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Article review

Drugs as corrosion inhibitors for the environment

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Abstract.

Recently, corrosion-inhibiting compounds have been discovered in a number of medications. In the past, corrosion inhibitors were used by researchers. Corrosion is a significant issue since it is difficult to eradicate completely. When metals interact with their surroundings, their chemical composition and physical properties change. Non-toxic antioxidants, such as organic and inorganic inhibitors, have been prohibited from use in corrosion prevention due to environmental concerns. Drugs can be utilized as corrosion inhibitors due to their minimal toxicity and impact on the environment. Corrosion inhibitors have been evaluated with a wide range of materials, including mild steel, carbon steel, and aluminum (melatonin, cephapirin and tramadol among them). By developing on the surface of mild steel, an insoluble compound has been discovered to inhibit corrosion. Because mass and charge transfer are blocked by the adsorption of modified dapsone medicine on mild steel, corrosion is inhibited. The corrosion inhibition was investigated using EFM, linear polarization resistance, and electrochemical impedance spectroscopy. XRD, SEM, and AFM techniques were utilized to evaluate the Metal surface morphology before to and following drug addition. Researchers discovered that expired Dapsone can be used to make a new corrosion inhibitor. According to an EIS investigation, during the inhibition phase, a charge transfer mechanism is at action. As the inhibitor concentration grew, so did the corrosion rate. Researchers used weight loss and electrochemical technologies to study the effect of cephapirin medications on carbon steel corrosion (CS). Density functional theory simulations revealed that cephapirin is an excellent carbon steel corrosion inhibitor (DFT).

Keywords. *Corrosion, Drugs, Inhibition efficiency, Corrosion inhibitors.*

Introduction

In recent years, there has been a rise in the use of pharmaceuticals as corrosion inhibitors.Environmentally friendly medications, according to Eddy and Odoemelam, have advantages over organic/inorganic inhibitors [1] [2]. Drugs, because to their low environmental impact, should be used instead of dangerous corrosion inhibitors. Most drugs, it is widely assumed, can be generated from natural sources and compete favorably with green corrosion inhibitors. This is due, in part, to the fact that: one can choose from a variety of pharmaceuticals to employ as corrosion inhibitors, and medications are regarded helpful to the environment and vital in biological interactions. [3] [4] [5] [6][7]. Antibacterial medications have lately been applied in the research of corrosion inhibitors for carbon steel and aluminum [8] [9][10]. Metals

deteriorate due to chemical processes, which create corrosion. It is, in reality, a significant problem that cannot be completely eliminated. As a result, rather than aiming for total elimination, it will be more realistic to use prevention methods [11]. Corrosion prevention can aid in the avoidance of a number of potential calamities that can result in major challenges such as loss of life, poor social effects, water supplies, and environmental contamination [12].Corrosion is becoming more widespread in the chemical and petrochemical industries, resulting in massive waste production and economic losses. Several steps are being implemented to decrease the negative impact of rusting. The use of corrosion inhibitors is the most important of these. To keep metals and alloys from corroding, a variety of effective organic inhibitors are used. N, O, S heteroatoms or electron-containing characteristics are found in the molecules of these organic compounds. These organic compounds limit metal ionization by producing a protective barrier on the metal's surface that prevents chemical species involved in metal ionization from migrating [13][14]. However, the majority of these organic inhibitors are costly, poisonous, and harmful to the environment. As a result, researchers from all around the world are investigating the use of drugs as corrosion inhibitors. Several research investigations have demonstrated that utilizing pharmaceuticals as rust inhibitors is safe, affordable, and has a low environmental impact, which has expanded the use of drugs as corrosion inhibitors, hence replacing traditional harmful corrosion inhibitors [11].In the petroleum sector, expired medications have not yet been used as corrosion inhibitors. Efforts are still being undertaken to identify corrosion inhibitors derived from expired medications that can be compared to conventional inhibitors with an inhibitory efficiency of greater than 99 percent. Expired drugs are inappropriate for consumption due to physical, chemical, or microbiological deterioration of active components and excipients [15]. Traditional and expired medications, according to our findings, have a similar structure to generic organic inhibitors, which are provided with functional groups and electrons to support their corrosion-inhibiting properties.A variety of approaches and mediums have been used to study drugs that work as corrosion inhibitors in metals and alloys[16]. [17][18]. Because green corrosion inhibitors, particularly drug-inhibitors, have not yet been widely accepted in the industrial arena, they must be kept up to date on their current state and future prospects. A review of earlier corrosion-inhibition research investigations is also included in this section. In recent years, there has been a lot of research into metal corrosion inhibitors. According to study [17], a variety of drugs, including Tramadol and Cephalophen, can protect metals and alloys against corrosion.

In the laboratory, there is evidence of medication inhibitors.

To test the inhibitory properties of A315 mild steel in 0.1 M hydrochloric acid and chloramphenicol medication solution, weight loss, linear polarization, and open circuit potential were all used [19]. (inhibitor). Extensive study has been conducted on the effects of pharmacological inhibitors on certain metals. In this study, it was discovered corrosion was decreased by increasing the concentration of the inhibitor medication molecule.According to experiments, Langmuir adsorption is the most accurate model. M. Abdallah and colleagues [20] used anodic and anodic polarization, galvanic impedance, and electrostatic impedance tests to show that corrosion can be inhibited. The results of polarization reveal that the inhibitory activity of TR medication rises with increasing concentration and temperature. Melatonin is the greatest treatment for corrosion of carbon steel, according to another study by the same author[21]. According to electrochemical impedance and results from

electrodynamic, potentiodynamic, and galvanostatic theories, as well as density functional theory, as melatonin concentrations increase, so do charge transfer resistance and inhibitory efficiency (DFT). In order to avoid mild steel corrosion, a sulfuric acid solution was utilized to modify the efficacy of expired Dapsone. Dapsone's potency was increased by 95 percent by using Schiff bases. The synergistic actions of KI offer additional inhibition. In a synergistic process, more than one is required for cooperation. For the time being, scientists are putting corrosion inhibitors manufactured from expired pharmaceuticals to the test. Recycled medications have a lower environmental impact as well as a lower financial and human cost than conventional drugs. Even though all four antibacterial medications are ineffectual in comparison to other treatments, expired antibiotics can be employed as corrosion inhibitors. Furthermore, the capacity of Cephapirin to suppress carbon steel corrosion was studied [22]. Charge transfer could explain the corrosion inhibition seen by EIS. The ability of corrosion inhibition to be improved as a function of inhibitor concentration and temperature was investigated using an electrochemical approach. Adsorption of drug molecules on metal surfaces is hypothesized to occur through physical and chemical mechanisms. These studies show that as the inhibitor molecule concentration increases, the corrosion rate reduces. In a wide variety of alkaline and acidic environments and concentrations, medications can effectively protect mild steel, carbon steel, copper, and aluminum steel from corrosion. As a result, unwanted or expired pharmaceuticals can be less hazardous to the environment, improving waste management and lowering expenses. In this approach, corrosion inhibitors can be utilized [17].

Expired corrosion-inhibiting medicines

These drugs can be used to treat a variety of ailments, including allergies and gastrointestinal issues. These disorders can also be treated with anti-inflammatory, antiviral, hypogonadism, antidepressant, and analgesic medications.Antibiotics and other medications with different clinical applications, for example, are examples of this group. The corrosion-inhibiting effects of expired drugs have been revealed for the first time. Each of the medications in Table 1 is classified into functional groups depending on how they are used clinically [23].

Table 1 Drug types, clinical applications, and molecular structure functional groups

Drug name	Clinical uses	Functional groups for corrosion inhibitor performance
Ranitidine (**1**)	Gastroesophageal problems	Heteroatoms, amine, heterocycle, nitro, sulfide
Carbamazepine (**2**)	Anticonvulsant/antiepileptic	Heteroatoms, aromatic ring, amine, amide, heterocycle
Paracetamol (**3**)	Analgesic, antipyretic	Heteroatoms, aromatic ring, amide, hydroxyl
1-Phenytoin sodium (**4**)	Anticonvulsant/antiepileptic	Heteroatoms, aromatic ring, amide, heterocycle
Declophen (**5**)	Analgesic	Heteroatoms, aromatic ring, amine, carboxylic acid
Lupicof: dextromethorphan (**6**), chlorphenamine (**7**)	Antihistamine	Heteroatoms, aromatic ring, amine, heterocycle, methoxy
Voltaren (**8**)	Analgesic	Heteroatoms, aromatic ring, amine, carboxylic acid
Farcolin: salbutamol (**9**) and ammonium chloride	Chronic bronchospasm, asthma	Heteroatoms, aromatic ring, amine, hydroxyl
Ambroxol (**10**)	Mucolytic	Heteroatoms, aromatic ring, amine, hydroxyl
Asthalin: salbutamol (**9**)	Chronic bronchospasm, asthma	Heteroatoms, aromatic ring, amine, hydroxyl
Amlodipine besylate (**11**)	Antihypertension	Heteroatoms, aromatic ring, amine, heterocycle, ester
Atorvastatin (**12**)	Antihyperlipidemic	Heteroatoms, aromatic ring, amine, amide, heterocycle, hydroxyl, carboxylic acid
Atenolol (**13**)	Antihypertension	Heteroatoms, aromatic ring, amine, amide, heterocycle, ether, hydroxyl
Gentamicin (**14**)	Antibiotic	Heteroatoms, amine, heterocycle, hydroxyl
Nifedipine (**15**)	Antihypertension	Heteroatoms, aromatic ring, amine, heterocycle, ether, ester
Carvedilol (**16**)	Antihypertension	Heteroatoms, aromatic ring, amine, ether, heterocycle, hydroxyl
Tramadol (**17**)	Analgesic	Heteroatoms, aromatic ring, amine, ether, hydroxyl
Pantoprazole sodium (**18**)	Gastroesophageal problems	Heteroatoms, aromatic ring, amine, heterocycle, ether, sulfoxide

Concor: bisoprolol (19)	Antihypertension	Heteroatoms, aromatic ring, amine, ether, hydroxyl
Doxercalciferol (20)	Secondary hyperparathyroidism	Heteroatom, hydroxyl
Lorazepam (21)	Sedative agent, anticonvulsant, antianxiety, and hypnotic agent	Heteroatoms, aromatic ring, amide, heterocycle, hydroxyl
Bactrim: sulfamethoxazole (22), trimethoprim (23)	Antibiotic	Heteroatoms, aromatic ring, amine, heterocycle, ether, sulfonamide
Moxifloxacin (24)	Antibiotic	Heteroatoms, aromatic ring, hydroxyl, ketone
Betnesol (25)	Antiinflammatory	Heteroatoms, aromatic ring, amine, heterocycle, ketone, carboxylic acid, methoxy
Podocip: cefpodoxime proxetil (26)	Antibiotic	Heteroatoms, aromatic ring, amine, amide, heterocycle, ether, hydroxyl, ester, sulfide
Fluoxymesterone (27)	Hypogonadism, breast cancer	Heteroatoms, hydroxyl, ketone
Amoxicillin (28)	Antibiotic	Heteroatoms, aromatic ring, amine, amide, heterocycle, hydroxyl, carboxylic acid , sulfide
Cefdinir (29)	Antibiotic	Heteroatoms, amine, amides, heterocycle, carboxyl, oxime, sulfide

The process that prevents rusting

C, S, N, and a number of other heteroatoms in the drug molecule, for example, serve as adsorption centers. Metal ions were discovered to be unable to cling to the surface due to big molecules covering a considerable amount of the surface. The effectiveness of corrosion inhibition is affected by molecular size and heteroatom composition[17].

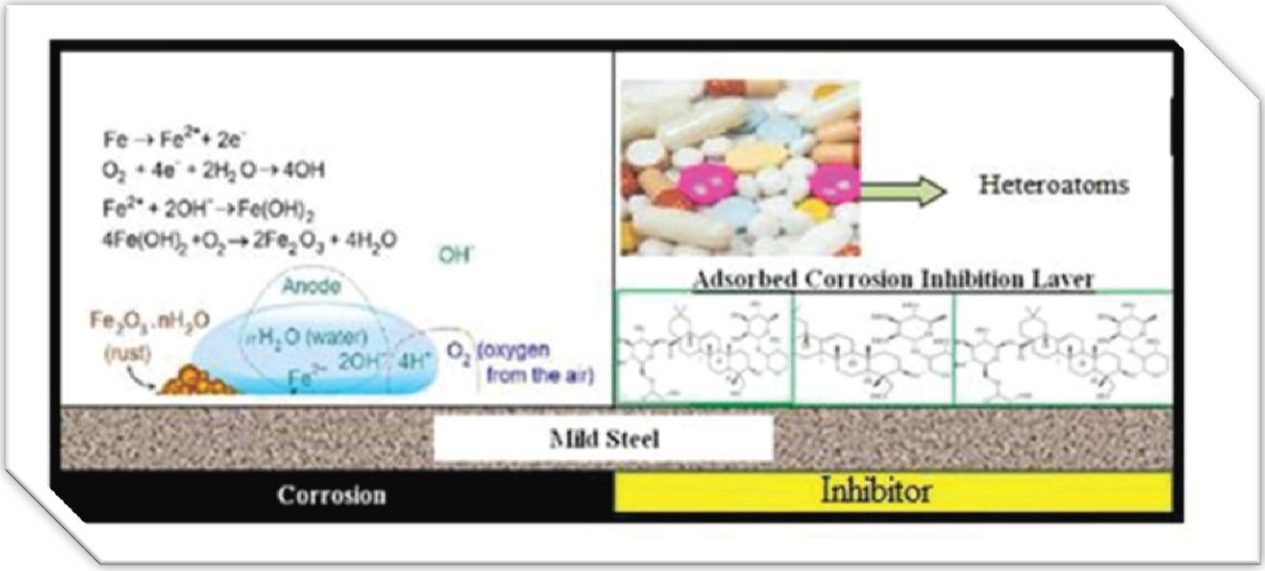

Figure1. An anti-corrosion system

Conclusions

As a result, waste management has improved, environmental repercussions have been mitigated, and economic losses have been minimized to a reasonable level. The molecular structure, affinity for metal surfaces, and chemical composition of antioxidant molecules all have an impact on their efficacy.corrosion inhibitors possessed N, O, S, and aromatic rings. The medicines' corrosion-inhibiting effects were assessed using weight loss, potentiodynamic polarization, and electrochemical

impedance spectroscopy. The effects of several medications on metal and alloy corrosion are investigated in this study. A protective layer forms as the concentration of the drug molecule increases, because more inhibitor molecules are adsorbable to metal surfaces. Drugs, rather than corrosion inhibitors, could be used, according to the findings.

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