RESEARCH ARTICLE

RSP Science Hub

International Research Journal on Advanced Science Hub
2582-4376
www.rspsciencehub.com
Vol. 07, Issue 04 April

Check for updates

http://dx.doi.org/10.47392/IRJASH.2025.037

An Insight into Anticorrosive Profiling of Drugs

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Article history

Received: 10 March 2025
Accepted: 23 March 2025
Published: 18 April 2025

Keywords:
Drugs; Corrosion; Inhibitor; Mild Steel; Carbon Steel; Antibiotic; Anti-Inflammatory.

Abstract

Drugs play an important role for the wellness of communities all over the world. In addition, their potential cannot be ignored for commercial point of view especially as anticorrosive agents. We have done an intensive study for drugs such as antibiotic, anti-inflammatory, antihistamine, antifungal, antibacterial, antihypertensive, antidiabetic and other categories, to explore their potential as anti-corrosive agents against various metals. These drugs have been studied in acidic environments such as HCl, H2SO4, H3PO4, and NaCl against a variety of metals including mild steel, carbon steel, aluminum, copper, iron, zinc, and their alloys. The outcome of our study revealed that drugs are equally effective as corrosion inhibitors. Furthermore, comparative studies of several drug categories revealed that antibiotic and anti-inflammatory drugs demonstrated significant potential of metal protection from corrosion and hence can be used for commercial purpose. The futuristic approach of our work is to give it an extension to the expired drugs' domain which contribute to the solid waste all over the world. Moreover, new dimension can be given to pharmaceutical and paint industries for the use of expired drugs as corrosion inhibitors.

1. Introduction

Corrosion is defined as the destruction or decadence caused by a lack of metals or alloys because of a chemical or electrochemical attack from the surrounding environment. The principal causes of metal corrosion include atmospheric, air, and water contamination, as well as the metals' conducting surfaces [1]. It is a natural process that has significant effects on metals or alloys in aqueous solutions. Corrosive substances in the fluids include water or saltwater, dissolved carbon dioxide, oxygen, and acids such as H2CO3, HCl, and H2SO4. Corrosion has become a major issue for several businesses throughout the world, particularly in the oil and gas industries. By electrochemical processes, the transportation of fluids containing crude oil, natural gas, and caustic compounds causes rust in the inner section of the pipeline [2]. This corrosion must be prevented or managed, otherwise the special qualities of low carbon steel may be lost. The cost of scale wastes from industries in India is 26.1 billion USD, or 2.4% of total GDP [3]. The worldwide loss due to corrosion is estimated to be $2.5 trillion (about $7,700 per person in the US) (about $7,700 per person in the US), or around 3.5% of global GDP (NACE March 2016) [4]. Corrosion costs have typically been expressed as a percentage of a country's Gross National Product (GNP), ranging from about 2% to 5%, depending primarily on whether indirect losses attributable to corrosion have been considered in addition to direct losses. GDP and

GNP have been used completely arbitrarily, with no clearly established criteria. So, corrosion is continuously affected on over GDP and GNP, some historic GNP data is given in the figure 1. [5]

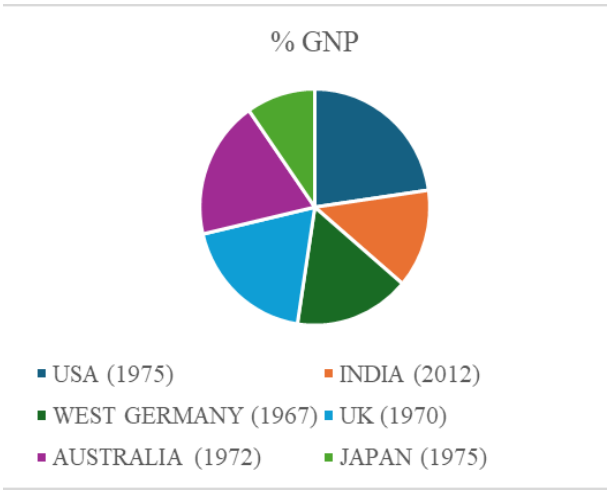


Figure 1 Some Historic Events of Corrosion Cost

In the twenty-first century, effectively reducing corrosion on metals in a range of conditions remains a difficulty. Because of the sustained economic progress and the cost-of-living efforts to reduce corrosion, various methods such as electrochemical defense and the addition of a small quantity of substances (inhibitor) that reduces the corrosion process in acidic environments were used. Inhibitors are added to the metal to protect the metal surface, resulting in the formation of stable compounds. Furthermore, numerous organic, inorganic, herbal extracts, pharmaceutical medications, ionic liquids, and synthetic chemicals were employed as inhibitors on a regular basis [6]. Because they include multiple functional groups and unsaturation as adsorption centers, pharmaceutically active substances are used as corrosion inhibitors. They are biodegradable and may be produced and processed at a low cost [7]. Antibiotics such as ampicillin, cloxacillin, flucloxacillin, and amoxicillin were among the first medications tested as corrosion inhibitors, with inhibitory efficiency reaching up to 90%. Antihypertensive medications (Enalapril maleate, Atenolol, and Etilefrine) were successfully evaluated in the same solutions [8]. The negative impact of inorganic inhibitors on environmental safety prompted researchers to shift their focus to organic chemicals or natural products. These compounds' inhibitory capacity is proportional to the availability of electrons and functional groups such as -CO2H, -CO2R, -NR2, -NH2, -OH, -OR, and -SR [9]. So yet, there is no information on the direct use of expired medications as corrosion inhibitors in the petroleum industry. Corrosion inhibitors derived from expired pharmaceuticals are still being studied to generate better inhibitors (with an inhibition efficacy of more than 99%) that can be compared to conventional inhibitors. Expired medications are unsafe to consume due to the degradation of active ingredients as well as excipients caused by physical, chemical, or microbiological influences such as humidity, pressure, temperature, bacteria, and light [10]. The structure of traditional and expired medications is comparable to that of general organic inhibitors, which include functional groups and electrons to enable their performance as corrosion inhibitors [11]. In our work, we tried to prepare a complete profiling of drugs in an arena of anticorrosion study on metals.

1.1. Useful Metals Which Can Be Protected by Corrosion Inhibitors:

There are many metals we use for daily or industrial purposes which are shown in figure 2.

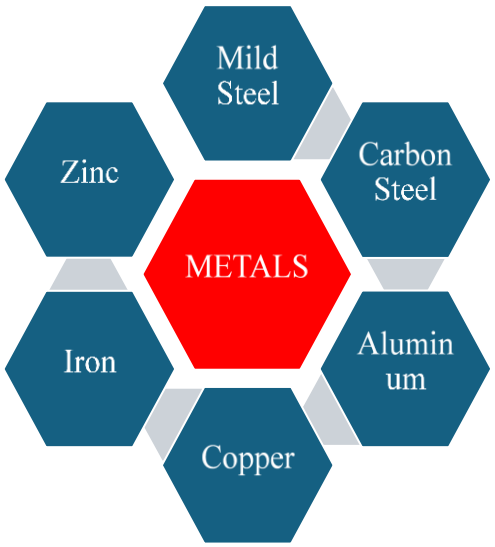


Figure 2 Useful metals for Corrosion Protection

1.2. Experimental Methods Used for Corrosion Inhibitory Study:

There are so many methods which are used to measure the corrosion inhibition efficiency such as Weight Loss, Potentio Dynamic Polarization (PDP), Galvanostatic Polarization (GAP), Electrochemical Impedance Spectroscopy (EIS), Electrochemical Frequency Modulation (EFM), and quantum analysis which is also useful. In addition, few methods are used to detect surface analysis like Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM) and Fourier Transform Infrared spectroscopy (FTIR). Few common methods with its scope are illustrated in figure. 3

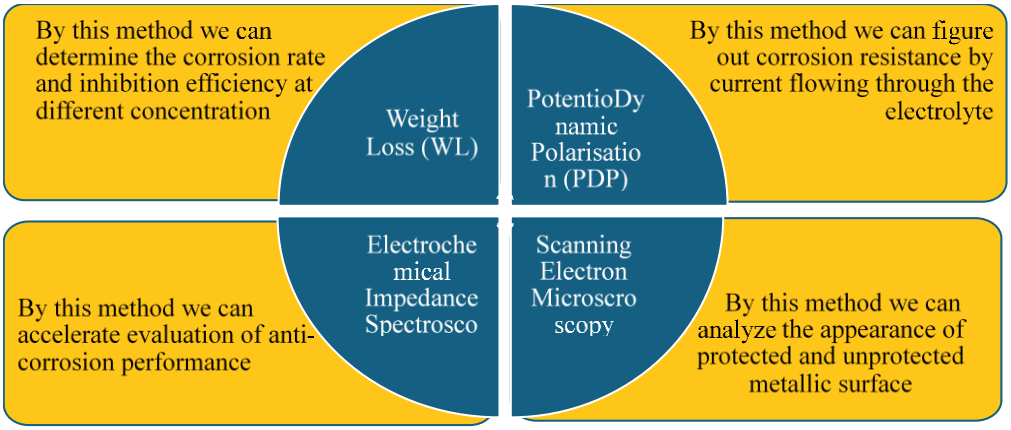
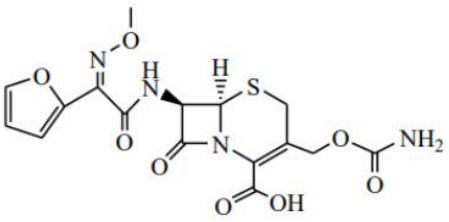
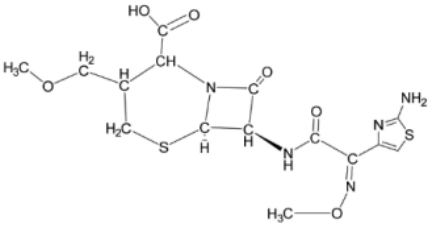


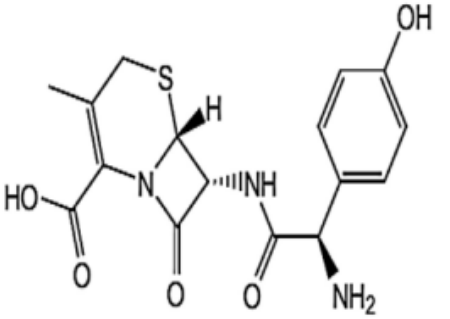
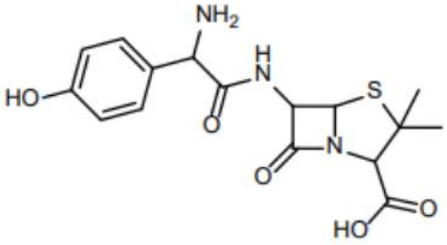
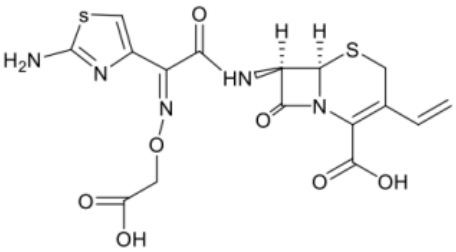
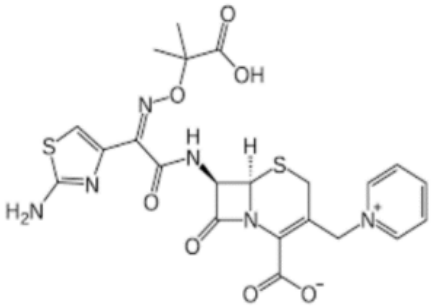
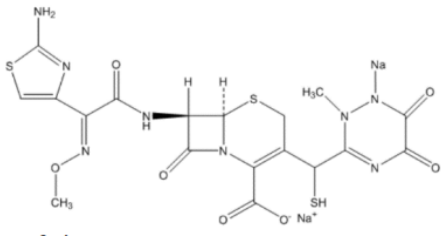
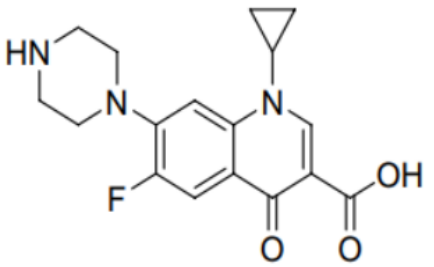
Figure 3 Useful Experimental Methods in Corrosion Inhibitory Study

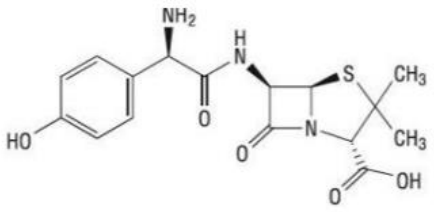
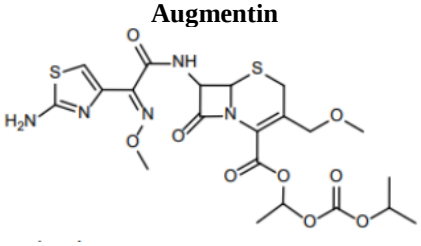
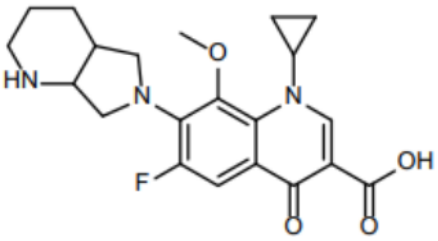
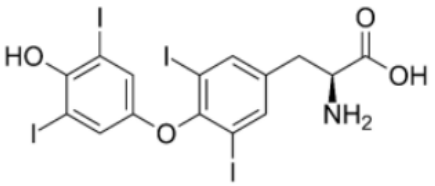
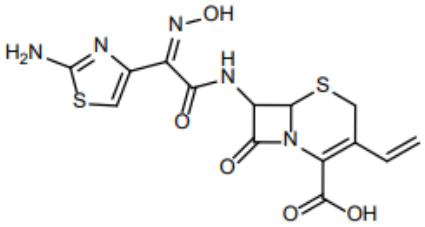
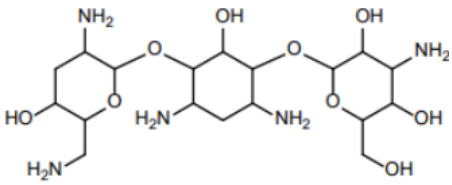
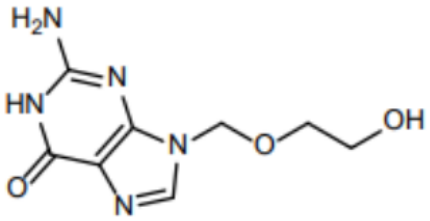
1.3. Study for Various Category Drugs Used for Corrosion Inhibition:

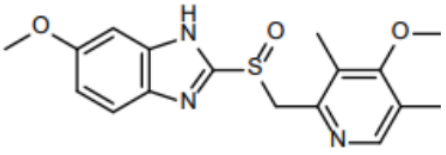
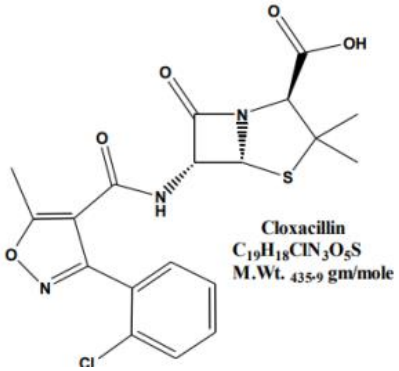
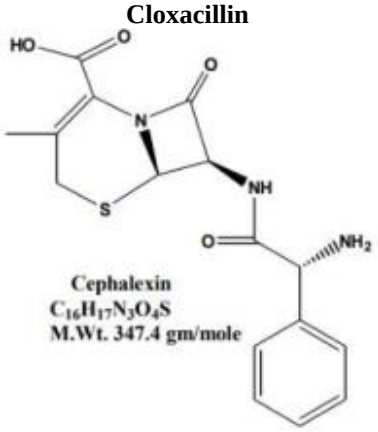
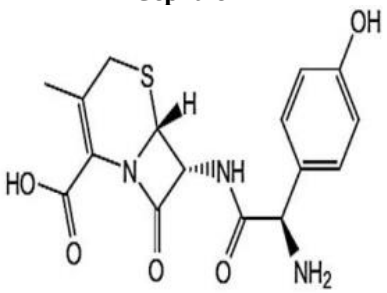
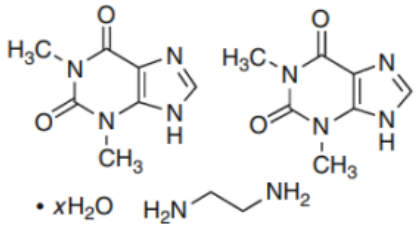
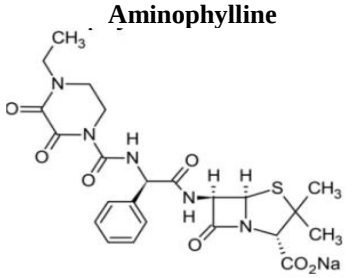
Our work explores different type of drugs like antibiotic, anti-inflammatory, antihistamine, antifungal, antibacterial, antidiabetic, analgesics, antiemetic, antihypertensive, anthelminthic, carbonic anhydrase, beta blocker, antiviral, laxative, skeletal muscle relaxant, antihyperlipidemic, depressant, antagonists, sedative hypertonic, amino sugar, gastroesophageal and antiarrhythmic. Table 1 illustrates the drugs with their anti-corrosive activities against metals, in different mediums, and inhibition efficiency.

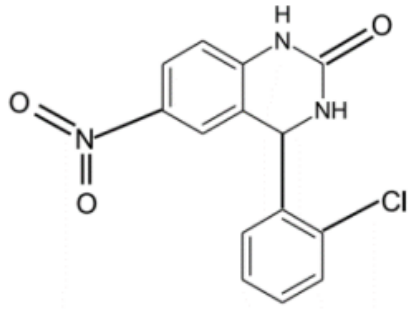
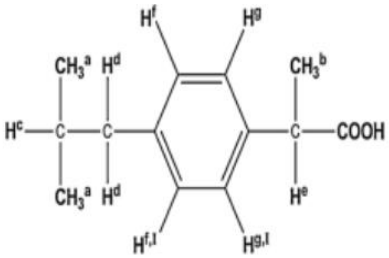
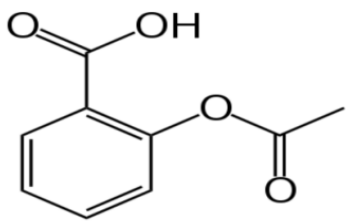
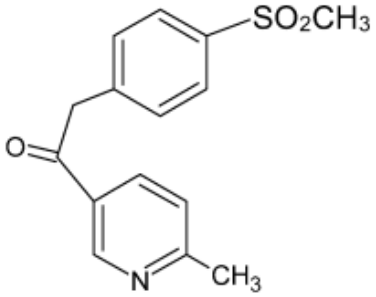
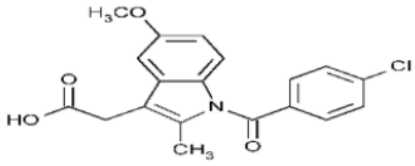
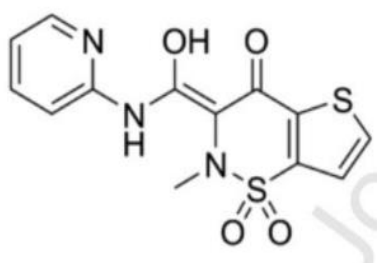
Table 1 Corrosion Analytics of Selected Category Drugs as Reported in Literature

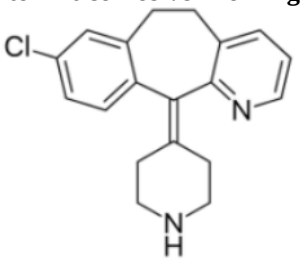
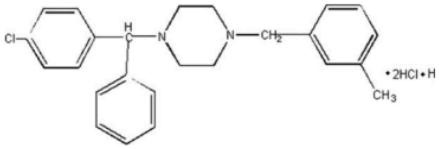
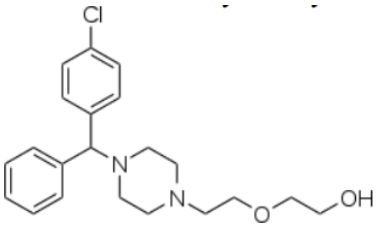
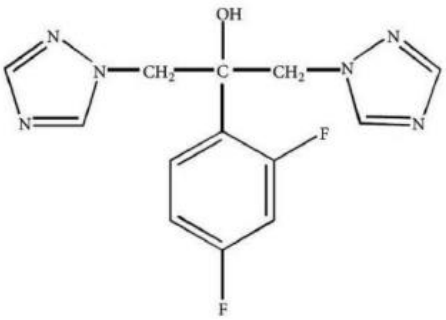
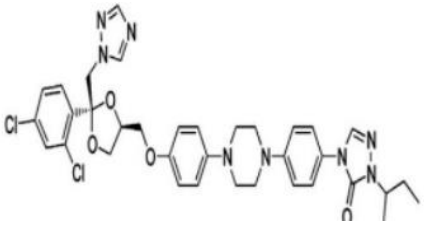
Drug category	Metal	Medium	Methods	Highest Corrosion Inhibition (IE%)	Reference No.
1. Antibiotics					
 **Cefuroxime**	Mild Steel	0.5M H_2SO_4	WL (4.5×10^{-4} M)	94.57	[12]
	Copper	1M HNO_3	WL (5mM)	57.50	[13]
	Aluminum	HCl	Gasometric (0.5C at 303K)	89.87	[14]
	Sabic iron	1M HCl	GAP (500 mg l^{-1}	96.58	[15]
	Zinc	1M H_2SO_4	PDP (0.1 M)	82.88	[16]
	Mild Steel	1N H_2SO_4	EIS (200ppm)	96.52	[17]
 **Cefpodoxime**	Copper	1M HNO_3	Quantum at B3LYP	6-31G	[18]
	Aluminum	0.1M H_2SO_4	Gasometric (0.5 gl^{-1})	89.10	[19]
	Cast Iron	1M HCl	WL (240ppm)	95.2	[20]
	Mild Steel	1M HCl	PDP (11.0×10^{-4} mol l^{-1})	96	[21]
	Aluminum 6063	0.5M H_2SO_4	PDP	58.9	[22]
	Copper	1M HNO_3	WL (2 mM)	94	[23]
	Cast Steel	1M HCl	EIS (10^{-2} M)	96.10	[24]

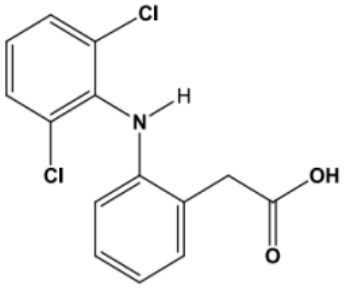
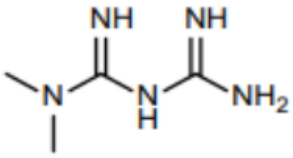
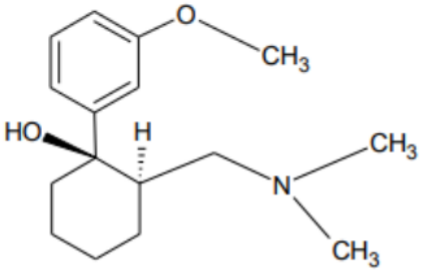
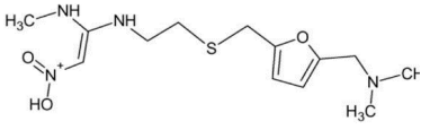
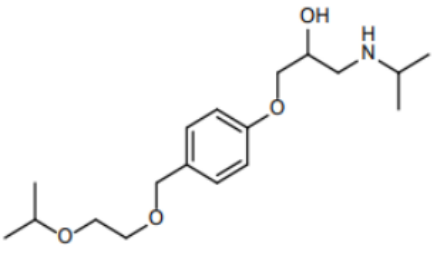
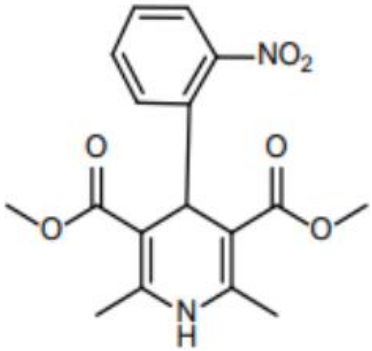
 **Cefadroxil**	Aluminum	0.1M H_2SO_4	PDP (2mM)	90.3	[25]
 **Amoxicillin**	Mild Steel	1 M HCl	Gravimetric (1800ppm)	94.47	[26]
	Carbon Steel	3.5%NaCl	PDP (250 gl^{-1})	91.2	[27]
	Aluminum	1 M HCl	PDP (150ppm)	73	[28]
	1020 Steel	NaCl	EIS (200ppm)		[29]
	Sabic Iron	1 M HCl	GAP (500ppm)	94.7	[30]
 **Cefixime**	Mild Steel	0.5M H_2SO_4	Gravimetric (3.5×10^{-4})	96.93	[31]
	Carbon Steel	H_2SO_4	WL (600ppm)	90.4	[32]
	Copper	1M HNO_3	WL (2 mM)	91.07	[33]
	Aluminum	HCl	ML (2 mM)	90.41	[34]
	Mild Steel alloy	AgNPs	WL (3×10^{-3} M)	93.90	[35]
 **Ceftazidime**	Mild Steel	HCl	PDP (250pm)	90.2	[36]
	Carbon Steel	Fuel	PDP (500ppm)	97.34	[37]
	Copper	1mol/L HCl	EFM (300ppm)	94.2	[38]
	Aluminum	0.1M NaOH	EIS (300ppm)	78.4	[39]
	Cu & Ni	Acidic	EIS	91	[40]
 **Ceftriaxone**	Mild Steel	1N HCl	PDP (400ppm)	90.95	[41]
	Carbon Steel	0.5M HCl	PDP (50ppm)	93.37	[42]
	Aluminum	2M HCOOH	PDP	88.09	[43]
	Nickel	1M HCl	EIS (10^{-5} mol L^{-1})	73.09	[44]
 **Ciprofloxacin**	Mild Steel	1M HCl	WL (0.009 M)	97.72	[45]
	Copper	SAR (synthetic acid rain solution)	EIS (600ppm)	90.1	[46]
	Bronze	Acid rain	PDP (2000ppm)	69.7	[47]

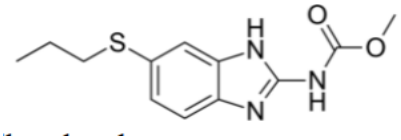
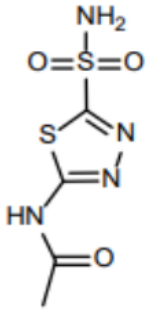
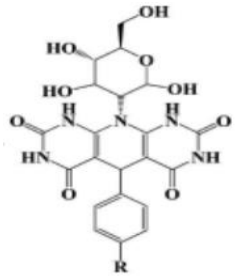
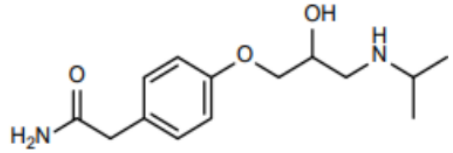
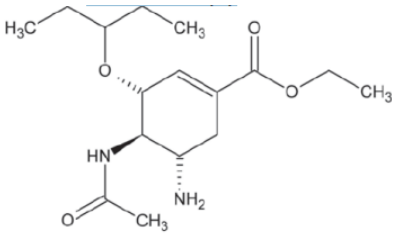
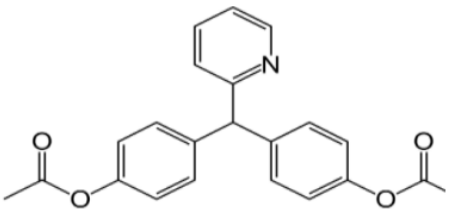
 **Augmentin**	Carbon Steel alloy	1N HCl	Acidimetric (300ppm)	98	[48]
	Copper	HCl	WL (500ppm)	93	[49]
	α-brass	0.5 M HNO_3	WL (300 ppm)	93.6	[50]
 **Podocip**	Carbon Steel	1M HCl	EIS (100 mg L^{-1})	97.3	[51]
 **Moxifloxacin**	Carbon Steel	1 M HCl	EIS (300ppm)	94.1	[52]
	Aluminum	1M H_2SO_4	PDP (400ppm)	86.17	[53]
	Steel	2 M HCl	PDP (400ppm)	97.63	[54]
 **Levothyroxine**	Stainless Steel	H_2SO_4	ML (150ppm)	94.3	[55]
 **Cefdinir**	Mild Steel	1 M HCl	WL (6.32 × 10–4 M at 35 °C)	97.9	[56]
 **Tobramycin**	Carbon Steel	2M HCl	PDP (400ppm)	92.6	[57]
 **Acyclovir (Exp)**	Sabic Iron	HCl	GAP (500ppm)	94.47	[58]
	Sabic Iron	HCl	GAP (500ppm)	95.26	[59]

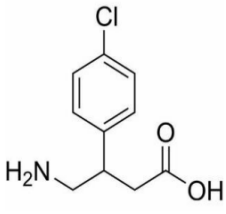
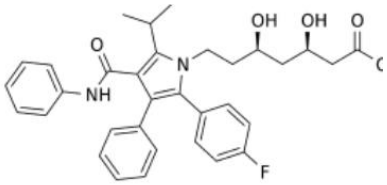
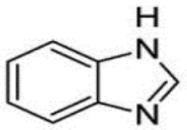
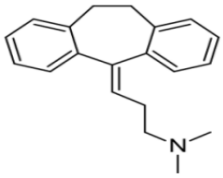
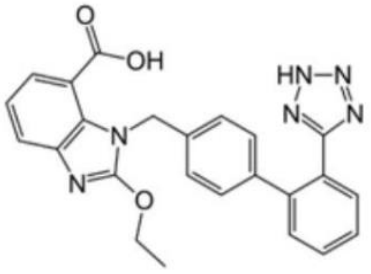
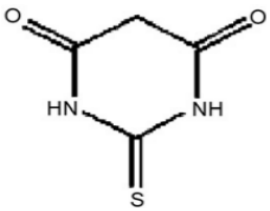
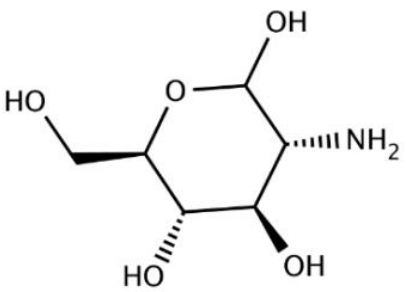
 **Omeprazole**	C38 Steel	1 M H_3PO_4	EIS (7x 10^{-4})	99	[60]
	C60 Steel	0.5 M H_2SO_4	EIS (300 mgL^{-1})	92.52	[61]
	Aluminum 6063	2M NaOH	WL (600 ppm)	87.7	[62]
 **Cloxacillin**	Carbon Steel	3.5% NaCl	EIS (750 mg L^{-1})	91.9	
 **Cephalexin**	Carbon Steel	Carbon Steel	EIS (750 mg L^{-1})	56.25	[63]
 **Cefadroxil**	Aluminum	0.5 HNO_3	PDP	44	[64]
 **Aminophylline**	Carbon Steel	HCl	EIS (0.6 mmol L^{-1})	87.3	[65]
 **Piperacillin sodium**	Mild Steel	HCl	WL (500ppm)	96.12	[66]

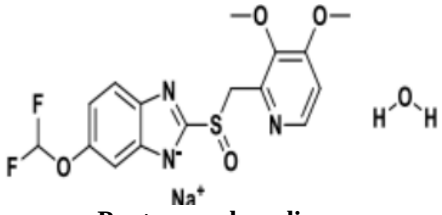
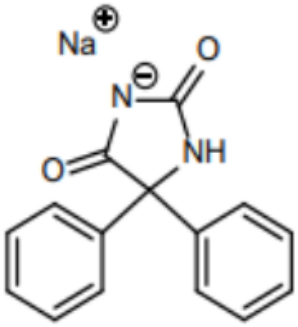
 **Clonazepam**	Mild Steel	3.5% NaCl	3.5% NaCl	92.1	[67]
2. Anti-inflammatory					
 **Ibuprofen**	Mild Steel	H_2SO_4	PDP	63.25	[68]
	Copper	0.5M H_2SO_4	EIS (5×10^{-3} M)	95.25	[69]
	Aluminum	0.5M H_2SO_4	PDP	80.58	[70]
	Stainless steel	0.5M H_2SO_4	PDP	60.59	[71]
 **Aspirin**	Mil Steel	0.5M H_2SO_4	WL (3×10^{-5} M)	71.80	[72]
	Copper	0.5M HCl	WL (3×10-5 M)	67	[73]
	Aluminum Pure	0.5 M H_2S	WL	96.98	[74]
	Carbon Steel XC48	1 M HCl	EIS (5×10^{-3} M)	96	[75]
 **Ketosulphone**	Mild Steel	1 M HCl	WL (200 ppm)	96.61	[76]
	Zinc	1 M HCl	PDP (20 ppm)	52.5	[77]
 **Indomethacin**	Carbon Steel	1M HCl	WL (500 ppm)	83	[78]
	Copper	Low pH		50	[79]
 **Tenoxicam**	Carbon Steel	0.5 M HCl	PDP (4×10^{-4} M)	90.3	[80]
	Copper	1 M HNO_3	Quantum	B3LYP	[81]
3. Antihistamine					

 **Desloratadine**	Carbon Steel	1M HCl	WL (19.3×10^{-5} M)	92.7	[82]
 **Meclizine Hydrochloride**	Aluminum	1M HCl	EIS (200 ppm)	95.39	[83]
 **Modazar**	Carbon Steel	1 M HCl	PDP (300 ppm)	86.9	[84]
 **Atarax**	Carbon Steel	0.5 M H_2SO_4	WL (400 ppm)	95	[85]
4. Antifungal					
 **Fluconazole**	Mild Steel	HCl	EIS (0.30 mM)	96	[86]
	5L X52 Steel	HCl	EIS (30 ppm)	96.6	[87]
	Aluminum	1M HCl	WL (1×10^{-4}M at 30$^{o)}$	82.4	[88]
	TM	HCl	EIS (100 ppm)	84.19	[89]
 **Itraconazole**	Mild Steel	HCl	WL (1.0l M at 303 K)	80.0	[90]
5. Antibacterial					
	Mild Steel	1M HCl	EIS (100 ppm)	98	[91]
	Aluminum 6061 alloy (Exp)	0.1 M HCl	EIS (150 ppm)	99.99	[92]
		3.5% NaCl	EIS (150 ppm)	83.32	

 **Diclofenac sodium**	Iron	1N H_2SO_4	WL (180 ppm at 303.15K)	42	[93]
6. Anti diabetic					
 **Metformin**	Mild Steel	1M HCl	EIS (400 ppm)	96	[94]
	C 1080 Steel (Exp)	CH_3COOH	EIS (200 ppm)	89.47	[95]
	Steel	HCl	WL (400 pm)	80.01	[96]
7. Analgesics					
 **Tramadol**	Steel	1 N H_2SO_4	WL (500 ppm)	93.2	[97]
	Aluminum	1.0 M HCl	EIS (500 ppm)	98.4	[98]
8. Antiemetic					
 **Ranitidine**	Mild Steel	1M HCl	EIS (400 pm)	97.55	[99]
	Aluminum	1M HCl	WL (333K)	88.7	[100]
9. Antihypertensive					
 **Concor**	Concor	2M HCl	EIS (300 ppm)	85.8	[101]
 **Nifedipine**	Mild Steel	1 M HCl	EIS	95.61	[102]
10. Anti-Helminthic					

 **Albendazole**	Mild Steel	1 M HCl	EIS (65 ppm)	86.66	[103]
 **Lidocaine**	QSARARX	QSARARX	EIS (100 ppm)	95.2	[104]
11. Carbonic Anhydrase					
 **Acetazolamide**	Mild Steel	HCl	EIS (500 ppm)	96.27	[105]
	Carbon Steel	1M HCl	WL (300 ppm)	86.1	[106]
12. Beta Blocker					
 **Glucosamine**	Carbon Steel	0.75 $mmolL^{-1}$	PDP (GS + 0.75 mmol L^{-1} KI)	91.2	[107]
 **Atenolol**	Mild Steel	1 M HCl	1 M HCl	93.29	[108]
13. Antiviral					
 **Oseltamivir**	Aluminum	3M HCl	WL (2 mg L^{-1})	99.10	[109]
14. Laxative					
 **Dulcolax (DULC)**	Carbon Steel	1 HCl	WL (500 ppm)	91.80	[110]

15. Skeletal Muscle relaxant					
 **Baclofen**	Steel	1 N HCl	Gasometric (100 ppm)	98	[111]
16. Antihyperlipidemic					
 **Atorvastatin**	Mild Steel	1M HCl	PDP (150 ppm)	99.08	[112]
17. Depressant					
 **Benzimidazole**	Mild Steel	1 M HCl	EIS (250 ppm)	90.4	[113]
 **Amitriptyline**	Mild Steel	3M HCl	PDP (2 mg L^{-1})	87.57	[114]
18. Antagonist					
 **Candesartan**	Carbon Steel	HCl	1M HCl	91.20	[115]
	Aluminum	1M HCl	EIS (20 ppm)	92.9	[116]
19. Sedative Hypertonic					
 **Barbiturates**	Mild Steel	HCl	PDP	97.7	[117]
	API 5L X60 steel	NaCl	PDP (75 ppm)	98.9	[118]
20. Amino Sugar					
 **Glucosamine**	Carbon Steel	H_2SO_4	PDP (200ppm)	82.2	[119]

21. Gastroesophageal					
 **Pantoprazole sodium**	Carbon Steel	1M HCl	ML (300 ppm)	93.3	[120]
22. Antiarrhythmic					
 **Phenytoin sodium drug**	Carbon Steel	1M HCl	PDP (500 ppm)	81.78	[121]

WL= Weight Loss ML= Mass Loss

2. Result and Discussion

2.1. Comparative Anti-Corrosive Efficiency of Various Category Drugs

After studying the table 1, we plotted a graph as shown in figure 4 which shows that antibiotic and non-steroidal anti-inflammatory drugs (NSAIDs) are mostly used as corrosion inhibition purpose. Therefore, we focused primarily on antibiotics and antibiotic, and secondarily on other drugs categories in this research work.

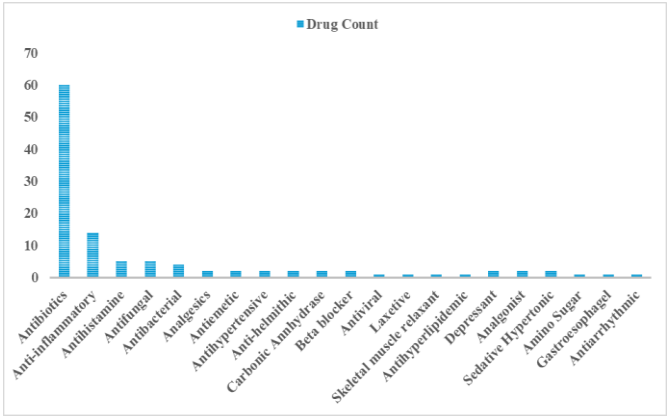


Figure 4 Anticorrosive Effect Given by Different Drug Categories

2.2. Study for Antibiotic Drugs' Anticorrosive Efficiency Against Metals

For this study we analyzed the percentage (%) inhibitory efficiency of antibiotic drugs on number of metals as given in table-2.

Table 2 Anticorrosive Action of Antibiotic Drugs on Metals

Metals	Antibiotic drugs	% inhibitory efficiency	Avg. of % inhibitory efficiency
Mild steel	Cefuroxime	94.57	95.00
	Cefpodoxime	96.52	
	Cefadroxil	96	
	Amoxicillin	94.47	
	Cefixime	96.93	
	Cefixime	93.90	
	Ceftazidime	90.2	
	Ceftriaxone	90.95	
	Ciprofloxacin	97.72	
	Cefdinir	97.9	
	Omeprazole	99	
	Omeprazole	92.52	
	Piperacillin sodium	96.12	
	Clonazepam	92.1	
Carbon steel	Amoxicillin	91.2	89.97
	Cefixime	90.4	
	Ceftazidime	97.34	
	Ceftriaxone	93.37	
	Augmentin	98	
	Podocip	97.3	
	Moxifloxacin	94.1	
	Tobramycin	92.6	
	Cloxacillin	91.9	
	Cephalexin	56.25	
	Aminophylline	87.3	

Aluminum	Cefuroxime	89.87	79.63
	Cefpodoxime	89.10	
	Cefadroxil	58.9	
	Cefadroxil	90.3	
	Amoxicillin	73	
	Cefixime	90.41	
	Ceftazidime	78.4	
	Ceftriaxone	88.09	
	Moxifloxacin	86.17	
	Omeprazole	87.7	
	Cefadroxil	44	
Copper	Cefuroxime	57.50	85.39
	Cefadroxil	94	
	Cefixime	91.07	
	Ceftazidime	94.2	
	Ciprofloxacin	90.1	
	Ciprofloxacin	69.7	
	Augmentin	93	
	Augmentin	93.6	
Iron	Cefuroxime	96.58	94.00
	Amoxicillin	94.7	
	Acyclovir (Exp)	94.47	
	Omeprazole	95.26	
Zn & Ni	Cefuroxime	82.88	82.23
	Ceftazidime	91	

2.3. Graphical Representation of Antibiotic Drugs' Efficiency Against Metals

Figure 5 indicates that anticorrosive action of antibiotic drug is highest on mild steel and iron whereas it is lowest on aluminum.

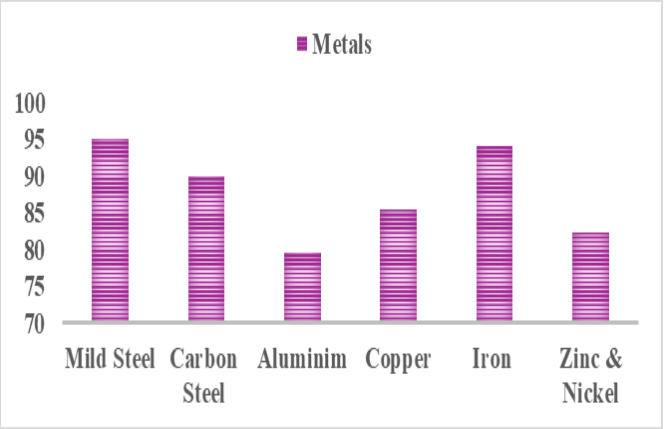


Figure 5 Average Inhibition Efficiency of Antibiotic Drugs

2.4. Study for Anti-Inflammatory Drugs' Anticorrosive Efficiency Against Metals

For this study we analyzed the percentage (%) inhibitory efficiency of anti-inflammatory drugs on number of metals as given in table-3.

Table 3 Anticorrosive Action of Anti-Inflammatory Drugs on Metals

Metals	Anti-inflammatory drugs	% inhibitory efficiency	Avg. of % inhibitory efficiency
Mild steel	Ibuprofen	60.59	73.06
	Aspirin	71.80	
	Keto sulphone	96.61	
Carbon steel	Aspirin	96	89.76
	Indomethacin	83	
	Tenoxicam	90.3	
Aluminum	Ibuprofen	80.58	88.78
	Aspirin	96.98	
Copper	Ibuprofen	95.25	70.75
	Aspirin	67	
	Indomethacin	50	
Iron	Keto sulphone	52.5	52.50

2.5. Graphical Representation of Anti-Inflammatory Drugs' Efficiency Against Metals

Figure 6 indicates that anticorrosive action of anti-inflammatory drug is highest on carbon steel and aluminum whereas it is lowest on iron.

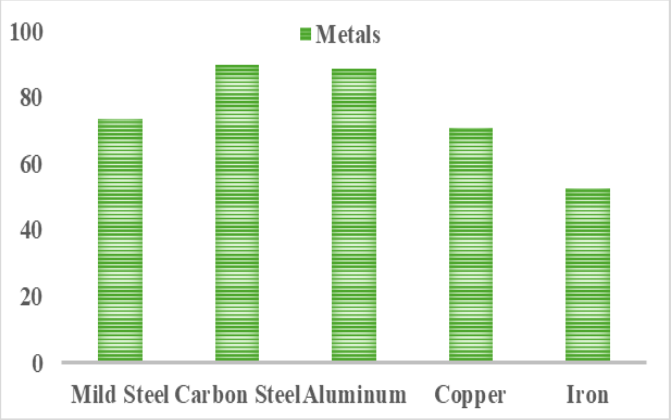


Figure 6 Average Inhibition Efficiency of Anti-Inflammatory Drugs

2.6. Study for Other Categories Drugs for Anticorrosive Efficiency Against Metals

For this study we analyzed the percentage (%) inhibitory efficiency of miscellaneous category drugs on number of metals as given in table-4.

Table 4 Anticorrosive Action of Other Category Drugs on Metals

Metals	Miscellaneous category drugs	% inhibitory efficiency	Avg. of % inhibitory efficiency
Mild steel	Fluconazole	96	85.57
	Itraconazole	80.0	
	Diclofenac sodium	98	
	Metformin	96	
	Metformin	80.01	
	Tramadol	93.2	
	Ranitidine	97.55	
	Nifedipine	95.61	
	Albendazole	86.66	
	Acetazolamide	96.27	
	Atenolol	93.29	
	Baclofen	98	
	Atorvastatin	99.08	
	Benzimidazole	90.4	
	Amitriptyline	87.57	
	Barbiturates	97.7	
Carbon steel	Acetazolamide	86.1	88.38
	Glucosamine	91.2	
	Dulcolax (DULC)	91.80	
	Candesartan	91.20	
	Glucosamine	82.2	
	Pantoprazole sodium	93.3	
	Phenytoin sodium	81.78	
Aluminum	Fluconazole	82.4	93.58
	Diclofenac sodium	99.99	
	Tramadol	98.4	
	Ranitidine	88.7	
	Oseltamivir	99.10	
	Candesartan	92.9	
Iron	Diclofenac sodium	42	42.00

2.7. Graphical Representation of Other Categories Drugs for Inhibitory Efficiency Against Metals

Figure 7 indicates that anticorrosive action of miscellaneous category drugs is highest on aluminum followed by carbon steel, mild steel and then iron.

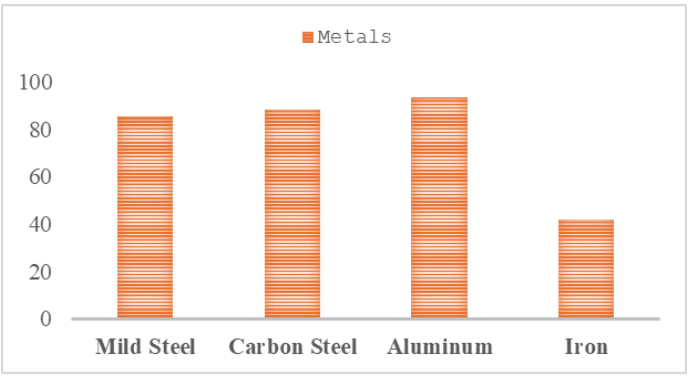


Figure 7 Average Inhibition Efficiency of Other Drugs Categories

Conclusion

Our work reveals that drugs in have potent anticorrosive efficiency on metals like mild steel, carbon steel, copper, aluminum, zinc, iron, etc. which have so many industrial as well as local applications. These metals can be protected by using corrosion inhibitors such as organic, inorganic, plant based, etc. Our work explored the anticorrosive potential of drugs, furthermore the discussion through various graphs revealed that antibiotic drugs emerged as leader followed by anti-inflammatory in all categories of drugs with good corrosion inhibition efficiency. If we study average corrosion inhibition efficiency rate especially in antibiotic drugs, it demonstrated that antibiotics have the greatest effects on mild steel and iron, and the least effects on

aluminum. Similar study for average corrosion inhibition efficiency rate in case of anti-inflammatory drugs, it showed the highest effect on carbon steel and aluminum content, followed by mild steel, copper, and iron. Other categories drugs showed that the metal with the highest corrosion inhibition efficiency rate is aluminum, followed by carbon steel, mild steel, iron, and finally steel. This work paves the way that for anticorrosive profiling for expired drugs. This futuristic study can give a tool to pharmaceutical industries for addressing the solid waste management generated by drugs all over the world, and to paint industries for preparing affordable emulsion with the help of expired medicines.

Declaration of Competing Interest: The authors declare that there is no conflict of interest.

Acknowledgements and Funding

The authors are very thankful for School of Chemical Engineering and Physical Sciences, Lovely Professional University for providing the necessary resources for this work.

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