2022;27(19):6414. doi:10.3390/molecules27196414
11. Li Y, Chen Y, Wang C, Li Y, Wu Y. Exploring the potential of plant extracts as corrosion inhibitors: a comprehensive review. Progress in Organic Coatings. 2025;198:108915. doi:10.1016/j.porgcoat.2024.108915
12. Ma IAW, Ammar S, Kumar SSA, Ramesh K, Ramesh S. A concise review on corrosion inhibitors: types, mechanisms and electrochemical evaluation studies. Journal of Coatings Technology and Research. 2022;19(1):241-68. doi:10.1007/s11998-021-00547-0

13. Makhlouf ASH, Herrera V, Muñoz E. Chapter 6 - Corrosion and protection of the metallic structures in the petroleum industry due to corrosion and the techniques for protection. In: Makhlouf ASH, Aliofkhazraei M, editors. Handbook of Materials Failure Analysis. Butterworth-Heinemann; 2018. p. 107-22. doi:10.1016/B978-0-08-101928-3.00006-9
14. Negi R, Thakur S, Singh R, Kaur V, Singh K. Double-layer protection of stainless steel by using triethylammonium-3-silatranylpropyldithiocarbamate as a corrosion inhibitor: experimental and computational studies. Journal of Molecular Structure. 2024;1309:138166. doi:10.1016/j.molstruc.2024.138166
15. Holla BR, Mahesh R, Manjunath HR, Anjanapura VR. Plant extracts as green corrosion inhibitors for different kinds of steel: a review. Heliyon. 2024;10(14):e33748. doi:10.1016/j.heliyon.2024.e33748
16. Singh A, Ansari KR, Chauhan DS, Quraishi MA, Lgaz H, Chung IM. Comprehensive investigation of steel corrosion inhibition at macro/micro level by ecofriendly green corrosion inhibitor in 15% HCl medium. Journal of Colloid and Interface Science. 2020;560:225-36. doi:10.1016/j.jcis.2019.10.040
17. Hidayatullah S, Sari NH, Pradityatama M, Suteja. Efektifitas perlindungan korosi aluminium menggunakan inhibitor ekstrak labu kuning: studi elektrokimia dan permukaan. Jurnal Mesin Nusantara. 2025;8(1):97-108. doi:10.29407/jmn.v8i1.24651
18. Wang H, Wang K, Wang W, Huang L, Peng P, Yu H. Microstructure and mechanical properties of dissimilar friction stir welded type 304 austenitic stainless steel to Q235 low carbon steel. Materials Characterization. 2019;155:109803. doi:10.1016/j.matchar.2019.109803
19. Yildiz Y, Karadag R, C apple I. Comparison of spectrophotometric methods for determination of iron in acid cleaning, and passivating stainless steel solution by UV-VIS, ICP/MS, and FAAS. Science Journal of Analytical Chemistry. 2021;9(2):32-9. doi:10.11648/j.sjac.20210902.11
20. Zhang X, Li W, Yu G, Zuo X, Luo W, Zhang J, *et al*. Evaluation of Idesia polycarpa Maxim fruits extract as a natural green corrosion inhibitor for copper in 0.5 M sulfuric acid solution. Journal of Molecular Liquids. 2020;318:114080. doi:10.1016/j.molliq.2020.114080
21. Zheng H, Zhang B, Wang X, Lu Y, Li F, Li C. Improved corrosion resistance of carbon steel in soft water with dendritic-polymer corrosion inhibitors. Chemical Engineering Journal. 2023;452:139043. doi:10.1016/j.cej.2022.139043
22. Zomorodian A, Behnood A. Review of corrosion inhibitors in reinforced concrete: conventional and green materials. Buildings. 2023;13(5):1170. doi:10.3390/buildings13051170

How to Cite This Article

Hidayatullah S, Suteja, Huda AA. The potential of kapok leaves as a corrosion inhibitor with optimal protection in acidic media. Int J Multidiscip Res Growth Eval. 2025;6(6):48–53. doi:10.54660/IJMRGE.2025.6.6.48-53.

Creative Commons (CC) License