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Plant based Sustainable Corrosion Inhibitors

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***Abstract:** In the present note we have discussed about the plant based corrosion inhibitors. Main focus of the article is on three types of functional interfacial materials with special wettability, viz. superhydrophobic, superamphiphobic and slippery liquid-infused porous surface (SLIPS) materials. Various available green corrosion inhibitors are summarized and discussed. Finally, we pointed out the bottlenecks and future research prospects of the interfacial materials with special wettability.*

***Keywords:** Green Chemistry, Corrosion Inhibitors, Sustainable Technology*

1. INTRODUCTION

Developed country like United States has been wasted 3.1 % of its GDP each year as result of metallic corrosion. By the use proper technologies almost 25 to 30% loss could be avoided. The long term toxicology effect on the environment and living being compel scientific community to rethink about the problem and find the solution through green inhibitors. The metal surface several conditions must be fulfilled for the selection of a suitable inhibitor (a) the cost and amount of the inhibitors, (b) long term toxicological effects on the environment and living species, (c) the inhibitor's availability and stability in the environment. The inhibitors are being used since nineteenth century. Vegetables, wastes, plant extracts and oils are used as corrosion inhibitors in vapour-phase due to it;s volatile nature Around 1940, oils derived from plants are also used to prepare coatings, which are used to prevent metals from corrosion. This is also an efficient method of preventing metals from corrosion by forming a surface film. These co-polymers are also safe to environment. Recently, drying oils have been primarily used in coatings in the form of low molecular weight resins. Phosphate ester polyols having varying hydroxyl content and viscosity were prepared anticorrosive properties and are also safe to environment. In the plant extracts, there are present large numbers of chemical compounds especially heterocyclic, which are involved in corrosion inhibition. The oils obtained from various plants are also used as corrosion inhibitors because they are cheap, renewable and environmentally safe Inhibitors are being found to inhibit corrosion of metals by means of adsorption of ions and molecules on the metal surface.

In this review and perspective, we mainly focus on three types of functional interfacial materials with special wettability, viz. superhydrophobic, superamphiphobic and slippery liquid-infused porous surface (SLIPS) materials. The brief introduction, fabrication strategies and functional protective applications as anti-corrosion/anti-biofouling barriers are summarized and discussed. Finally, we summarized and pointed out the bottlenecks and future research prospects of the interfacial materials with special wettability

Methodology used for corrosion analysis:

Weight loss method: This is the primary method to calculate weight loss of mild steel coupon dipping in aloe vera and wheat grass mixture with the help of rust format

Galvanostatic technique: Galvanostatic polarisation studies of mild steel carried out in 1M H_2SO_4 at four different temperatures 298K, 308K, 318K and 328K gave the cathodic and anodic polarization curves Logarithm of current density was plotted against the corresponding electrode potential Tafel slopes for cathodic and anodic process were calculated from which the nature and mechanism of hydrogen evolution and anodic metal dissolution reaction can be established. Corrosion parameters for mild steel in 1M H_2SO_4 are given . As the temperature increases the corrosion current value also increases which indicates that the extent of corrosion increases with increase in temperature Galvanostatic studies in presence mixture of alveolar and wheat grass 1M H_2SO_4 containing various concentration of aloe vera and wheat grass was used for polarization studies at 298K, 308K, 318K and 328K.

Potentiostatic technique: With the help of potentistat The effects of the anodic dissolution parameters (i_c, $E_{pp,}$ I

$_p$) of mild steel in presence of different inhibitor can be calculated.

SEM: surface study has been done by dipping mild steel coupon in the mixture of aloevera gel and wheat grass. clarity of surface describe the efficiency of inhibitor.

Infrared spectroscopy:-The purpose of IR adsorption studies here is to show that these additive are adsorbed to a certain extent on silica gel. It is anticipated that this adsorption shall also be taken place on mild steel surface as well. Because it has iron as a major constituent and the vacant d-orbital of Fe will be expected to have some interaction with the delocalized electrons associated with this additive.

Quantum chemical Analysis: The relation between inhibition characteristics and quantum chemical data shows that log I_{cor} mostly depends upon the energy of the HOMO and LUMO. In addition to the data, it can also be related to dipole moment charge on phosphorous and the shapes of the additive. The energy of HOMO is the theoretical analogue of the ionization potential of the additive whereas, the energy of LUMO represent electron affinity of the substance, that is why good donor and bad acceptor will be indicator of good inhibitor. Dipole charge value indicate that there is a possibility of donation of electron in the metal surface.

Comutational chemistry (DFT): Now a days software are available to help in calculating different parameter which is required for calculating corrosion efficiency.

2. PLANTS AS GREEN CORROSION INHIBITORS

The extracts of plants act as a important inhibitors due to it's environment friendly nature. Now a range of Plant inhibitors has been used by researchers for growing need of inhibitors which have high inhibition efficiency and non-toxic in nature. many plant extracts and eco-friendly inhibitors draw the attention of the researchers. Always find out natural inhibitors which are cheap and ecologically have no threat to the environment. In this connection mixture of aloe Vera juice and wheat grass can do wonder. Being a medicinal plant it Could be a boon for corrosion stopping research. From ancient times we were using oil extracted from plant was studied the corrosion inhibition of ethnol extract of aloe vera on mild steel in acid media. The corrosion of mild steel in sea water by aloe vera extract .Garlic has been used as a corrosion inhibitors .Alkaloid extracted from Captis used because of its anticorrosion effect for mild steel corrosion in H2SO4 medium. Curcumin have been used as a corrosion inhibitors for α-brass in 2 M nitric acid solution already investigated. All the part of tobacco from twigs to leaves can protect steel and aluminum in saline solutions and strong acid. Eucalyptus leaves extract protect mild steel and copper in 1M HCl solution from corrosion .Extract of Hibiscus sabdariffa is very effective corrosion inhibitor Lawsonia extract has effective for acid induced corrosion of metals. Opuntia extract was investigated for the corrosion of Aluminum in acid medium and vanillin act as a corrosion inhibitor for mild steel in acid media. Papaia, Poinciana pulcherrima, Cassia occidentalis and Datura stramonmium seeds, Calotropis procera, Azydracta indica and Auforpio turkiale sap are useful as acid corrosion inhibitors. Datura metel as corrosion inhibitor for mild steel in acid medium. Quinine has been studied for its anticorrosive effect of carbon steel. So many other plant draw attention of scientific community towards plant inhibitors now combination can also work while dealing with problems of corrosion that's why I have chosen aloe Vera and wheat grass extract in 70and 30% ratio Corrosion inhibitors usually contain polar groups with atoms such as nitrogen, sulphur and oxygen. Correspondingly inhibitors include a wide list of organic and inorganic compound These inhibitors could be effective for aluminum, nickel and copper. Many important applications of Aluminum and its alloys has resulted due to its electrochemical behavior and corrosion resistance in a wide variety of media, and the properties of the surface oxide film formed naturally

Now a days efforts have been made to ameliorate mild steel surface film dissolution and hence protect the integrity of the metal in aggressive acid medium. For this one of the most important methods is the use of inhibitors to suppress the corrosion reaction and thus retard the corrosion rate. The use of natural products for protecting metal is being more importance because it is less costly, readily available and renewable in nature. Ecologically acceptable and environmental friendly in nature. Aloe vera extract is organic in nature and can be used as a green inhibitor and it is one of natural inhibitor which has an inhibitive action on the corrosion of metals. Aloe Vera gel is the colorless mucilaginous gel obtained from the parenchymaous cell in the fresh leaves of Aloe Vera. It contains of various activecompounds such as: salicylates, magnesium lactate, acemennan, lupeol, campestrol, sterol, linolenic, aloctin and anthraquinones.

Chemical and electrochemical methods are applied to study the corrosion behavior of mild steel in sulphuric acid. The inhibition efficiency of Aloe extract could act as natural inhibitor for the corrosion of mild steel in 0.5M H2SO4 and the effect of iodide ions were also studied. Wheat grass can also act as a good inhibitors due to presence of electron donating group, long chain and double bond which is act as effective inhibitors by blocking the active side of iron for being corroded. Wheat grass contains potassium, phosphorus, VitaminE, Vitamin C which has long chain and electron donating group. It contains chlorophyll, amino acid, minerals, vitamins and enzymes in all these lot many electron donating groups and elements, long chain, double bond are present which full the requirement of good corrosion inhibitor groups and enzymes .The key elements of an amino acid are carbon, hydrogen, oxygen and nitrogen. In which nitrogen and oxygen could be a good donor of electron and effectively block the active site of mild steel and check the corrosion.

Since Nineteenth century Vegetables, wastes, plant extracts and oils are used as corrosion inhibitors. Putilova et al. (1966) described metallic corrosion inhibitors. Because of their volatile nature the oils extracted from different plant have been used as vapor-phase corrosion inhibitors (Putilova et al., 1966) [1]Plant oils are also used to prepare coatings, which is very effective to prevent metals from being corroded Recently, Low molecular weigh drying oils resins (Booth et al., 2007; Hare, 1994)[2] have been used in coating .. Phosphate ester polyols having varying hydroxyl low coast and low-VOC polyols for coating applications (Mannari and Massingill, 2006).[3] Bouyanzer et al. (2006) [4] was extracted pennyroyal oil from menthe pulegium (Bouyanzer et al., 2006) which is used as corrosion inhibitor for mild steel in 1M HCl and shows an efficiency of about 80 percent at 343k. Pennyroyl mint oil behave as a cathodic inhibitor by changing the hydrogen reduction mechanism. Hammouti et al. (1997)[5] has extracted Artemisia oil from Artemisia herba-alba from Ains-es-sefra-algeria and utilise as corrosion inhibitor in steel at 2 M H_3PO_4. Poongothai et al. (2005)[6] extracted oil from the bark of Cassia siamea-gonrai, Cassia auriculata, Crataeva religiaso and Strychnos nuxvomica and apply as vapor-phase corrosion inhibitors for copper and mild steel. in NaCl and So_2 environments.

Jojoba oil as corrosion inhibitor has been studied against iron in 1 M HCl by Hammouti et al. (1997) and Chetouani et al. (2004) [7] and found to show a maximum efficiency of about 100 percent at concentration of about 0.515g/l. The adsorption of jojoba oil occur by means of frumkin adsorption. Rosemary oil (Chaieb et al., 2004, 2005)[8] as corrosion inhibitor for mild steel.

Eco-friendly curing agents derived from modified vegetable oils for use in coating materials are highly anticorrosive. Plant extracts (dried stems, leaves and seeds) of Cheliodonium majus and other plants are also used in acid pickling bathes in 1930. Animal proteins (by products of meat and milk industries) and derivatives of polysaccharides were also used for retarding corrosion in acid media. The derivative of chitin-a natural polysaccharide-carboxymethylchitosan was investigated and he draw the conclusion that it as an essential anticorrosive agent for mild steel in 1 M HCl (Cheng et al., 2006, 2007).[9] The additives required in acid, including flour, yeast, vegetable oil (Li et al., 2004)[10], bran, starch, a mixture of molasses and hydrocarbons (tars and oils). Organic matter shows influence on corrosion inhibition. Cheng et al. (2006, 2007) [11]is being studied the effect of organic matter on orthophosphate corrosion in combination with bacterial secretion like sodium alginate and fulvis acid (Cheng et al., 2006, 2007) [12]in copper with soft water. Antra, made by sulphonating anthracene oil and TM consisting of heavy oils were used in the fractionation of coal tar in Russia (Sanyal, 1981).[13] (Putilova et al., 1966). Aloevera leaves, orange, mango peals and opuntia extract all have given required protection to steel in acid in 5 and 10 percent HCl at 25 and 40C (Saleh et al., 1982).[14] El-Etre (2003) [15-16] used Opuntia extract (pointier ficus mill) used as corrosion inhibitor against aluminium in 2.0M HCl, It has an efficiency of about 98 percent. Guerreiro da Trindade and Goncalves (2009)[17] did the action of caffeine as corrosion inhibitor for low carbon steel in ethanol Cabrera et al. (1977) [18]given that molasses treated in alkali solution suppress the corrosion of steel in HCl which is used in acid cleaning.Khamis and Al-Andis (2002)[19] has been proved that Herbs such as coriander, hibiscus, anis, black cumin and garden cress as new type of green corrosion inhibitor . Anthony et al. (2004) [20] was studied synergetic effect of caffeine with Mn^{+2} found effective as corrosion inhibitor for steel. Fallavena et al. (2006) [21] studied the effect of caffeine on corrosion inhibition for copper in aqueous solutions of potassium nitrate.

Sathiyanathan et al. (2005a, b) [22] was investigated the ethanolic extract of Ricinus communis leaves for corrosion inhibitory effects of mild steel in sodium chloride solution it shows an efficiency of about 85 percent in 300 ppm. Natural honey is also act as corrosion inhibitor for copper and steel in aqueous solution (El-Etre, 2005; El-Etre and Abdallah, 2000).[23,2425,] Chaieb et al. (2004, 2005) [26-27]investigated which has been showing the effect of eugenol (Eu) and its derivatives acetyl eugenol (AcEug) derived from the nail of giroflier on the corrosion of steel in 1M HCl. The inhibition efficiency found to increase with acetyl eugenol content to attain 91 percent efficiency 0.1737 g/l concentration.

Pomegranate and Beetroot were investigated as corrosion inhibitor and found them very influensive against mild steel in acid media (Arockia Selvi et al., 2009; Jha et al., 1991).[28] Abdel-Gaber et al. (2006) [29] was investigated the corrosion inhib occidentalis and Datura stramonmium seeds, Calotropis procera, Azydracta indica and Auforpio turkiale sap are useful as acid corrosion inhibitors. Vinod Kumar et al. [30] studied the corrosion inhibition of acid extract of the pericarp of the fruit of G. mangostana on mild steel in hydrochloric acid medium. G. mangostana, colloquially known as “the mangosteen”, is a tropical evergreen tree. Mangosteen fruit, on ripening the fruit, turns from green to purple in Deepa Rani and Selvaraj [31] report the inhibition efficacy of Punica granatum extract on the corrosion of Brass in 1 N HCl evaluated by mass loss measurements at various time and temperature. Langmuir and Frumkin adsorption isotherms appear to be the mechanism of adsorption based on the values of activation energy, free energy of adsorption. Few researchers have summarized the effect of plant extracts on corrosion [32-35]. of the studyThe use of dyes such as azo compounds methyl yellow, methyl red, and methyl orange [36] as inhibitors for mild steel has been reported [37-40].

Surface wettability is one of the most significant properties of solid surfaces playing an important role in determining the chemical and physical performance. Inspired by the unique surface/interface properties of natural organisms, functional interfacial materials with special wettability (superhydrophobic, superamphiphobic, ultra-slippery etc.) provide promising applications in oil–water separation,[41-42] self-cleaning,[43-44] anti-icing,[45-46] drag reduction,[47-48]energy harvesting [49-50]water collection,[51-52] surface enhanced Raman spectroscopy,[53-54]etc. It is particularly worth mentioning that typical interfacial air–liquid–solid contacts of these materials can be considered as alternative means for improving the corrosion resistance [55-56] and the biofouling suppression performance [57-58] under different environmental circumstances.

A superhydrophobic surface is a surface with a WCA higher than 150° and a sliding angle (SA) lower than 10°, describing a state of perfect non-wetting contact. Superhydrophobic surfaces are inspired from the typical non-wetting behavior of the interface of natural organisms (Fig. 3), such as lotus leaves,59 water strider legs,60 peanut leaves,61 rose petals,62 rice leaves,63 taro leaves,64 butterfly wings,65mosquito eyes,66 cicada wings,67and gecko feet.68 German botanists Barthlott and Neinhuis 69 discovered the self-cleaning properties of lotus leaf surfaces, viz. “Lotus effect”. It was believed that this unique property is based on the surface roughness caused by the micrometer-scale papillae and the epicuticular wax.70 However, the fundamental mechanism remains unclear. Jiang et al.71 first reported the hierarchical micro-nano structures in a lotus leaf systematically. The binary synergistic effects of micro-papillae and branch-like nanostructures both contribute to the surface superhydrophobicity.

3. CONCLUSIONS

As the sciences have grown towards the traditional scientific disciplines doing agglomeration of different field have begun to work together towards interdisciplinary scientific approach to full fill the scientific need of the original innovative idea .It breaks all the boundaries of unidirectional approaches and convert it into multidirectional alliances to address particular areas of concern. Now the university and colleges all the departments of science even geography and philosophy also comes under the domain of interdisciplinary innovation. It reflects that society needs all the development through common platform involving protagonists of every field can share their view from chemistry to environment and earth to space. According to Professor Haken synergetics is a new field of interdisciplinary research and describes its achievements altogether, the mix of research and library techniques needed by scholars and students in interdisciplinary fields may be unique to such fields. These Multi approach scientific community could create a significant and distinctive class of scholars, They could do most innovative research on their information desire and shed light on the deeper side of questions regarding history corrosion inhibition and there disciplines .Now a days in smart city concept always draw an attention for stopping corrosion of all the metals through environmental friendly way i.e. follow the path of greener side by selecting green corrosion inhibitor.

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