International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.9, No.06 pp 251-259, 2016

Drugs/Antibiotics as potential corrosion inhibitors for Metals - A Review

S.Karthikeyan*

School of Mechanical Engineering, VIT University,Vellore-632014, India

Abstract : Corrosion protection of metals and alloys is a prime activity of technical, economic, environmental, and aesthetical significance. The use of inhibitors is one of the best choice of combating metals and alloys against detoriation against environmental impact. The toxicity of organic and inorganic corrosion inhibitors to the environment has provoked the search for eco-friendly corrosion inhibitors like green corrosion inhibitors as other more environmental friendly corrosion inhibitors, most of which are biodegradable and do not possess heavy metals orother harmful functional atoms and groups in their molecular structure. Antibiotic is believed to have the efficacy to retard corrosion of several metals such as carbon steel, Aluminium, zinc, tin and copper. It behaves as an inhibitive agent in different corrosive media. Numerous techniques such as Mass loss method, Electro chemical polarization study and AC impedance spectra have been used to evaluate the corrosion inhibition performance ofantibiotics. The formation of corrosion inhibitor barrier layer has been analysed by IR spectroscopy, atomic force microscopy, scanning electron microscopy and auger electron spectroscopy. Adsorption of antibiotics on metal and alloy surfaces obeys Langmuir, Temkin isotherm, depending on nature of metal and corrosive environment and adsorption could be of chemisorption, physorption or both processes. Electrochemical Polarization study pointed out that that antibiotics can follow anodic or cathodic or mixed mode of inhibition based on chemical nature of metals and operating environment. This paper reckons several antibiotics being used as inhibitors against corrosion of metals in different environments.
Keywords : corrosion, inhibitors, drugs, antibiotics, electrochemical.

Introduction

Corrosion is electrochemical phenomenon which is the destruction of metals by environment. It is a constant and continuous problem, often difficult to eradicate completely. Prevention would be more practical and attainable than complete removal. Corrosion protection of metals and alloys is a prime activity of technical, economic, environmental, and aesthetical significance. The use of inhibitors is one of the best choice of combating metals and alloys against detoriation against environmental impact[53-67]. The toxicity of organic and inorganic corrosion inhibitors to the environment has provoked the search for eco-friendly corrosion inhibitors like green corrosion inhibitors as other more environmental friendly corrosion inhibitors, most of which are biodegradable and do not possess heavy metals or other harmful functional atoms and groups in their molecular structure. Inhibitors are chemical substances which when added in small quantity to a corrosive environment, reduces the rate of corrosion to a considerable extent. They reduce the corrosion by either performing as a barrier, by establishing an adsorbed layer or retarding the cathodic and / or anodic reactions i.e., oxidation of metal and evolution of hydrogen gas.

Several researches have proven that antibiotics can be used as potential corrosion inhibitors because, through their functional groups, they form complexes with metal ions and on metal surfaces. Antibiotics fall under the category of eco-friendly compounds and hence claimed as Green corrosion inhibitors which are completely soluble in aqueous media and obtainable with high purity and relatively cheap. These properties would validate their use as corrosion inhibitors in various media. It has the efficacy to combat the corrosion of a wide variety of metals such mild steel, stainless steel, Aluminium zinc and nickel. Several techniques have been used to evaluate the corrosion inhibition performances of antibiotics and to analyse the nature of protective film formed on the metal surface.

Carbocyclic and heterocyclic systems are omnipresent in drug structure. Five- and six-membered rings are quite common, but small ring systems occur with rational regularity (for example, the cyclopropane ring in ciprofloxacin and the aziridine ring in mitomycin C). Of the five- and six-membered systems, the mainstreams of compounds are aromatic or pseudo-aromatic. Hence, substituted benzene ringsare very recurrent, and heterocycles such as pyridines, furans, thiophenes, imidazoles, isoxazoles and others befall generally in antibiotics molecular structure. Due to above-mentioned structural ring closures, corrosion protection properties of many drugs have attracted too much attention in recent years. This review summary the existing research on several drugs used as corrosion inhibitors for various metals, highlighting a background for the classification on the basis of their performance in media. Depending on the nature of metal and nature ofcorrosive environment antibiotics obey different types of isotherms and perform as different type ofinhibitor, namely anodic, cathodic or mixed type.

Antibiotics as Potential Corrosion inhibitors

Eddy et.al. [1,2]reported that Penicillin's as mild steel corrosion inhibitors. They explained the inhibitory action of Penicillin G (Table 1a) and Penicillin V are chiefly through the physorption of the compounds on mild steel. It was further studied that the adsorption of Penicillin's on the mild steel surface is realized by weak intermolecular interactions. Similar observation was made by Alder et al.[3].This was attributed to the existence of amino and carbonyl moieties as well as nitrogen and sulphur atoms in the aromatic/cyclic structure of Penicillin's. .Eddy and Ebenso[4] have also investigated the synergetic effect of iodide ions of Pencillin G .They found that inhibition efficiency of Penicillin V is lower than Pencillin G due to the effect of synergism by Iodide ions.

Hari Kumar and Karthikeyan[5] found that the traces of a semisynthetic antibiotic, cloxacillin inhibited the corrosion of mild steel in acid medium. They have evaluated the inhibitory action of cloxacillin using weight loss, Tafel polarization, electrochemical impedance spectroscopy and hydrogen permeation studies. In their paper, hydogen permeation measurements indicated that the compound behaved as cathodic inhibitor, but predominantly under mixed control. Heterocyclic organic compounds namely ciprofloxacin and norfloxacin were used as corrosion inhibitor by Dubey, Potdarand Yogesh[6] for protection of 304 stainless steel in 1.5 percent NaCl solution . The results obtained from electrochemical studies revealed that these compounds are very good corrosion inhibitors and showed their best performance at a concentration of 1800 ppb. Potentiodynamic curves indicated that these compounds have acted as anodic type of inhibitors. I.A. Adejoroa, F.K. Ojoa, b, S.K. Obafemib[7] studied the influence of ampicillin drug on the corrosion of mild steel in HCl acid medium. Some antibiotic derivatives namely, neomycin sulphate and amoxicillin were investigated as corrosion inhibitors for carbon steel in 1 M HCl solutions was investigated by Fouda et al[8].

Electrochemical impedance spectroscopy (EIS), potentiodynamic polarization, electrochemical frequency modulation (EFM) and weight loss methods were used to study the inhibition action of carbon steel in 1 M HCl solutions at 30ºC. Electrochemical results showed that these compounds are efficient inhibitors for carbon steel and the efficiency reached to 81 %. The adsorption of these compounds on carbon steel surface followed the Freundlich adsorption isotherm. Polarization curves indicated that investigated antibiotic derivatives are mixed-type inhibitors. Raja and his co workers[9] proved that The dissolution behaviour of SS 304 pipes in 2M Sulphuric acid with green inhibitor (namely neomycin) as corrosion inhibitor using Mass loss ,Potentiodynamic polarization, electrochemical impedance spectroscopy and hydrogen permeation studies. Polarization studies indicated that inhibitors are acted as mixed type. The adsorption of the compounds on SS 304 surface obeyed Langmuir adsorption isotherm. The corrosion inhibition of galvanized steel (GI steel)sheets in 5% NaCl with Esomeprazole (EPZ) as green inhibitor has been reported by Karthikeyan et al.,[10] employing mass loss, Potentiodynamic polarization, electrochemical impedance spectroscopy , hydrogen permeation and

quantum mechanical studies. All these techniques reveal that the EPZ inhibits the corrosion of galvanized steel in 5% NaCl medium.Polarization studies indicated that inhibitors are acted as mixed type inhibitor. The adsorption of the compounds on galvanized steel surface follows Langmuir adsorption isotherm.

Fouda et al.,[11] are of view that the addition of cefixime to the corrodent solution lowered the corrosion rate of carbon steel. Also, the inhibition efficiency of cefixime was found to increase with concentration and decreased with temperature. Adsorption of cefixime molecule on carbon steel surface was found to obey the Langmuir adsorption isotherm. The phenomenon of physical adsorption was proposed from the obtained thermodynamic parameters.

The inhibition of mild steel corrosion in hydrochloric acid solution by ciprofloxacin drug as an eco-friendly and commercially available inhibitor was studied by Inemesit and his team[12] by weight loss technique. It was found that the test drug had a promising inhibitory action against corrosion of mild steel in the hydrochloric acid medium .The inhibition efficiency was found to increase with a corresponding increase in the concentration of the inhibitor. It was also found that the adsorption as well as the thethe inhibition process followed a first-order kinetics and obeyed Langmuir's adsorption isotherm. Inhibition of nickel corrosion in 1 M HCl solution in the absence and presence of some Cephalosporin antibiotics derivatives was investigated by Fouda et al[13] using potentiodynamic polarization, electrochemical impedance spectroscopy (EIS), and electrochemical frequency modulation (EFM) techniques. The inhibitive action of these compounds was discussed in terms of blocking the electrode surface by adsorption of the molecules through the active centers contained in their structures following the Langmuir adsorption isotherm. The polarization measurement showed that these inhibitors are acting as mixed inhibitors for both anodic and cathodic reactions. Aziz[14] and his co investigators have compared the inhibiting efficiency of antibiotic drugs (ciprofloxacin, cloxacillin, and amoxicillin) on the corrosion of mild steel in 1 $mol \cdot L^{-1}$ HCl using mass loss measurement. The adsorption of drugs on the mild steel surface was found to be spontaneous and obeyed the Langmuir adsorption isotherm model. Imran Naqvi et al.,[15] have reported the corrosion inhibition of mild steel in 1M HCl solution by Cefixime using weight loss measurement and electrochemical techniques i.e. Polarization Resistance, Potentiodynamic Polarization and Electrochemical Impedance Spectroscopy(EIS). The adsorption of Cefiximeoccurred according to Langmuir`s adsorption isotherm. Kinetic parameters (activation energy, and pre-exponential factor, λ) as well as thermodynamic parameters (enthalpy, entropy and free energy of adsorption) were also calculated.

The effect on metallic corrosion of antibiotics containing the fused-ring structure of tetracycline (doxycycline and the dihydrate and hydrochloride salts of oxytetracycline) when present in 1% KCl solution was investigated by von Fraunhofer andStidham[16]. They observed that corrosion potential and zero resistance ammetry results were variable and depended upon the nature of the metal and its surface condition. All three antibiotics appeared to stimulate the corrosion of Vitallium (cobalt-chromium alloy), but corrosion inhibition was found for as-received titanium with all three antibiotics, for abraded titanium with doxycycline and for stainless steel with oxytetracycline dehydrate. Lakshmi et al.,[17] have investigated the influence of sulfamerizine (SMZ) drug as anti-scalant in water containing 0.7 M Gypsum salt (CaSO4) and brine water (0.7 M) has been studied by weight loss, potentiodynamic polarization and A.C impedance measurements. The formation of protective layer of SMZ was justified by chronoamperometry technique. Quantum chemical methods confirmed the absorption of anti-scalant on steel. SEM studies evidenced the formation of stable anti-scalant film on steel in presence of gypsum salt water and brine water.

The reduction of corrosion and hydrogen permeation through mild steel in 0. 5M H_2SO_4 and 1M HCl has been studied using weight loss measurements and various electrochemical techniques in the presence and absence of a green inhibitor viz., Carbenicillin (CBN) were studied by Karthikeyan et al.[18]. The inhibitor was found to be more effective in H_2SO_4 than in HCl. Potentiodynamic polarization studies proved that the compound acted as a mixed inhibitor.

Shukla et al.,[19]found that Streptomycin inhibits the corrosion of mild steel in HCl solution. The inhibitor acted as cathodic inhibitor.

The inhibitive action of lansoprazole (LPZ) on stainless steel 304 corrosion and permeation of hydrogen gas in 2N H_3PO_4 has been analyzed using weight loss, gasometric and electrochemical studies has been assessed by Karthikeyan[20] et al. Hydrogen permeation and EIS measurements have confirmed that LPZ

retards the corrosion of SS 304 effectively . Also, the authors have validated the performance of the inhibitor molecule through its effective adsorption on steel surfaces using theoretical values of E_{HOMO}, E_{LUMO}, ΔE and dipole moment of inhibitor.

Akpan and Offiong[21] have reported that electrochemical investigation of the inhibitory action of Ciprofloxacin drug on the acid corrosion of mild steel and the adsorption of inhibitor obeyed langumuir adsorption isotherm. Hari kumar and Karthikeyan[22,23] investigated that performance of torsemide and furosemide drugs as corrosion inhibitors for mild steel in 1 N HCl was thoroughly investigated by weight loss and electrochemical methods. The inhibition efficiencies of drugs obtained by all methods were in good agreement with each other. Torsemide exhibited higher inhibition efficiencies than furosemide in all the experimental studies. Polarization studies revealed that the inhibiting action of the compounds is under mixed control. The free energy of adsorption and the influence of temperature on the adsorption of inhibitors onto a mild steel surface have been reported. The adsorption of the compounds was found to obey the Langmuir adsorption isotherm. The mechanism of inhibition and formation of the Fe–inhibitor complex were confirmed by FT-IR and UV–visible absorption spectral analysis. The scanning electron microscopy (SEM) and atomic force microscopy (AFM) results established the formation of a protective layer on the mild steel surface. Quantum chemical calculations were applied to correlate the inhibition performance of inhibitors with their electronic structural parameters. 4-Chloro-2-((furan-2-ylmethyl)amino)-5-sulfamoylbenzoic acid (FSM) and N-(isopropylcarbamoyl)-4-(m-tolylamino)pyridine-3-sulfonamide (TSM) drugs were tested as inhibitors by the same authors[23] for mild steel corrosion in 1 N sulphuric acid solution by weight loss studies and electrochemical methods. The weight loss measurements were carried at different temperatures ranging from 303 to 333 K. The adherent film of FSM and TSM formed on metal surface obeyed Langmuir adsorption isotherm. Fourier transform infrared spectroscopy and Ultraviolet–visible absorption spectral analysis were used to validate the mode of inhibition reaction to form complex between metal and inhibitor. The formation of protective layer on the mild steel surface was also confirmed by scanning electron microscopy (SEM) results. GeethaMani[24] et al have examined the inhibitive action of an examined expired Ambroxol drug on the corrosion of mild steel in 1 M HCl and 1 M H_2SO_4 acid medium. According to them, inhibitor acted as a mixed type inhibition and followed Langmuir adsorption isotherm. The influence of Sulfalene (SFL) on corrosion and hydrogen permeation through Stainless steel 304 in 5% NaCl has been studied by Karthikeyan et al.,[25]using weight loss measurements and various electrochemical techniques. Potentiodynamic polarization studies clearly indicated that SFL behaved as a mixed inhibitor. Hydrogen permeation studies and AC impedance measurements also proved an excellent performance of the compound in 5% NaCl. The adsorption of this compound on the mild steel surface obeyed Temkin's adsorption isotherm which was further validated by Quantum chemical calculations. Further the authors[26] have evaluated the inhibition performance of Tobramycin (TBN) on stainless steel 304 dissolution and ingress of hydrogen gas in 2N H_3PO_4 and 2N HCl employing mass loss, gasometric and electrochemical studies. The antibiotic seems to be more effective in reducing the dissolution of steel in 2N H_3PO_4 than in 2N HCl. Potential- Current plots evidently pointed out that the inhibitor followed mixed mode of inhibition in acidic media. Hydrogen permeation and EIS measurements have confirmed that TBN retards the corrosion of SS 304 effectively in both the acids. The theoretical values of E_{HOMO}, E_{LUMO}, ΔE and dipole moment in the presence of inhibitor confirmed its effective adsorption on SS 304 surface. The significance of Azithromycin (AZ) on corrosion of aluminium alloy 2024 in 0.1N Hydrochloric acid was examined by Lakshmi et al[27] using weight loss measurements, Tafel polarization studies and scanning electron microscopy. The results indicated that AZ is a good inhibitor for aluminium alloy in 0.1N HCl and maximum efficiency obtained was 91% at 450ppm concentration of azithromycin. Potentiostatic Polarization analyses displayed that AZ works as a mixed type of inhibitor. Electrochemical impedance plots were used to examine the mechanism of corrosion. Quantum chemical studies were done for azithromycin and its various quantum chemical parameters were calculated. Also the influence of Roxithromycin (RZ) on corrosion of aluminium in 0.1N Hydrochloric acid was investigated by the same authors[28]. Abdallah et al[29]have investigated the influence of three antihypertensive drugs namely Enalapril maleate,Atenolol and Etilefrine hydrochloride on the corrosion behavior of aluminum and three aluminum–silicon alloys in different concentrations of HCl solutions. The adsorption followed Langmuir adsorption isotherms. It was found that the drugs compounds provided protection to Al and Al–Si alloys against pitting corrosion by shifting the pitting potential to more positive direction until critical drug concentrations (250 ppm). After this critical concentration the inhibition against to pitting corrosion started to decrease. The interfacial behavior of fluconazole (FLC) between aluminium and hydrochloric acid has been investigated by Obot and Egbedi[30]. The adsorption of the inhibitor on the aluminium surface is found to accord with Temkin adsorption isotherm. The correlation of inhibition

effect and molecular structure of fluconazole was then discussed by quantum chemistry study to further provide insight into the mechanism of the inhibitory action. The same authors have also examined the performance of clotrimazole[31] as the corrosion inhibitor for aluminium in hydrochloric acid medium. The compound was effectively adsorbed on Al surface and possesses a number of active centres concentrated mainly on the imidazole moiety of the molecule. The highest occupied molecular orbital (HOMO), and the lowest unoccupied molecular orbital (LUMO) were also found around the nitrogen atoms and the cyclic of the benzene rings. The effectiveness of expired Voltaren (EV) drug as corrosion inhibitor for aluminium in 1 M HCl was investigated by Abdel Hameed et al[32]. The Polarization measurements confirmed that the inhibiting action of the compound was mixed-type. The adsorption of the inhibitor was found to obey the Langmuir adsorption isotherm.

Al-Shafey and his co-workers[33] have studied the inhibition efficiency of the expired Phenytoin sodium drug (PSD) as corrosion inhibitor of carbon steel in 1 M HCl solution. The adsorption of phenytoin sodium obeyed Langmuir adsorption isotherm. Polarization curves indicated that they are mixed type of the inhibitors. Abdel Hameed[34] had tested the expired ranitidine was tested as a corrosion inhibitor for mild steel in 1 M HCl. The adsorption of the inhibitor on the mild steel surface followed Langmuir adsorption isotherm model. The negative value of ΔGads (-40 kJ mol-1) indicated spontaneous chemical adsorption of Ranitidine drug on mild steel surface. The electrochemical and surface characterization studies on Azathioprine drug as corrosion inhibitor for carbon steel in HCl Solutions was cariedout by Foudaet. al[35]. The drug absorption on metal surface was obeyed Temkin's isotherm. According to Hoseinpoor and Davoodi[36], two antithyroidal drugs namely methimazole (MMI) and propylthiouracil (PTU) could effectively reduced the corrosion of mild steel in 0.1 M HCl. .Also, inhibitor molecules directly adsorb at the surface on the basis of donor–acceptor interactions between the p-electrons, sulfur and oxygen atoms and the vacant d-orbitals of iron atoms.The adsorption process followed by MMI and PTU was Langmuir adsorption isotherm. Ameh and Sani[37] are of view that , Cefuroxime axetil (CA) a pro-drug was used as corrosion inhibitor for aluminum in hydrochloric acid solution .The authors have used the techniques such as thermometric, gasometric weight loss and scanning electron microscope (SEM) to screen the performance of the inhibitor. The adsorption of the inhibitor was also found to be spontaneous, exothermic and best fitted the Langmuir adsorption model. The influence of Ketosulfone as a green corrosion inhibitor for mild steel in 1 M HCl medium was studied by Matadet. al[38]. The Polarization measurements revealed that Ketosulfone acts as a mixed-type inhibitor. The adsorption of the inhibitor on the mild steel surface in acid solution was found to obey the Langmuir adsorption isotherm. The activation and thermodynamic parameters of dissolution and adsorption were calculated for this compound. Akpan and Offiong[39] have evaluated inhibition of mild steel corrosion in acidic medium by amlodipine drug using chemical and electrochemical methods. The adsorption mode of the drug was found to be by monolayer chemisorption having found the experimental data obeyed the Langmuir adsorption isotherm.

The corrosion inhibition of mild steel in acidic media using Trazodone (Tz) drug was studied by Manimegalaiet. al[40]. Vaszilcsinet. al[41] have examined the inhibitive action of expired Carbamazepine and Paracetamol tablets drugs for the corrosion of mild steel in acidic media. Meclizine hydrochloride was tested as a corrosion inhibitor for mild steel in 1 M HCl by Ishwara and Alva[42]. The adsorption of the inhibitor on the mild steel surface followed Langmuir adsorption isotherm model. The activation and thermodynamic parameters of dissolution and adsorption were calculated. Samide et al[43] have examined the inhibition effect of two antibiotics namely Sulfathiazole and sulphonamide on the corrosion of mild steel in IN HCl medium. The authors have performed surface characterization studies using SEM and XPS. XPS analysis revealed that the corrosion product consists of an oxy hydroxide/oxide mixture and that the iron oxy hydroxide proportion is higher than the iron oxide proportion.The inhibition of the corrosion of zinc in 4 M HCI by Naproxen has been investigated by Emad Yousifl et al[44]. Ofoegbu and Ofoegbu[45] have carriedout trail studies on Chloroquine diphosphate as corrosion inhibitor for mild steel in 0.1M HCl. The adsorption of the inhibitor followed Langmuir adsorption isotherm. Narayana Hebbar and his co-investigator[46] studied the influence of Anthranilic acid on the corrosion of mild steel in 1M HCl. The studies showed the mode of corrosion inhibition by this compound followed mixed type. Polyethelene Glycol-Anthranilic Acid Composite as Corrosion Inhibitor for Mild Steel in Acid Medium was investigated by Banumathi et al[47]. Experimental studies showed that the maximum inhibition efficiency was found to be 97%. The adsorption of compound was found to fit with Langmuir adsorption isotherm. Electrochemical studies confirmed the inhibitive nature of the PGA composite and also the mixed nature of the inhibitor. The polymer is found to be highly efficient non-toxic and environmentally safe. Ananthkumar et al[48] have analysed the performance of MephentermineSulfate drug solution to inhibit corrosion of mild steel in hydrochloric acid (HCl) media and the adsorption of inhibitor is

found to follow Langmuir adsorption isotherm. The inhibition performance of mebendazole, a drug, on mild steel in molar hydrochloric acid solution was studied by Ahamad and Quaraishi[49].The Adsorption of inhibitor obeyed Langmuir adsorption isotherm model.

Recently Karthikeyan et al[50] investigated the inhibitive effect of dicloxacillin on the corrosion of mild steel in acid medium and found that dicloxacillin acted as cathodic inhibitor. Further the authors have evaluated the influence of Cefalotin drug [51] on the corrosion resistance of Al-SiC composites in sea water . This study has confirmed that the compound retarded the dissolution of Al-SiC in sea water environment by acting as mixed inhibitor. The adsorption of the compound on composite surface followed Temkin's adsorption isotherm. The quantum chemical analysis validated the inhibition action of the green inhibitor determined by electrochemical methods.Harish et al [52] have investigated that the inhibition of corrosion of reinforcing steel in simulated concrete pore solution (SCPS) by Mezlocillin (MZN) as a green inhibitorusing mass loss, gasometric measurements, potentiodynamic polarization and impedance studies .

Mechanism

Corrosion inhibition of mild steel , Aluminium, Al-SiC composites, Zinc,Nickel,Copper in acidic and sea water medium by antibiotics/drugs which were reported as potential green inhibitors could be be explained on the basis of molecular adsorption of inhibitor on to the metal surface. It is generally considered that the corrosion inhibition of a metal is the adsorption of the inhibitor molecules at metal / solution interface.

Organic compounds are adsorbed on the metal surface by,

1. Electrostatic interaction between the changed molecules and charged metal
2. Interaction of electrons with the metal
3. Interaction of unshared pair of electrons in the molecule with the metal and
4. The combination of the all the effects.

The inhibition efficiency of the inhibitors also depends on many factors such as the adsorption centers, mode of interaction with metal surface, charge density, molecular size, and the formation of the metallic complexes .Physical adsorption of the inhibitor molecule required both electrically charged surface of the mild steel and charged inhibitor species in the corrosive solution. The inhibitor molecule is protonated in the acid medium. Thus they became cation, existed in equilibrium with the corresponding molecular form. It is well known fact that the steel surface bears positive charge in acid solution. The protonated inhibitor molecule could be attached to the mild steel surface by electrostatic interaction between negatively charged ions of electrolyte/corrosive media and protonated drug molecules. The decrease in the inhibition efficiency obtained with rise in the temperature supported the electrostatic interaction.

Conclusions

It has been shown that Antibiotics/ drug molecules are efficient corrosion inhibitors in aqueous media. The review paper detailed that considerable research has been carried out using antibiotics as corrosion inhibitors for different metals in different electrolyte. The outcomes of the sequence of surveys have disclosed that the processes involved in corrosion inhibition are varying with respect to all classes of compounds so far explored and are not even constant or consistent with one inhibitor in a given system. Indeed, the overall process is a function of the metal, corrodent, inhibitor structure, and concentration, as well as temperature.

This paper concerned the role of antibiotics as inhibitor for the corrosion and summarized details fall from a decade of publications by several researchers (2004-2015) in this area of interest. However few more important and basic research findings that dateback to years have also been included. This review is mainly focusing on recent innovationsin the field of green corrosion inhibition by drugs/antibiotics for metals in different environment and has been discussed in a detailed manner.

References

1. Eddy N, Odoemelam S, Ekwumemgbo P. Inhibition of the corrosion of mild steel in H2SO4 by penicillin G. Sci. Res. Essays 2009;4(1):033-038.

2. Eddy N, Odoemelam S. Inhibition of the corrosion of mild steel in acidic medium by penicillin V potassium. Advances in Natural and Applied Sciences 2008;2(3):225-233.
3. Alder AC, McArdell CS, Golet EM, Ibric S, Molnar E, Nipales NS, Giger W. Occurrence and fate of fluoroquinolone, macrolide, and sulfonamide antibiotics during wastewater treatment and in ambient waters in Switzerland. 2001.
4. Eddy NO, Ebenso EE. Quantum chemical studies on the inhibition potentials of some penicillin compounds for the corrosion of mild steel in 0.1 M HCl. Journal of molecular modeling 2010;16(7):1291-1306.
5. Kumar SH, Karthikeyan S. Inhibition of mild steel corrosion in hydrochloric acid solution by cloxacillin drug. J. Mater. Environ. Sci 2012;3(5):925-934.
6. Dubey R, Potdar Y. Corrosion inhibition of 304 stainless steel in sodium chloride by ciprofloxacin and norfloxacin. Indian Journal of Chemical Technology 2009;16(4):334.
7. Adejoro I, Ojo F, Obafemi S. Corrosion inhibition potentials of ampicillin for mild steel in hydrochloric acid solution. Journal of Taibah University for Science 2015;9(2):196-202.
8. Fouda A, Elmorsi M, Fayed T, Hassan A, Soltan M. Corrosion Inhibitors Based on Antibiotic Derivatives for Protection of Carbon steel Corrosion in Hydrochloric Acid Solutions. International Journal 2014;2(4):788-807.
9. Raja K, Jeeva P, Karthikeyan S. Reduction of hydrogen embrittlement and green inhibition of stainless steel pipes in acid environment.International Journal of ChemTech Research,2015 ,7(5):2425-2431,
10. Karthikeyan S, Jeeva PA, Raja K. Corrosion Inhibition and Quantum Mechanical Studies of Galvanized Steel Sheets in Chloride Environment. Asian Journal of Applied Sciences 2015;3(1):14-21.
11. Fouda A, Abdallah A, Yousef M. Corrosion Inhibition and Adsorption Properties of Cefixime on Carbon Steel in Acidic Medium. Chemical Science Review and Letters 2014;3(11S):130-143.
12. Akpan IA, Offiong N-AO. Inhibition of mild steel corrosion in hydrochloric acid solution by Ciprofloxacin drug. International Journal of corrosion 2013;2013.
13. Fouda AE-AS, Farahat MM, Abdallah M. Cephalosporin antibiotics as new corrosion inhibitors for nickel in HCl solution. Research on Chemical Intermediates 2014;40(3):1249-1266.
14. Md A Aziz M, Khan Z, Mst S, Hasan MR. Corrosion Inhibition Study of Mild Steel in Acidic Medium by Antibiotic Drugs: A Comparative Study. Aceh International Journal of Science & Technology 2014;3(1).
15. Naqvi I, Saleemi A, Naveed S. Cefixime: A drug as Efficient Corrosion Inhibitor for Mild Steelin Acidic Media. Electrochemical and Thermodynamic Studies. Int. J. Electrochem. Sci 2011;6:146-161.
16. Von Fraunhofer J, Stidham S. Effects of fused-ring antibiotics on metallic corrosion. Journal of biomedical engineering 1991;13(5):424-428.
17. Lakshmi N, Karthikeyan S, Jeeva P, Paramasivam M, Narayanan S. The influence of an eco-friendly antibiotic as anti-scalant and inhibitor for steel in gypsum solution and brine water. Desalination and Water Treatment 2014(ahead-of-print):1-9.
18. Karthikeyan SJ, P.A., Raja, K.,Paramasivam, M. Studies on the reduction of mild steel corrosion and hydrogen permeation in acidic media. Journal of Corrosion Science and Engineering 2015;18(8).
19. Shukla SK, Singh AK, Ahamad I, Quraishi M. Streptomycin: A commercially available drug as corrosion inhibitor for mild steel in hydrochloric acid solution. Materials Letters 2009;63(9):819-822.
20. S. Karthikeyan PAJaKR. Quantum mechanical and hydrogen permeation studies on the corrosion of stainless steel in acid medium using a novel inhibitor. Der Pharmacia Lettre 2015;7(2):22-26.
21. Akpan I, Offiong N. Electrochemical Investigation of the Inhibitory Action of Ciprofloxacin Drug on the Acid Corrosion of Mild Steel. Chemical and Process Engineering Research 2014;26:20-23.
22. Hari Kumar S, Karthikeyan S. Torsemide and furosemide as green inhibitors for the corrosion of mild steel in hydrochloric acid medium. Industrial & Engineering Chemistry Research 2013;52(22):7457-7469.
23. Sappani HK, Karthikeyan S. 4-Chloro-2-((furan-2-ylmethyl) amino)-5-sulfamoylbenzoic Acid (FSM) and N-(Isopropylcarbamoyl)-4-(m-tolylamino) Pyridine-3-sulfonamide (TSM) as Potential Inhibitors for Mild Steel Corrosion in 1 N H2SO4 Medium. Part I. Industrial & Engineering Chemistry Research 2014;53(9):3415-3425.
24. Geethamani P, Kasthuri P, Foreman MRS. Adsorption and corrosion inhibition of mild steel in acidic media by expired pharmaceutical drug. Cogent Chemistry 2015;1(1):1091558

25. S.Karthikeyan PAJ, M.Paramasivam. The influence of sulfalene drug (SFL) on the corrosion and hydrogen permeation through stainless steel 304 in 5% NaCl-part I. Journal of Corrosion Science and Engineering 2015;17(5).
26. Karthikeyan S, Jeeva, P.A., Narayanan, S. Inhibition performance of tobramycin on the dissolution of stainless steel 304 and ingress of hydrogen gas in acid medium. Journal of Corrosion Science and Engineering 2014;17(9).
27. Lakshmi NVK, S. Arivazhagan, N. Azithromycin: A potential corrosion inhibitor for aluminum 2024 in acidic medium. Journal of Corrosion Science and Engineering 2014;17(7).
28. N.V.Lakshmi SK, N.Arivazhagan. Controlled dissolution of aluminum 2024 in acidic medium. Journal of Corrosion Science and Engineering 2014;17(6).
29. Abdallah M, Zaafarany I, Al-Karanee S, El-Fattah AA. Antihypertensive drugs as an inhibitors for corrosion of aluminum and aluminum silicon alloys in aqueous solutions. Arabian Journal of Chemistry 2012;5(2):225-234.
30. Obot I, Obi-Egbedi N. Fluconazole as an inhibitor for aluminium corrosion in 0.1 M HCl. Colloids and Surfaces A: Physicochemical and Engineering Aspects 2008;330(2):207-212.
31. Obot I, Obi-Egbedi N, Umoren S. Adsorption characteristics and corrosion inhibitive properties of clotrimazole for aluminium corrosion in hydrochloric acid. International journal of electrochemical science 2009;4:863-877.
32. Abdel Hameed R. Ranitidine Drugs as Non-Toxic Corrosion Inhibitors for Mild Steel in Hydrochloric Acid Medium. Portugaliae Electrochimica Acta 2011;29(4):273-285.
33. Hussin I. Al - Shafey RSAH, F. A. Ali, Abd el - Aleem S. Aboul - Magd, M. Salah. 2015 Effect of Expired Drugs as Corrosion Inhibitors for Carbon Steel in 1M HCL Solution. <http://globalresearchonline.net/journalcontents/v27-1/26.pdf>.
34. Hameed RA, Ismail E, Abu-Nawwas A, Al-Shafey HI. Expired Voltaren Drugs as Corrosion Inhibitor for Aluminium in Hydrochloric Acid. Int. J. Electrochem. Sci 2015;10:2098-2109.
35. A.S. Fouda AME-w, H.A. Mostafa,K.M.A. Elawayeb. Electrochemical and surface characterization studies on Azathioprine drug as corrosion inhibitor for carbon steel in HCl Solutions. Der Pharma Chemica 2015;7(9):22-32.
36. Hoseinpoor M, Davoodi A. Studies on corrosion-inhibiting performance of antithyroid drugs on mild steel in hydrochloric acid. Research on Chemical Intermediates:1-18.
37. Sani POAaUM. 2015 Cefuroxime Axetil: A Commercially Available Pro-Drug as Corrosion Inhibitor for Aluminum in Hydrochloric Acid Solution. <http://edelweisspublications.com/edelweiss/article/Cefuroxime-Axetil-Pro-Drug-Corrosion-Inhibitor-Aluminum-Hydrochloric-Acid-Solution-JOH-1-101.pdf>.
38. Matad PB, Mokshanatha PB, Hebbar N, Venkatesha VT, Tandon HC. Ketosulfone drug as a green corrosion inhibitor for mild steel in acidic medium. Industrial & Engineering Chemistry Research 2014;53(20):8436-8444.
39. Akpan I, Offiong N. Electrochemical Study of the Corrosion Inhibition of Mild Steel in Hydrochloric Acid by Amlodipine Drug. International Journal of Chemistry and Materials Research 2014;2(3):23-29.
40. S.Manimegalai RRaPM. Inhibition of corrosion mild steel in acid media by trazodone drug. Research Desk 2015;2(4):326-333.
41. Vaszilcsin N, Ordodi V, Borza A. Corrosion inhibitors from expired drugs. International journal of pharmaceutics 2012;431(1):241-244.
42. Bhat JI, Alva VD. Meclizine hydrochloride as a potential non-toxic corrosion inhibitor for mild steel in hydrochloric acid medium. Archives of Applied Science Research 2011;3:343-356.
43. Samide A, Tutunaru B, Negrila C. Corrosion inhibition of carbon steel in hydrochloric acid solution using a sulfa drug. Chemical and Biochemical Engineering Quarterly 2011;25(3):299-308.
44. Emad Yousifl AA-M, Bashar Abdullah. Corrosion inhibition of zinc metal in 4m hydrochloric acid solution by using naproxen drug (2-(6-methoxynaphthalen-2-yl) acetic acid) as an inhibitor. Yanbu Journal of Engineering and Science 2013;7:37-40.
45. Ofoegbu SU, Ofoegbu PU. Corrosion inhibition of mild steel in 0.1 M hydrochloric acid media by chloroquine diphosphate. ARPN Journal of Engineering and Applied Sciences 2012;7(3):272-276.
46. Hebbar N, Praveen B, Prasanna B, Venkatesha T, Hamid SA. Anthranilic Acid as Corrosion Inhibitor for Mild Steel in Hydrochloric Acid Media. Procedia Materials Science 2014;5:712-718.
47. Banumathi N, Subhashini S, Rajalakshmi R. Polyethelene Glycol-Anthranilic Acid Composite as Corrosion Inhibitor for Mild Steel in Acid Medium. Journal of Chemistry 2010;7(S1):S67-S74.

48. Kumar SA, Sankar A, Kumar SR. Mephentermine Sulphate Drug as Non-Toxic Corrosion Inhibitor for Mild Steel in 1m Hcl Medium. International Journal of Chemistry and Chemical Engineering 2013;3(1):15-22.
49. Ahamad I, Quraishi M. Mebendazole: new and efficient corrosion inhibitor for mild steel in acid medium. Corrosion Science 2010;52(2):651-656.
50. S. Karthikeyan PAJ, K. Raja. Dicloxacillin: An effective retarder for steel dissolution in acid medium. International Journal of ChemTech Research 2015;8(3):1391-1395.
51. Karthikeyan S, Anthony Xavior, M.,Jeeva, P.A., Raja, K. A green approach on the corrosion studies of a SiC composites in sea water. International Journal of ChemTech Research 2015;8(3):1109-1113.
52. Harish, E.L., Karthikeyan, S., Sekar, S.K., Corrosion inhibition of reinforcing steel in simulated concrete pore solution-An ecofriendly approach, 2015 7(4),2003-2006.
53. Mary Anbarasi C and Jerli Auxilia A, Surface Modification of Carbon Steel by Hexanesulphonic Acid-Ni^{2+} System and its Corrosion Study, International Journal of ChemTech Research,2016, Vol.9, No.01 pp 218-225.
54. P.R.Thyla, N. Tiruvenkadam, M. Senthil Kumar; Investigation of Corrosion Behavior of Light Weight NanoHybrid Al 6061-ZrO2 –SiC- Gr Composites; International Journal of ChemTech Research;
55. Sravani Pappu, Vamsi Kamal, M. K. Mohan; Effect of Heat Treatment on the Electrochemical Corrosion Behavior of Ti- 15 V- 3 Al- 3 Cr- 3 Sn Alloy in HCl and NaCl Media; International Journal of ChemTech Research;2015, Vol.8, No.1, pp 155-163.
56. G. Kavitha, S. Jegannathan, and C. Vedhi; Inhibition of corrosion of mild steel in sulphuric acid by 2-Picoline N-Oxide and 4-Picoline N-Oxide; 2015, Vol.7, No.4, pp 1693-1701.
57. S.Karthikeyan, P.A.Jeeva; Hydrogen permeation analysis of corrosion of stainless steel in pickling solution; International Journal of ChemTech Research;2015, Vol.8, No.7, pp 335-339.
58. Ashish Kumar, Sumayah Bashir; Review on Corrosion inhibition of Steel in Acidic media; International Journal of ChemTech Research;2015, Vol.8, No.7, pp 391-396.
59. Charitha B.P., and Padmalatha Rao; Ecofriendly biopolymer as green inhibitor for corrosion
60. control of 6061-aluminium alloy in hydrochloric acid medium; International Journal of ChemTech Research;2015, Vol.8, No.11 pp 330-342.
61. V.Saravanan, P.R. Thyla, N. Nirmal, S.R. Balakrishnan; Corrosion Behavior of Cenosphere - Aluminium Metal Matrix Composite in Seawater Condition; International Journal of ChemTech Research;2015, Vol.8, No.2, pp 726-731.
62. J. Yamuna, Noreen Anthony; Corrosion Protection of Carbon Steel in Neutral Medium using Citrus medica [CM] leaf as an Inhibitor; International Journal of ChemTech Research;2015, Vol.8, No.7, pp 318-325.
63. S.Karthikeyan, M.Anthony Xavior, P.A.Jeeva, K.Raja; A green approach on the corrosion studiesof Al-SiCcomposites in Sea water; International Journal of ChemTech Research;2015, Vol.8, No.3, pp 1109-1113.
64. A.V.Balan, T.Kannan; Effect Of Heat Input On Pitting Corrosion Resistance Of Super Duplex Stainless Steel Weld Claddings; International Journal of ChemTech Research;2016, Vol.9, No.03 pp 358-362.
65. M. Gnanasekaran, A. Kumaravel, S. Jerome; Effect of oxide layer and activating flux on corrosion behavior of TIG welding of 304 austenitic stainless steel weldments; International Journal of ChemTech Research;2016, Vol.9, No.04 pp 350-356.
66. R. Ganapathi Sundaram, and M. Sundaravadivelu; Electrochemical and Surface Investigation of Quinoline-8-sulphonyl chloride as Corrosion Inhibitor for Mild Steel in Acidic Medium; International Journal of ChemTech Research;2016, Vol.9, No.03 pp 527-539.
67. Mary Anbarasi C* and Jerli Auxilia A; Surface Modification of Carbon Steel by Hexanesulphonic Acid- Ni2+ System and its Corrosion Study; International Journal of ChemTech Research;2016, Vol.9, No.01 pp 218-225.

*****