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# A Review on Metal Corrosion Inhibitors

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## ABSTRACT

Currently, the problem of reducing losses caused by the corrosion of metal structure is is becoming increasingly acute in the world. In fact, the costs due to corrosion in industrial countries range from 3.5 to 5% of the total GDP. Thus this short review provides an outline of related literatures in which scientists and researchers used different types and procedure to find out corrosion inhibitors to reduce corrosion that takes place in various equipment and structures made of metals or alloys. All organic, inorganic and natural products which were studied for corrosion inhibitors have been reviewed in this article.

## INTRODUCTION

Corrosion is a natural process that converts a refined metal into a more chemically stable oxide. It is the deterioration of a metal as a result of chemical or electrochemical reactions between it and the surrounding environment e.g. acid base water or air etc [1]. Both the type of metal and the environmental conditions, particularly gasses that are in contact with the metal, determine the form and rate of deterioration i.e. corrosion. To ensure long and trouble-free operation in a media it is of utmost importance to have knowledge about corrosion and the effect it can have on the product and the system in the operating environment [2]. A significant proportion of material damage and subsequent component failure caused by corrosion can be eliminated by selecting the optimum material for a given application and by use of suitable corrosion inhibitors [3 - 7]. The corrosiveness of a liquid on metals is mainly dependent on oxygen, chloride and/or sulphide content, temperature and pH - value. When a metal corrodes or deteriorates, it cannot hold the same loads as it did before corrosion began. At a certain point, corrosion can lead to dangerous conditions. Metal used in bridges, railroad tracks, and buildings are all subject to corrosion. Because of this, it is important to monitor and manage corrosion to avoid structural collapse.

## *REVIEW ON CORROSION INHIBITORS*

Corrosion inhibitor is a chemical compound (Organic or Inorganic) that, when added to a liquid or gas, decreases the corrosion rate of a material. The effectiveness of a corrosion inhibitor depends on fluid composition, quantity of

water, and flow regime [8,9]. A common mechanism for inhibiting corrosion involves formation of a coating, often a passivation layer, which prevents access of the corrosive substance to the metal. corrosion inhibitors are common in industry, and also foundin over-the-counter products, typically in spray form in combination with a lubricant and sometimes a penetrating oil. Corrosion inhibitors are compounds that control, reduce, or prevent reactions between a metal and its surroundings when added to the medium in small quantities. Inhibitors are usually used to minimize the corrosive attack on metallic materials, and are widely used in the corrosion protection of metals in several environments [10,11]. Thus corrosion is very very important field of research since long past. Now researchers are regularly doing their work to find good corrosion inhibitors to stop big loss due to corrosion.Thus much have been done in this field and much more is yet to be done. We therefore surveyed some recent studies and reviewed in this article.

Fatech sudied corrosion of copper and its alloys in corrosive environments and their corrosion inhibitors. The main corrosion inhibitor groups for copper are introduced and reviewed. Adsorption model has been provided for corrosion inhibitor activity. The main part of this work was to investigate different corrosive environments for copper and its alloys and their corrosion inhibitors used in such environments to protect copper [12]. The increasing awareness of people on green materials and chemistry has stimulated researchers around the globe to turn towards natural resources. As a growing topic with limitless potential, plants as corrosion inhibitors (PCI) have received substantial attention due to their eco-friendly, biodegradable, inexpensive, and abundantly availability [13] . Traditionally, reduction of corrosion has been managed by various methods including cathodic protection, process control, reduction of the metal impurity content, and application of surface treatment techniques, as well as incorporation of suitable alloys. However, the use of corrosion inhibitors has proven to be the easiest and cheapest method for corrosion protection and prevention in acidic media. These inhibitors slow down the corrosion rate and thus prevent monetary losses due to metallic corrosion on industrial vessels, equipment, or surfaces [14]. In a review possibility of copper corrosion prevention has been discussed. Focus has been paid on the efficiency obtained using various organic compounds as corrosion inhibitors in numerous conditions. Several groups of compounds are found to be particularly important such as: azoles , purine and derivatives and amino acids. On the other hand plant extracts and natural products have also found prominent positions in these studies [ 15 ]. A review provides an outline of related litterateurs in which scientists and researchers used different types and procedure of corrosion inhibitors to reduce corrosion that takes place in various equipment made of alloys or metals. Different chemical inhibitors were used to reduce the rate of corrosion in various alloys. The inhibition rates ranged between 30-80% in acidic environments with different molar concentrations [ 16 ]. Laurhydrazide N′-propan-3-one was used as an eco-friendly inhibitor for the corrosion of mild steel in 5M HCl at elevated temperatures. Various electrochemical techniques and surface characterization methods were utilized in this study. In addition, the kinetics and thermodynamic parameters were calculated and discussed. Furthermore, a geometry optimization of LHP was performed and the time dependent density functional theory was utilized to calculate the electronic absorption spectra [ 17 ]. Acetophenone derivatives are eco-friendly corrosion inhibitors to prevent corrosion of mild steel (MS) in acidic medium. The inhibition effect of 3-nitroacetophenone (3-NA) on the corrosion of MS in acidic medium (1 N $H_4Cl$ ) was investigated using weight loss measurements, electrochemical measurements, scanning electron microscopy, energy-dispersive X-ray spectroscopy, and quantum chemistry analysis [18]. The corrosion inhibition of mild steel in 0.5 M hydrochloric acid by six synthesized hetero cyclic compounds was studied using weight loss measurements. The inhibition efficiency exceeded 95%. The excellent inhibitor performance was attributed to the formation of protection adsorption films on the steel surface. The structures of compounds were confirmed by Fourier transform infrared and nuclear magnetic resonance analysis. The adsorption of

inhibitor on steel surface followed the Langmuir adsorption isotherm [19]. A study analyzed the corrosion inhibitory effects and the antibacterial action of the quinoline derivative, namely N'-(2-hydroxybenzylidene)-2-(quinolin-8-yloxy) acetohydrazide (NHQA). NHQA prevention of corrosion behavior was investigated using weight loss experiments on mild steel coupons in HCl solution. Weight loss tests achieved improved inhibition performance for NHQA, and the high inhibitor efficiency was reached at 303 K, of 93.4 percent at 500 ppm NHQA. Moreover, the effect of immersion time on carbon steel corrosion was investigated using strategies for weight loss [20]. The corrosion performance of mild steel (MS) in 1M HCl solution was examined by weight loss (WL), potentiodynamic polarization (PDP), electrochemical impedance spectroscopy (EIS), electrochemical frequency modulation (EFM), and open circuit potential (OCP) measurements in the absence and presence of nonanedihydrazide . PDP measurements indicated that nonanedihydrazide acts as a mixed inhibitor due to its adsorption on the MS surface, exhibiting an inhibition efficiency of more than 97% [21]. The study investigates corrosion inhibition of mild steel in acid medium using Acalypha chamaedrifolia leaves extract as potential inhibitor. Gravimetric (weight loss) technique was used for the corrosion studies. The results show that corrosion rates dropped from a value of 0.49 mg cm−2 h−1 for the uninhibited medium to a value of 0.15 mg cm−2 h−1 for the inhibited medium of 1 M HCl in 0.25 g/L of the extract [22] . Two ethoxylated nonionic surfactants (L400 and L600) based on Schiff base are prepared from polyoxyethylene, glyoxalic acid, and phenylenediamine. They are evaluated electrochemically as carbon steel corrosion inhibitors in 1 M HCl by electrochemical impedance spectroscopy (EIS) and Tafel techniques and complemented with microscopic analysis methods [23]. The pipeline system in the oil and gas industry is the heart for transportation of crude and refined petroleum. Nevertheless, continuous exposure of the pipeline surfaces to impurities and sources of corrosion such as sulfur and chromate is totally unavoidable. Vast employment of commercial corrosion inhibitors to minimize the corrosion is being restrained due to toxicity towards the environment [24]. Inorganic anions, such as chloride, carbonate, phosphate, sulfate and nitrate are ubiquitous in water, they will react with hydroxyl radical and sulfate radical produced during advanced oxidation processes (AOPs), to form chlorine radical, carbonate radical nitrate radical, phosphate radical and sulfate radical, which have a significant influence on the transformation of organic pollutants [25]. A review provides an outline of related literatures in which scientists and researchers used different types and procedure of corrosion inhibitors to reduce corrosion that takes place in various equipment made of alloys or metals. Different chemical inhibitors were used to reduce the rate of corrosion in various alloys [26]. Corrosion inhibition of mild steel in hydrochloride acid solution was performed by a two pyrazole carboxamides named 5-(4-(dimethylamino)phenyl)-3-phenyl-4,5-dihydro-1H-pyrazole-1-carboxamide DPC-1 and (E)-5-( 4 - ( dimethylamino)phenyl ) - 3-(4-(dimethylamino)styryl)-4,5-dihydro-1H-pyrazole-1carboxamide DPC-2 using weight loss measurements, Tafel polarization curves and electrochemical impedance spectroscopies (EIS). The obtained results show that DPC-1 and DPC-2 are effective corrosion inhibitors in 1 mol l−1 HCl solution [ 27 ] .Thiophene derivatives, namely (E)-thiophene-2-carbaldehyde oxime (OXM) and (E)-5-(thiophen-2-yl)-1H tetrazole (TET), were synthesized and characterized via 1 H and 13C NMR. Furthermore, their inhibitory property for AA2024-T3 in 1 M HCl solution was investigated via electrochemical impedance spectroscopy and potentiodynamic polarization at 293 K, together with DFT/B3LYP-based calculations. Numerous global and local descriptors of reactivity such as EHOMO, ELUMO, energy gap, electronegativity (c), hardness (h), and frontier molecular orbital repartitions were investigated to describe the reactivity of each molecule [28]. Natural-based corrosion inhibitors have gained great research interest thanks to their low cost and higher performance. In this work, the chemical composition of the methanolic extract of Ammi visnaga umbels (AVU) was evaluated by gas chromatography (GC) coupled with mass spectrometry (MS) and applied for corrosion inhibition of carbon steel (CS) in 1.0 mol/L HCl using chemical and electrochemical techniques along with scanning electron microscope (SEM) and theoretical calculations [29] . The corrosion inhibition of 5-O-β-D-glucopyranosyl-7-methoxy-3′,4′-dihydroxy-4- phenylcoumarin (4-PC) in AISI 1018 steel immersed in 3% NaCl + $CO_2$ was studied by electro- chemical impedance

spectroscopy (EIS). The results showed that, at just 10 ppm, 4-PC exerted protection against corrosion with η = 90% and 97% at 100 rpm [30]. Novel modified coumarin bearing thiosemicarbazide pendant moiety prepared by the reaction of 3 - ( 6 - methyl - 2 -ketoquinoline ) methanal with thiosemicarbazide through a condensation reaction. The synthesized coumarin namely 2-((6-methyl-2-ketoquinoline-3-yl) methylene) hydrazinecarbo-thioamide (MKMHCT) was characterized using spectroscopic techniques (proton and carbon 13 nuclear magnetic resonance and Fourier transform infrared) [31]. The use of corrosion inhibitors is a cost-effective corrosion mitigation strategy for carbon steel. There is an increased focus on developing and using low-cost, biodegradable and environmentally friendly inhibitor formulations. Plant-based extracts have been evaluated in many studies using a multitude of electrochemical methods and characterization techniques. Although plant extracts appear as promising alternatives for commercially synthesized inhibitor formulations, a significant amount of optimization is required [32]. Most studies on the corrosion inhibition performance of organic molecules and (Nano) materials were conducted within "carbon steel/1.0 M HCl" solution system using similar experimental and theoretical methods. As such, the numerous research findings in this system are sufficient to conduct comparative studies to select the best-suited inhibitor type that generally refers to a type of inhibitor with low concentration/high inhibition efficiency, nontoxic properties, and a simple and cost-economic synthesis process [33]. In a study some organic natural products were studied, namely tannic acid, Gallic acid, mimosa tannin and chestnut tannin, as potential green corrosion inhibitors of the aluminium alloy AA2024-T3. The anodizing treatment was performed in a solution of the referred organic compounds in diluted sulphuric acid. [34].

## REFERENCES

1. E. McCafferty ; Introduction to Corrosion Science; Springer Science & Business Media(2010)

2. https://en.m.wikipedia.org/wiki/Corrosion

3. M. Stern and A.Geary ; A Theoretical Analysis of the Shape of Polarization Curves ; Electrochem. Soc.; 104 : 56-63 (1957)

4. A. S. Fouda et al. ;The role of some thiosemicarbazide derivatives in the corrosion inhibition of aluminium in hydrochloric acid ; Corros. Sci.; 26 : 719 - 726 (1986)

5. E. E. Ebenso et. al. ; The corrosion inhibition study of Al-PureByp- Anisidine-N-Benzylidene Schiff base in HCL solution ; Anti-Corros ; Meth.Mat. ; 37 : 381-386 (2003)

6. G.Bereket et. al. ; Benzimidazole-2-tione and benzoxazole-2-tione derivatives as corrosion inhibitors for aluminum in hydrochloric acid;Anti-Corros ; Meth. Mat. ; 51(4) : 282-293 (2004)

7. A. K. Maayta and N.A.F. Al-Rawashdeh ; Inhibition of acidic corrosion of pure aluminum by some organic compounds ; Corros Sci. ; 46 (5):1129-1140 (2004)

8.G. Trabanelli ; Inhibitors an old remedy for a new challenge ; Corros. 47 (6): 410-419 (1991)

9.M. Lebrini; Corrosion Inhibition of Carbon Steel by Cationic Surfactants in 0.5 M HCl Solution ; Appl. Surf. Sci. ; 253:9267-9275 (2007)

10. N.V. Likhanova Xomet; Corrosion Inhibition of Carbon Steel in Acidic Environment by Imidazolium Ionic Liquids Containing Vinyl-Hexafluoro phosphate as Anion; Electrochem Sci. 6 : 4514 - 4536 (2011)

11. D. Hmamou ; Inhibition of steel corrosion in hydrochloric acid solution by chamomile extract ; De rPharm Chem. ; 4 (4):1496 - 1505 (2012)

12. A. Fateh et al ; Review of corrosive environments for copper and its corrosion inhibitors ; Arabian Journal of Chemistry ; 13 ; 481–544 (2020)

13. N. A. Mohd. Nasir ; 25 years of progress on plants as corrosion inhibitors through a bibliometric analysis using the Scopus database; Arabian Journal of Chemistry ; 15 ; 103655-103664 (2022)

14. M. Chigondo et.al. ; Recent Natural Corrosion Inhibitors for Mild Steel; Journal of Chemistry; 10; 1-7 (2016)

15. M. B. Petrović Mihajlović et.al. ; Copper Corrosion Inhibitors ; Int. J. Electrochem. Sci.; 10 ; 1027 - 1053 (2015)

16. A. Kadhim et al ; Corrosion inhibitors. A review ; Int. J. Corros. Scale Inhibit ; 10 (1); 54–67 ( 2021 )

17. M. M. El-Haddad et al ; Highly efficient eco-friendly corrosion inhibitor for mild steel in 5M HCl at elevated temperatures ; Experimental & molecular dynamics study Scientific Reports ; 9 (1) ; 3695-3703 (2019)

18. Sani Ibrahim et al; Effect of 3-Nitroacetophenone on Corrosion Inhibition of Mild Steel in Acidic Medium Hindawi ; International Journal of Photo energy ; 22 ; 1-9 (2022)

19. S. K. Ahmed et al ; Synthesis and investigations of heterocyclic compounds as corrosion inhibitors for mild steel in hydrochloric acid ; International Journal of Industrial Chemistry ; 10 ; 159–173 (2019)

20. A. A. Alamiery ; Investigations on Corrosion Inhibitory Effect of Newly Quinoline Derivative on Mild Steel in HCl Solution Complemented with Antibacterial Studies; Platinum open access journal; 12 (2) ; 1561 - 1568 (2022)

21. A..Al-Amiery et al; Experimental and theoretical study on the corrosion inhibition of mild steel by nonanedioic acid derivative in hydrochloric acid solution ; Scientific Reports ; 12 ; 4705-4713 (2022)

22. D. E. Arthur et.al. ; Corrosion inhibition studies of mild steel using Acalypha chamaedrifolia leaves extract in hydrochloric acid medium ; SN Applied Sciences ; 1; 1089 -1097 (2019)

23. A. G. Bedir et.al. ; Corrosion Inhibition of Carbon Steel in Hydrochloric Acid Solution Using Ethoxylated Nonionic Surfactants Based on Schiff Base: Electrochemical and Computational Investigation ; ACS Omega ; 6 ; 4300−4312 (2021 )

24. K. Tamalmani et.al; Review on Corrosion Inhibitors for Oil and Gas Corrosion Issues ; Appl. Sci. ; 10 ; 3389-3399 ( 2020)

25. J. Wang et.al. ; Effect of inorganic anions on the performance of advanced oxidation processes for degradation of organic contaminants ; Chemical Engineering Journal ; 411 ; 128392 - 128400 ; ( 2021 )

26. A. Kadhim, et.al. ; Corrosion inhibitors A review ; Int. J. Corros. Scale Inhib. ; 10 ( 1 ) ; 54–67 ( 2021 )

27. A. Sehmi et. Al. ; Corrosion Inhibition of Mild Steel by newly Synthesized Pyrazole Carboxamide Derivatives in HCl Acid Medium: Experimental and Theoretical Studies ;Journal of The Electrochemical Society ; 167 ; 155508-155516 ( 2020 )

28. N. Arrousse et,al. ; Thiophene derivatives as corrosion inhibitors for 2024-T3 aluminum alloy in hydrochloric acid Medium ; the Royal Society of Chemistry RSC Adv. (12) ; 10321–10335 ; ( 2022)

29. A. Zaher et.al. ; A combined computational & electrochemical exploration of the Ammi visnaga L. extract as a green corrosion inhibitor for carbon steel in HCl Solution ; Arabian Journal of Chemistry ; 15, 103573 - 103585 (2022)

30. A. E. Vázquez et.al. ; 4-Phenylcoumarin (4-PC) Glycoside from Exostema cerebrum as Corrosion Inhibitor in 3% NaCl Saturated with CO2 in AISI 1018 Steel: Experimental and Theoretical Study ; Int. J. Mol. Sci. ; 23 ; 3130-3139 ; (2022)

31. M. M. Hanoon et.al. ; Theoretical and Experimental Studies on the Corrosion Inhibition Potentials of 2-( ( 6-Methyl-2-Ketoquinolin-3-yl ) Methylene ) Hydrazinecarbothioamide for Mild Steel in 1 M HCl ; Prog. Color Colorants Coat. ; 15; 21-33; (2022)

32. B.R. Fazal , et.al. ; A review of plant extracts as green corrosion inhibitors for CO 2 corrosion of carbon steel; npj Materials Degradation; 5; 1-14 (2022)

33. L. Chen , et.al. ; Organic Compounds as Corrosion Inhibitors for Carbon Steel in HCl Solution: A Comprehensive Review ; Materials ; 15, 2023-2035 ( 2022)

34. Carla Sofia Proença , et . al. ; Evaluation of Tannins as Potential Green Corrosion Inhibitors of Aluminium Alloy Used in Aeronautical Industry ; Metals ; 12 ; 508-516 (2022)