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Review Paper

Green corrosion inhibitors for brass: an overview

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Abstract

Metals are protected from corrosion by using inhibitors. To replace the environmentally hazardous inorganic and organic chemicals, various plant extracts were tested as green inhibitors. In this paper, inhibition of corrosion of various types of brass, medium and green inhibitors have been reviewed. The green inhibitors are eco-friendly, cheap and easily available. Protective films on metal surface is formed by adsorption of polar atoms present in inhibitors onto the metal surface. Inhibition efficiency of inhibitors depends on their chemical structure and properties. Adsorptions of these ingredients on metal surface obey various adsorption isotherms. Corrosion of metals and its inhibition was analyzed by weight loss method with different time and temperatures. Corrosion study was carried out by Open Circuit Potential (OCP), Galvanostatic polarization and Electrochemical Impedance Spectra (EIS) methods. The protective films have been analyzed by various techniques such as X-ray Diffraction spectroscopy (XRD), Energy Dispersive X-ray Spectroscopy (EDX), Scanning Electron Microscope (SEM), UV-Visible spectra, AFM and Fourier Transform Infrared (FTIR) spectroscopy. The present review paper is an overview of works published on protection of brass metal from corrosion by using green inhibitors.

Keywords: Corrosion, brass, green inhibitors, polarization, EIS, SEM, FTIR.

Introduction

Corrosion of metal/alloy, which can be defined as the deterioration of materials due to their reaction with the environment. Brass is an alloy of copper and zinc. Recently, brass and its alloys are widely used in the manufacture of integrated circuits. They are widely used as tubing material in condensers and as heat exchangers for water cooling systems. Hence the study of brass corrosion inhibition is of great importance.

Corrosion inhibitors are chemical compounds usually used in small concentrations which are added to aggressive medium to reduce corrosion. To prevent corrosion various organic and inorganic substances are used. But the toxicity of most corrosion inhibitors made us heading for the use of environment friendly inhibitors. The plant extracts are ecofriendly, biodegradable, readily available and potentially low cost, and can be used nowadays as 'Green Inhibitors'. Various parts of plants such as their seeds, leaves, flowers, fruits and barks etc., have been used as green corrosion inhibitors. Extracts of plant materials contain various organic compounds having hetero atoms such as P, N, S and O. These atoms adsorb on metal surface through their electrons. It has been observed that the adsorption depends mainly on functional groups, steric effect, aromaticity, electron density of the donor atoms and pi orbital character of donating electrons. It has been reported that many plant extracts were proved as effective inhibitor for the corrosion of brass in acid as well as in other medium[1-24].

Metals used: Various green inhibitors were used to control the corrosion of different gradesbrass such as Brass[1,3,5,6,10,13-15, 18,21,23-25], Brass (Cu-40Zn)[2,8], Brass (Cu-40Zn)[3], Duplex (α, β) brass[4,9], α-Brass[7,11,12,16,17,19,20], Cu-30Zn Alloy[14] and Brass (60/40)[22].

Medium: In this overview, plant extracts are used for controlling the corrosion of brass alloy in various medium has been studied. This research is mainly focused on acidic medium[1,3,4,7,8,11-19,21-25]. But few mediums like sodium chloride [20], sodium sulfate[9] and sea water medium[2,3,5,6,10], have been used for this purpose.

Plant materials as green inhibitors: Different parts of the plant such asleaves[3-5,10,14,16-18,21-24], fruits[1], seeds[2,6,23], peel[18], plant extract[7,9,12,13,25], seed oil[8,11] and algae[15] were used as corrosion inhibitors.

Extracts used: Various solvents like alcohol[1-4,6,12-20,24,25], acid [21], water[22,23], were used to prepare extract of plant materials.

Additives to study synergistic effect: In few cases, additives such as KSCN [7] and S^{-2}[20] were used in combination with green inhibitor to study their synergistic effect.

Methods: Various methods such as weight loss method[1-9,11-18, 20-24], Potentiometric polarization[7,9-13,15,16,17,19-23,25], Electro chemical Impedance Spectroscopy (EIS)[9-13,15,20-23], Open Circuit Potential[4,20], Synergistic effect[7,20] and Kinetic parameters: Rare

constant and Half- life period[15,22] were used to study the corrosion mechanism and for calculation of percentage of inhibition efficiency of different inhibitors.

Temperature effect: Room temperature[1-9,11-18,20-24] and higher temperatures[1-3,5,6,8,11,17,18,20-24] were used to study percentage of inhibition efficiency.

Adsorption isotherms: The adsorption characteristic of the phytoconstituents present in the green inhibitors onto the brass surface has been studied. For this, various types of adsorption isotherms, such as Langmuir adsorption isotherm[1,2,3,5,6,8,9,12-14,18-24], Freundlich adsorption isotherm[1,3,7,8], Temkin adsorption isotherm[2,5,11,14,15] and Frumkin adsorption isotherm[1,3] were suggested.

Metal surface analysis: When plant extracts were added in corrosive solutions to prevent the corrosion of metal a protective films formed on metal surface which is confirmed by different examination techniques, such as SEM[9,12-15,18,19,21-25], AFM[20], FTIR[8,14,15,18-20,24], UV spectra[1-3,5,6,8,14,18,20,24], Energy Dispersive X-ray (EDX) technique[13,14,24,25], X-Ray Diffraction (XRD)[1,8,10,14,19], IR spectroscopy[1-3,5,6,19], AFM[20], EFM[11,12,25], GC[25], GC-MS[19,25].

List of various green inhibitors for prevention of corrosion of brass is shown in Table-1.

Table-1: Green corrosion inhibitors for Brass in different media.

Metal	Medium	Inhibitor	Additive	Methods	Findings	Ref.
Brass	1N HCl	*Punica granatum* fruit	-	Weight loss measurments with time and temperature. UV, IR, XRD studies.	It is mixed type inhibitor. Langmuir and Fremkin adsorption isotherms. Maximum 94.52 % inhibition efficiency found.	1
Brass (Cu-27Zn)	Sea water	*Vitis vinifera* (grape) seed and skin.	-	Weight loss with time, temperature and various concentration of inhibitor, UV, IR.	Langmuir and Temkin adsorption isotherm	2
Brass (Cu-40Zn)	1 N HCl and Sea water	*Jatropha curcas* Leaves	-	Weight loss with time, temperature and various concentration of inhibitor, UV, IR.	Langmuir, Frundlich and Frumkin adsorption isotherms, Maximum of 92.29 % inhibition efficiency found.	3
Duplex (α, β) brass	1M HNO_3	*Carica Papaya* and *Camellia Sinensis* (tea) Leaves	-	Weight loss with time, potential measurement,	synergism.	4
Brass	Natural Sea Water	*Azadirachta indica* Leaves	-	Weight loss measurement at various temperature and immersion time. UV and IR studies	Langmuir and Temkin isotherms , maximum of 83% inhibition efficiency found.	5
Brass	Natural Sea Water	*Emblica officinalis* seed (Amla)	-	Weight loss with time and temperature, UV & IR studies.	Langmuir adsorption isotherm, maximum of 74.99 % inhibition efficiency found.	6
α-Brass	HNO_3	*Curcumin* Derivatives	KSCN	Weight-loss, galvanostatic polarization	It is mixed type inhibitor, Frumkins adsorption isotherm	7
Brass (Cu-40Zn)	1N HCl	*Calophyllum inophyllum* seed oil (Tamanu oil extract)	-	Weight loss measurements with temperature,UV, FTIR and XRD studies.	Langmuir and Frumkin adsorption isotherms Maximum of 72.97% inhibition efficiency found.	8
Brass (Cu65/Zn35)	0.1 M Na_2SO_4	*Camellia sinensis*	-	Weight loss with time, potentio dynamic polarization,	Langmuir adsorption isotherm, maximum inhibition efficiency was achieved 91.67%.	9

				EIS, SEM methods		
Brass	Sea water	*Jatropha Curcas* leaves Extract	-	Potentiodynamic polarization, Electro impedance spectroscopy and XRD spectral techniques.	Maximum of 90.93% of inhibition efficiency	10
α-brass	1 M HNO_3	Lemon essential oil	-	Weight loss with Higher temperature effect, Galvanostatic polarization, EIS and EFM measurements.	It is mixedtype inhibitor,Temkin's adsorption isotherm.	11
α-brass	1 M HNO_3	*Thymus vulgarise* plant extract	-	Weight loss with time, potentio dynamic polarization, SEM, EIS, EFM techniques.	It is mixed type but mainly cathodic inhibitor. Langmuir adsorption isotherm.	12
Copper and Brass	1 M HNO_3	*Ceratonia Siliqua* plant Extract	-	Weight loss, Potentiodynamic polarization, EIS, SEM and EDX techniques.	It is mixed type inhibitor but predominantto cathodic, Langmuir adsorption isotherm.	13
Cu-30Zn Alloy	1 M HCl	*Cnidoscolus Chayamansa* Leaves	-	Weight loss with time and temperature, UV, FTIR, XRD and SEM-EDX.	Langmuir, Temkin adsorption isotherm.	14
Brass	0.1 N H_3PO_4	*Sargassum wightii* (Algae)	-	Weight-loss method, potentiodynamic polarization,EIS,rate constant and half-life period,FTIR and SEM technique.	It is mixed type inhibitor. Temkin adsorption isotherm.	15
α-Brass	HCl	*Allium Sativum* (garlic)	-	Weight losswith various time, potentiodynamic polarization measurement	It is mixed type inhibitor.	16
α-Brass	0.5M HNO_3	*Allium Sativum* (garlic)	-	Weight losswith various time, potentiodynamic polarization measurement	It is mixed type inhibitor	17
Brass	1.0 N HCl	*Wrightia tinctoria* leaves	-	Weight loss with time and temperature. UV, FTIR, SEM image.	Langmuir adsorption isotherm. Maximum 87.06 % inhibition efficiency is attained.	18
a-Brass	H_2SO_4	*Pomegranate* Peel Extract	-	Gas Chromatography Mass Spectroscopy (GC-MS) and potentiodynamic polarization. X-ray Diffraction (XRD) analysis, SEM, FTIR.	It is mixedtype inhibitor. Langmuir adsorption isotherm Maximum 91.86% inhibition efficiency is attained.	19
α-brass	3.5% NaCl	*Myrrh* extract	16 ppm sulfide	Weight loss with temperature, OCP,potentiodynamic	It is mixed-type inhibitor, Langmuir adsorption isotherm, synergistic effect, Maximum 67%	20

				polarization, Electochemical Impendance spectroscopy (EIS), EFM, AFM, UV spectroscopy and FTIR.	inhibition efficiency is attained.	
Brass	HNO_3	*Azadirachta indica leaves*	-	Weight-loss, Higher temperature, galvanostatic polarization, Electochemical Impendance spectroscopy and SEM study.	It is mixedtype inhibitor, Langmuir adsorption isotherm, Arrhenius plot. Maximum 97.26 % inhibition efficiency is attained.	21
Brass (60/40)	HNO_3	*Bacopa monnieri* Leaves	-	Weight-loss, Higher temperature, Rate constant and Half-life, galvanostatic polarization, EIS, SEM study.	It is mixedtype inhibitor, Langmuir adsorption isotherm, Arrhenius plot. Maximum 97.87 % inhibition efficiency is attained.	22
Brass	HNO_3	*Cuminum cyminum* seed	-	Weight-loss, Higher temperature, galvanostatic polarization, EIS, SEM studies.	It is mixedtype inhibitor, Langmuir adsorption isotherm, Arrhenius plot.	23
Brass	1.0 N HCl	*Cardiospermum Halicababum* Leaves	-	Weight loss with time and temperature. UV, FT-IR, EDX and SEM image.	Langmuir adsorption isotherm.	24
copper and α-brass (60-40,Cu--Zn)	1 M HNO_3	*Pistacia atlantica* plant	-	Galvanostatic polarization, EIS studies. EDX. GC & GC-MS, EFM, SEMstudies.	It is mixed type inhibitor but predominant to cathodic.	25

Conclusion

In the recent years there has been great deal of work concerning the applicability of various natural products as corrosion inhibitors. The major reason for exploring them has been the fact that these inhibitors are bio-degradable and eco-friendly. They do not pose threat to the environment as compared to synthetic compounds. The literature gathered above states that extracts of various natural substances have demonstrated efficient corrosion inhibition on metal surfaces.

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