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Review Paper

Corrosion inhibition by seeds extract on mild steel – An overview

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Abstract

Corrosion inhibition process helps in reducing the safety and economic input of corrosion damage environmentally and ecologically. The use of inhibitors is one of the most practical options to preserve metal from corrosion and they are required to be acceptable and eco-friendly. Some of the researchers are tried to make use of green/natural seed extract products as corrosion inhibitors. In this review paper, corrosion inhibition of different kind of medium and green inhibitors (seeds extract) have been reported. Among the studied many green seed extract are showed better inhibition performance 98.68 % in Mustard seed in H_2SO_4. As a part of our ongoing reported work regarding an utilization of seed extracts as corrosion inhibitor for mild steel and its alloys inhibition was analyzed by weight loss, thermodynamic and kinetic parameters as well as hydrogen evolution methods. Electrochemical methods such as, Potentiodynamic polarization, Linear polarization resistance and Electrochemical Impedance Spectra (EIS) were also used. The protective film formation on mild steel surface have been analyzed by different techniques such as Scanning Electron Microscope (SEM), AFM, FT-IR, UV-Visible spectra, X-ray Diffraction spectroscopy (XRD). This review paper provides new information on the possible application some of seed extract as eco-friendly inhibitor.

Keywords: Mild steel, Seed extract, Medium, Corrosion inhibition, Adsorption, SEM.

Introduction

Corrosion is determine as the reasonable process that causes the modification of pure metals to undesirable substances when they react with substances such water or air. This reaction causes damage and decentralization of the metal starting from the portion of the metal exposed to the environment and spreading to the entire bulk of the metal. As per IUPAC, Corrosion is an irreversible interfacial reaction of a material such as metal, ceramic, polymer with its environment which results in its consumption or dissolution into the material of a component of the environment. Oftenally, but not necessary, corrosion results in effects detrimental to the usage of the material considered. Exclusively physical or mechanical processes such as melting and evaporation, abrasion or mechanical fracture are not included in the term corrosion Mild steel, also known as plain-carbon steel, is now the most common form of steel because its price is comparatively low, while it provides constructional material properties that are tolerable for many industrial applications included chemical processing, construction, petroleum production and refining, metal processing, marine application and other industries. Solution of acid, it is widely used in the industry with the main area of applications being cleaning and elimination of localized deposition such as bacterial, rusting, deposits etc., the aggressiveness of these acid solutions leads to the use of essential corrosion inhibitors in order to limit the attack of metallic materials.

Corrosion inhibitors are chemicals which when add on to the corrosion nature has the ability to cut down the corrosion rate. Synthetic organic and inorganic inhibitors had extensively applied in the industries due to their excellent corrosive properties but their use is now being marred by their toxicity and high cost of building. However, most of them cause damages to environment. At present environmentally concern related to the use of various organic compounds has received universal attentiveness. Green technology is a new extent that is come out rapidly at both the national and international level. In this think of ‘green chemistry’ provides many environmentally-friendly corrosion inhibitors, called ‘green inhibitors’. This has give rise to researchers to survey other areas to construct eco-friendly, cheap, and biodegradable green corrosion inhibitors to replace inorganic and synthetic organic inhibitors. Plant extracts are viewed as rich source of naturally synthesized chemical compounds that can be extracted by simple procedures with low cost. These natural extracts are corresponding to the synthetic organic inhibitors and are being proven to work as much as their synthetic counterparts. This review gives an overview of recent work on the inhibitive effect of different seed extracts on mild steel in acidic medium so as to provide industrialists with vital relative literature for possible large scale use of natural inhibitors in their operations. This will be contribute to sustainable and green manufacturing. The effects of temperature, concentration, and reaction medium on the inhibition efficiency were compared.

Seeds extract were used to control the corrosion of mild steel and its alloy. In this overview, various seeds extracts in controlling corrosion on mild steel in acidic environments has been investigated. This review is mainly focused on acidic medium.

Various methods such as weight loss, hydrogen evaluation, potentiodynamic polarization (PDP) and Electrochemical Impedance Spectroscopy (EIS) were used to study the percentage of inhibition efficiency of different seeds extract on mild steel of corrosion inhibition. The adsorption isotherm model of the active-chemicals present in the different seeds extract onto the mild steel surface has been investigated. For this, different kind of adsorption isotherms, such as Langmuir, Temkin, Freundlich and Flory-Huggins observed.

Metal Used: Seed extracts as a green inhibitors were used to control the corrosion of different grades mild steel[1-3,5-17, 19-40] and its alloy[4,18].

Medium: Different seed extracts for corrosion control of mild steel and its alloy in acidic medium such as HCl[2-4,6-12,14,15,18,20,21,23,25-28,30-32,35-40], H_2SO_4[1,4,5,13,17,19,20,22,24,29,33-35] and alkaline medium such as NaCl[16] has been investigated.

Methods: Various methods such as Weight loss method[1-4,6-15,17-21,23,25,27-40], Thermodynamic method[1,3,5,7,8,10,11,13-16,18,19,23,24,27-33,35-37,40], Kinetic parameters[9,15,19,22,28,35], Potentiodynamic polarization[1,2,4,6-8,10,11,13,14,16,20,21,25,26,28-32,34,35,37,39] and Electrochemical Impedance Spectroscopy (EIS)[1,3-6,8,10-14,16,18,20-22,25,26,29-31,33,35,37-40] were used for consideration of corrosion inhibition mechanism and to calculate the percentage of inhibition efficiency of different seed extract as a green inhibitors.

Adsorption isotherms: The adsorption isotherm representation for phyto-chemicals present in different seed extracts as a green inhibitors into the metallic surface has been studied. For this, different kind of adsorption isotherms, such as Langmuir[1,2,4,6-16,19,20,25,28-31,33,35-37,39,40,] Temkin[2,3,5,9,23,33,35,] Fruendlich[15,19,35] and Flory-Huggins[17].

Surface Morphological Studies: Seeds extract are added in corrosive solutions to prevent the corrosion of mild steel a protective films formed on metal surface which is confirmed by various surface examination technique, such as Scanning Electron Microscope (SEM)[1,3,4,6,7,10,21,26,30,31,34,35,40], Atomic Force Microscopy (AFM)[1,30,31], Fourier Transform-Infrared Spectroscopy (FT-IR)[1,11,30,31,34,35,37,40], Ultra Violet (UV) visible spectroscopy[1,8,30,31], Nuclear Magnetic Resonance (NMR)[40] technique, Open Circuit Potential (OCP)[4,40], X-Ray Diffraction (XRD)[26], Infrared (IR) spectroscopy[3,17], Response Surface Methodology (RSM)[27], Gas chromatography-Mass spectroscopy (GC-MS)[8], Density Functional Theory (DFT)[1,23], Linear Polarization Resistance (LPR)[4,11,20,25,26,37].

The protection of mild steel and its oxide film against the corrosive action of acids has been extensively investigated and a great number of inhibitors have been studied by several authors on the inhibition of mild steel and its alloy by different seeds extract are shown in Table-1.

Table-1: Green corrosion inhibitors (seeds extract) for mild steel in different medium.

Inhibitor	Metal & Medium	Finding	Method	I.E. (%)	Remark	Ref.
Saraca ashoka	MS in H_2SO_4	Weight loss and thermodynamic method	Potentiodynamic polarization parameter, EIS, AFM, FT-IR, UV visible spectra, SEM and Quantum chemical studied like HOMO and LUMO	89.98	Mixed type of inhibitor, Langmuir adsorption isotherm	1
Cyamopsis tetragonaloba	MS in HCl	Weight loss method	Potentiodynamic polarization parameter	92.00	Mixed type of inhibitor, Langmuir and Temkin adsorption isotherm	2
Areca catechu	MS in HCl	Weight loss and thermodynamic method	Electrochemical parameters, IR and SEM technique	96.97	Temkin adsorption isotherm	3
Mustard	X60 MS in HCl and H_2SO_4	Weight loss method	Potentiodynamic polarization parameter, EIS, OCP, LPR and SEM technique	68.49 98.68	Mixed type of inhibitor, Langmuir adsorption isotherm	4
Radish	MS in H_2SO_4	Thermodynamic method	Electrochemical measurement	80.18	Temkin adsorption isotherm	5

Cotton	MS in HCl	Weight loss method	Potentiodynamic polarization parameter, EIS and SEM technique	95.70	mixed type of inhibitor, Langmuir adsorption isotherm	6
Mangifera odorata Griff	MS in HCl	Weight loss and thermodynamic method	Potentiodynamic polarization parameter and SEM technique	90.00	Mixed type of inhibitor, Langmuir adsorption isotherm	7
Sunflower	MS in HCl	Weight loss and thermodynamic method	Potentiodynamic polarization parameter, EIS, GC, UV visible	98.00	Langmuir adsorption isotherm	8
Prunus dulcis (Almond)	MS in HCl	Weight loss and kinetic method	-	69.95	Langmuir and Temkin adsorption isotherm	9
Mangala dry areca nut	MS in HCl	Weight loss and thermodynamic method	Tafel polarization, impedance and SEM techniques	93.04	Langmuir adsorption isotherm	10
Pongamia pinnata (Karanj)	MS in HCl	Weight loss and thermodynamic method	Potentiodynamic polarization parameter, EIS, LPR, and FT-IR techniques	98.00	mixed type of inhibitor, Langmuir adsorption isotherm	11
Allium cepa L.	MS in HCl	Weight loss method	Electrochemical techniques	94.50	Mixed type of inhibitor, Langmuir adsorption isotherm	12
Abelmoschus esculentus	MS in H_2SO_4	Weight loss and thermodynamic method	Potentiodynamic polarization and EIS techniques	90.00	Mixed type of inhibitor, Langmuir adsorption isotherm	13
Foeniculum vulgare Mill (Fennel)	MS in HCl	Weight loss and thermodynamic method	Potentiodynamic polarization and EIS techniques	89.00	Mixed type of inhibitor, Langmuir adsorption isotherm	14
Coffea arabica (roasted coffee)	MS in HCl	Weight loss, thermodynamic and kinetic method	-	74.11	Langmuir and Fruendlich adsorption isotherm	15
Nigella sativa	MS in NaCl	Thermodynamic method	Potentiodynamic polarization parameter and electrochemical techniques	91.00	Mixed type of inhibitor, Langmuir adsorption isotherm	16
Azadirachta indica	MS in H_2SO_4	Weight loss and hydrogen evolution method	IR technique	94.24	Flory-Huggins adsorption isotherm	17
Cucumis sativus (Cucumber)	AISI 1007 steel in HCl	Weight loss and temperature effect	Electrochemical technique	39.23	Mixed type of inhibitor	18
Citrus aurantifolia (Lime)	MS in H_2SO_4	Weight loss, thermodynamics and kinetic method	-	66.67	Langmuir and Freundlich adsorption isotherm	19
Syzygium cumini (Jamun)	MS in HCl and H_2SO_4	Weight loss method	Potentiodynamic and linear polarization parameter, EIS	94.28	Langmuir adsorption isotherm	20
Pithecellobium dulce	MS in HCl	Weight loss method	Potentiodynamic polarization parameter, EIS and SEM technique	79.76	Mixed type of inhibitor	21
Azadirachta indica (Neem)	MS and Cu in H_2SO_4	Hydrogen evaluation method and kinetic parameters	Electrochemical potential technique	54.74 60.00	Using a zero order kinetic mode	22
Cucumeropsis	MS in HCl	Weight loss,	Atomic absorption	82.70	Temkin adsorption	23

mannii N (Melon)		thermodynamic and hydrogen evaluation method	spectrophoto-metric assessment and DFT technique such as HOMO and LUMO		isotherm	
Garcinia kola	MS in HCl and H_2SO_4	Hydrogen evolution method and temperature effect	-	92.85 93.17	-	24
Cuminum cyminum (Jeera)	MS in HCl	Weight loss method	Potentiodynamic and Linear polarization parameter, EIS technique	93.00	Mixed type of inhibitor, Langmuir adsorption isotherm	25
Phoenix dactylifera (date palm)	MS in HCl	Hydrogen evolution method	Potentiodynamic polarization parameter, LPR, EIS, SEM, XRD and chrono-ampero metry (CA) technique	97.30	Mixed type of inhibitor	26
Katemfe seed	MS in HCl	Weight loss and thermodynamic method	Phyto- chemical analysis, response surface methodology (RSM)	-	-	27
Phaseolus aureus	MS in HCl	Weight loss, thermodynamic and kinetic method	Potentiodynamic polarization parameter	93.00	Mixed type of inhibitor, Langmuir adsorption isotherm	28
Ceiba pentandra	MS in H_2SO_4	Weight loss and thermodynamic method	Potentiodynamic polarization parameter and EIS technique	90.00	Mixed type of inhibitor, Langmuir adsorption isotherm	29
Mustard seed	MS in HCl	Weight loss and thermodynamic method	Potentiodynamic polarization parameter, EIS, FT-IR, SEM, AFM and UV-visible technique	97.00	Mixed type of inhibitor, Langmuir adsorption isotherm	30
Peganum harmala	MS in HCl	Weight loss and thermodynamic method	Potentiodynamic polarization parameter, FT-IR, SEM, AFM, UV-Visible and EIS technique	95.00	Mixed type of inhibitor, Langmuir adsorption isotherm	31
Mucuna pruriens	MS in HCl	Weight loss and thermodynamic method	Potentiodynamic polarization parameter	92.89	Mixed type of inhibitor	32
Benincasa hispida	MS in H_2SO_4	Weight loss and temperature effect	Electrochemical technique	94.70	mixed type of inhibitor, Langmuir and Temkin adsorption isotherm	33
Persea americana mill (Avocado)	MS in H_2SO_4	Weight loss method	Potentiodynamic polarization parameter, SEM and FT-IR technique	74.56	Mixed type of inhibitor	34
Coriandrum sativum L.	MS in HCl and H_2SO_4	Weight loss, temperature and kinetic effect	Potentiodynamic polarization parameter, Bode plots, EIS, SEM and FT-IR techniques	93.70 96.70	Mixed type of inhibitor, Langmuir, Temkin and Freundlich adsorption isotherm	35
Blighia sapida (Akee Apple)	MS in HCl	Weight loss and thermometric method	-	86.90	Langmuir adsorption isotherm	36
Strychnos	MS in HCl	Weight loss and	Potentiodynamic	98.00	Mixed type of	37

nuxvomica (Kuchla)		Thermodynamic method	and Linear polarization parameter, EIS and FT-IR technique		inhibitor Langmuir adsorption isotherm	
Moroccan flax	MS in HCl	Weight loss and physico-chemical analysis	EIS technique	94.00	-	38
Kimbiolongo seed	MS in HCl	Weight loss method	Potentiodynamic polarization parameter and EIS technique	96.00	Mixed type of inhibitor, Langmuir adsorption isotherm	39
Dipteryx odorata (Cumaru)	MS in HCl	Weight loss, thermodynamic method	OCP, EIS, FT-IR, NMR and SEM technique	98.00	Mixed type of inhibitor, Langmuir adsorption isotherm	40

Conclusion

In this review paper, reported research works produced over the past background on the corrosion of mild steel and its alloy in various medium and their corrosion inhibition by using a variety of seeds extract as green inhibitors was presented. Mild Steel and its alloy material were tested where inhibition efficiency increases with their concentration of the seeds extract as green inhibitors increased. Corrosion rate and inhibition efficiency of green inhibitors were found using methods like, weight loss, thermodynamic and kinetic studies. Inhibition efficiency was found good agreement in almost all green inhibitors. Many investigators were performed Potentio-dynamic polarization, LPR and EIS and found mixed type inhibition in most of the green inhibitors. Investigators were also investigated adsorption isotherm through the Langmuir, Temkin and Fruendlich. Investigators were used methods like, SEM, AFM, FT-IR, UV visible spectroscopy, RSM, DFT and Quantum Chemical study such as HOMO and LUMO of the molecular modeling for the understand surface morphological studied.

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