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Corrosive Inhibitive Study of Stainless Steel in Hydrochloric Acid Using Eco-Friendly *Sesmum Indicum* Oil

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ABSTRACT

The inhibitive and adsorptive properties of *Sesmum indicum* eco-friendly oil for stainless steel corrosion in hydrochloric acid was investigated using weight loss technique as well as electrochemical technique. The result has proved that the oil is excellent inhibitor for stainless steel in hydrochloric acid. The inhibition efficiency of oil for stainless steel increased with increase the amount of oil. The mechanism of the oil on the surface of stainless steel was found to be spontaneous, exothermic and physical adsorption. The experimental data fitted well to Langmuir adsorption isotherms. Obtained results were justified from the galvanostatic polarization method.

Keywords: Langmuir adsorption, Weight loss technique, *Sesmum indicum* oil, Electrochemical technique.

INTRODUCTION

Stainless steel's strength, resistance to corrosion and low maintenance make it the ideal material for a wide range of applications such as pharmaceutical industry, architecture, medical, energy, heavy industry, construction, automotive, transportation, food and catering.

Corrosion is chemical or electrochemical reaction between materials, usually a metal, and its environment that produces a deterioration of the material. The annual loss due to corrosion has been estimated for any country at about 4 percent of gross domestic product.

In stainless steel there are some amounts of chromium which can be able to forms a passive film, this passive film can protect metal from corrosive medium. Corrosion inhibitors can protect passive film from corrosive medium. Due to chloride ions pitting corrosion is occur in stainless steel which

Research Article

Inhibition of Zinc by Natural Oil in 0.5N Hydrochloric Acid and 0.5N Sulfuric Acid

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ABSTRACT

Consequence of *Helianthus annuus* oil on corrosion of zinc metal in Hydrochloric acid and Sulfuric acid by weight loss method was investigated with and without of oil. It has been found that inhibition efficiency increases with amount of *Helianthus annuus* oil in 0.5N Hydrochloric acid and 0.5N Sulfuric Acid. *Helianthus annuus* oil was found more effective in 0.5N Hydrochloric acid than 0.5N Sulfuric acid. Different adsorption isotherm shows that *Helianthus annuus* oil physical adsorbed on metal. Kinetics and thermodynamics parameters also have been concluding in 0.5N Hydrochloric acid and 0.5N Sulfuric acid.

Keywords: Weight loss, *Helianthus annuus,* Adsorption Isotherms, Kinetics.

INTRODUCTION

Acid solutions are often used in industry for pickling, decaling and cleaning of metals structures, processes which are normally accompanied by considerable dissolution of the metal. A useful method to protect metals deployed in service in such aggressive environments against corrosion is the addition of species to the solution in contact with the surface in order to inhibit the corrosion reaction and reduce the corrosion rate. A number of organic compounds are known to be applicable as corrosion inhibitors for metal in acidic environments.[1-8] Such compounds typically contain nitrogen, oxygen or sulphur in a conjugated system and function via adsorption of the molecules on the metal surface, creating a barrier to corrosion attack. However, there is increasing concern about the toxicity of most corrosion inhibitors. The toxic effect does not only affect living organisms but also poison the environment. Due to the toxicity of some corrosion inhibitors, there has been increasing search for green corrosion inhibitors. Inhibitors in this class are those that are environmentally friendly and are gotten from natural products such as plant extracts and natural seeds oil. Several studies have been carried out on the inhibition of corrosion of metals by plant extract and natural seeds oil. [9-12] *Helianthus annuus* oil is one of the non-volatile oil, expressed from *Helianthus annuus* seeds. The oil of *Helianthus annuus* is rich in Palmitic acid 4 - 9%, Stearic acid 1 - 7%, Oleic acid 14 - 40%, Linoleic acid 48 -74% according to British Pharmacopoeia. *Helianthus annuus* oil contains predominantly linoleic acid in triglyceride form. The object of the present work to study the effects of *Helianthus annuus* oil on corrosion in 0.5N HCl and 0.5N H_2SO_4 solution by using gravimetric method. Thermodynamic and kinetic parameters were estimate and discussed in absence and presence of *Helianthus annuus* oil.

MATERIALS AND METHODS

Material preparation

The sheet of zinc of thickness 0.2 cm and chemical composition of Zinc specimens – 1.03% Pb, 0.04% Cd, 0.01% Fe and balance part zinc have been used for the experimental method. The zinc was mechanically press-cut into 3 X 2 cm coupons; they were degreased in acetone, rinsed with double-distilled water, dried in oven and then stored in calcium chloride moisture free desiccators. The *Helianthus annuus* used as inhibitor was obtained from sunflower plant seeds.

Weight loss determination

The weight loss was determined following the method reported earlier.[13] Sets of experiments were carried out consisting of 50ml beakers, previously weighed zinc coupons were each suspended in each beaker with the help of glass hooks. The zinc coupons were retrieved from the acidic solutions at 1hours. Each retrieved coupon was scrubbed several times to remove corrosion product, dried in oven, reweighed and weight loss was calculated in grams. Experiments were repeated with the inhibitor different concentrations.

The weight loss which was used to compute the corrosion rate given by:

$$\text{Corrosion Rate (mmpy)} = \frac{87.6\,W}{dAt} \qquad (1)$$

Where W is the weight loss (milligrams), d is the density of the specimen (g/cm^3), A the area of the specimen (square inch) and *t* the exposure time (hrs).

The inhibition efficiency of sunflower oil acting as inhibitor in 0.5 N HCl and 0.5N H_2SO_4 were calculated using the following expression:

Research Article

Study of Green and Eco Friendly Corrosion Inhibitor to Protect the Iron in Acidic Environment

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ABSTRACT

Literature reveals that numbers of organic compounds are known to be applicable as corrosion inhibitors for metal in acidic environments. Such compounds typically contain nitrogen, oxygen or sulphur in a conjugated system and function via adsorption of the molecules on the metal surface, creating a barrier to corrosion attack. But, unfortunately they have the unwanted destructive effect on environment, aquatic and animal life and expensive as well. Therefore, plants, natural product extracts, natural oils have been posed to achieve the target of employing as a cheap, environmentally acceptable, abundant source, readily available and effective molecules having very high inhibition efficiency and low or zero environmental impact. The inhibitory action of green and eco-friendly *sesmum indicum* oil on the corrosion of iron in 0.5 N hydrochloric acid was studied using gravimetric and galvanostatic polarization techniques. The corrosion rates of iron in the HCl acid solution containing *sesmum indicum* oil were measured as a function of the inhibitor concentration. The inhibitor efficiency depends on the concentration of the *sesmum indicum* oil. Adsorption of *sesmum indicum* oil on iron surface was found to obey the Langmuir adsorption isotherm. The phenomenon of physical adsorption has been proposed on the basis of obtained thermodynamic parameters. Results from this study showed that *sesmum indicum* oil was an attractive alternative to prevent corrosion as it shows the great inhibition efficiency.

Keywords: Corrosion, Gravimetric technique, *Sesmum indicum*, Galvanostatic polarization.

INTRODUCTION

The appearance of corrosion is an interface problem between a metal and gaseous leading to a destruction of metallic materials. This phenomenon took today a considerable importance in view of the increasing use of different metals in modern life. It is a very common in industries used the acids such as acid pickling, industrial cleaning. The search for new and efficient corrosion inhibitors has become a necessity to protect metallic materials against corrosion. The considerable efforts have been made to find suitable compound of organic origin to be used as corrosion inhibitors in various corrosive media, to either stop or delay to the maximum attack of a metal. On account of the known hazardous effects of most synthetic organic inhibitors and the need to develop cheep, non-toxic and environmentally benign processes, the efforts have been made by several researchers to focus on the use of natural products as corrosion inhibitor.[1-8] Some of the natural oils are also found to be the good corrosion inhibitor like natural Artemisia oil on steel and Jojoba oil on aluminium.[9-10] It has also been found that substances containing polar functions with nitrogen, sulphur and oxygen in conjugated system exhibit good corrosion inhibiting property.[11] The oil of *Sesmum indicum* is rich in manganese, copper and also contains vitamin B_1 (thiamine) and vitamin E (tocopherol). They contains lignans such as sesamol, sesamin and sesamolin. The percentage composition of fatty acid is 44%, stearic acid 4.2%, palmitic acid 9% and arachidic acid 0.7%.[12] The presence of sesamol, sesamin and sesamoline in *Sesmum indicum* oil worked as inhibitor in 0.5N HCl solution. Thermodynamic, electrochemical and adsorption parameters for iron in absence and presence of the inhibitor were evaluated and interpreted.

In view of the above, it was spurred us to study the effects of *Sesmum indicum* oil on corrosion of iron in 0.5N HCl solution by using gravimetric method and galvanostatic polarization method.

METHODOLOGY

Materials

The experiments were performed with iron coupons of the 99.5% pure iron.

Solutions

The test solutions used were made of AR grade HCl. Appropriate concentration (0.5N) of acid was prepared using de-ionized water in the absence and presence of various concentrations of *Sesmum indicum* oil. The employed concentration range of *sesmum indicum* was of 1g to 6g in 1000ml of 0.5N hydrochloric acid.

Corrosion Rates Measurements

The non-electrochemical technique of weight loss was done in order to determine the corrosion rate and percentage of inhibition.

This physical measurement will provides direct result on how the corrosive environments affect the test samples and also to give the average corrosion rate during the experiment.

Triple-Notched Band CPW fed UWB Antenna with Metallic Reflector for High Gain Performance

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Abstract

This paper exhibits the design and performance of a coplanar waveguide (CPW) fed triple notched band ultra-wide band (UWB) antenna. Proposed prototype has two U-shaped slots on the patch and an inverted U slot in feed line with a metal reflector beneath the radiating element. Proposed structure renders wider impedance bandwidth extended between frequencies 2.71GHz to 12.92 GHz for VSWR < 2 with three rejection bands in the frequency ranges 3.456 to 3.988 GHz (WI-MAX IEEE 802.16), 5.27 to 6.032 GHz (WLAN IEEE 802.11 a/h/j/n) and 7.88 to 8.65 GHz (X-band down link satellite system) for VSWR > 2. The utmost simulated gain of proposed antenna with reflector is close to 9.9dBi at 7.4GHz. A sharp reduction observed in the efficiency values of the proposed structure at stop bands. Perhaps, this structure proved as a useful tool for various applications in modern communication systems including UWB.

1. Introduction

The outspread bandwidth of ultra wideband technology is extensively preferred by academia and industry due to its credible usage in high-speed data transfer and microwave imaging [1-2]. In 2002, the Federal Communications Commission (FCC) released an unlicensed band for commercial use in radio communications in the frequency range of 3.1-10.6 GHz. Since permitted power emission level of UWB band is quite low so this band is easily interfered by other adjoining high power communications systems such as WiMAX communication system, WLAN communication system, and ITU X-band communication. The disruptions of these high power communication systems with UWB communication systems can evade by applying the band rejection filter [3]. Many UWB antennas with band-notched characteristics proposed in the literature [4-13]. Zarrabi [4] reported a triple notch band UWB antenna that had a fractal Koch structure with a T-shaped stub. The central frequency of these notch bands is 2 GHz, 3.5 GHz, and 5.8 GHz subsequently. M. Sharma [5] presented an Urn-shaped UWB antenna along with T-shape stub and two C-shaped slots resulted in a triple notch band with central frequencies allocated for WI-MAX IEEE 802.16, WLAN IEEE 802.11 a/h/j/n and X-band down link satellite systems. Syed and Aldhaheri [6] proposed a CPW fed UWB antenna with eliminating IEEE 802.11 and HIPERLAN/2 frequency bands. Hu [7] reported a novel rectangle tree fractal structure which constituted with superposition of a number of rectangular patches. Ultra wide band performance obtained by embedding defects on the ground plane and band rejection characteristics achieved through inserting three U-slots on the fractal tree shaped patch structure. A novel triple notch UWB antenna reported by Tang and Yang [8] which have a circular patch structure with a partially truncated ground plane. To incur band rejection characteristics, a square ring short stub loaded resonator embedded. Amiri [9] investigated an inverted triangle-shaped patch with the trapezoid shaped ground plane for extreme wide band operation. The dual rejection characteristic for C and WLAN bands obtained through embedding a pair of L-shaped slots in radiating structure. A novel modified octahedron shaped structure with dual rejection band characteristics reported by Mishra and Shau [10]. Ding and Wong [11] communicated an elliptical UWB antenna with single band rejection. The overall size of this antenna reduced through cutting a half elliptical opening from the main radiator. Das [12] reported a low-cost and simple rectangular monopole antenna in which single, double as well as triple notched bands achieved by fluctuating spiral slot length with a median frequency of 3.57 GHz, 5.12 GHz, and 8.21 GHz respectively. S. Yadav [13] communicated a rectangular shaped radiator with a modified ground plane. The bandwidth of this structure extended from 5.0 GHz to 25.5 GHz. Single WLAN band rejection obtained by etching an L-shaped slot in the radiating patch structure.

In this communication, a design and performance of a planar CPW feed edge truncated circular patch having triple band-notched characteristics have discussed. Two U-shaped slots in the radiating patch and an inverted U-shaped slot in the feed line has introduced one by one to obtain the triple band-notched characteristics. The WI-MAX, WLAN, and ITU 8.0 GHz bands cater electromagnetic interference with the UWB communication system; hence the rejection of

Ring Slotted Circularly Polarized U-Shaped Printed Monopole Antenna for Various Wireless Applications

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Abstract

In this communication, the design and performance of micro strip line feed U-shaped printed monopole antenna for Bluetooth/WI-MAX/WLAN communications systems is reported. The proposed monopole antenna has an eight shaped slot on the patch and an eight shaped ring structure in the ground with a metallic reflector beneath the ground plane. The CST Microwave Studio 2014 used for the simulation analysis of antennas while measurements performed by applying Vector Network Analyzer (R&S-ZVA 40). This radiating structure provides triple broad impedance bandwidths, i.e. 265MHz (in 2.280 GHz to 2.545 GHz frequency range), 116 MHz (in 2.660 GHz to 2.776 GHz frequency range) & 2.12 GHz (in 3.83 GHz to 5.956 GHz frequency range), wider 3dB axial ratio bandwidth 1.33 GHz (in 4.69GHz to 6.02GHz range), nearly flat gain (with maximum gain close to 5.56 (dBi) and good radiation patterns in the desired frequency range. This antenna may be a useful structure for 2.45GHz Bluetooth communication band as well as in WLAN & WI-MAX communications bands.

1. Introduction

The rapid advancements in the wireless communication systems, especially in the field of high data transfer, have awakened more interest of the scientific community towards the performance enrichment of the wireless antennas. These antennas must perform well for application in communication systems, including WLAN applications specifically 802.11b and 802.11g for 2.4 GHz communication systems, 802.11a standard for the 5 GHz communication system, high-speed 802.11n for operation in both 2.4 GHz and 5.0 GHz bands as well as in WI-MAX applications [1-2]. Circularly polarized planar monopole patch antennas are found suitable for these bands due to their flexibility in orientation, easy feeding, low profile structure and low fabrication cost of mass production [3]. Looking these advantages, extensive efforts have been made by researchers to improve the inherent limitations of planar antennas [4-17]. These include design of fork like monopole with a wide slot ground [4], wideband E-shaped micro strip patch antenna for 5-6 GHz wireless communications systems [5], miniaturized U-slot patch antenna with enhanced bandwidth [6], Wideband omni directional monopole antenna [7], flared monopole antenna with a V-shaped sleeve [8], L-shaped printed monopole antenna with wide impedance bandwidth [9] etc. A trapezoid conductor backed plane applied to get a dual band antenna incubating WLAN and WI-MAX in [10]. A triple-band monopole patch covering the WLAN & WI-MAX communication systems obtained by using electric-LC (ELC) and EBG structures [11]. A new design of coaxial probe feed dual layer circular patch antenna presented in [12]. With the substantial bonding between two patches, a wide bandwidth approx. 25% obtained. Most of these references have larger patch size, but the compactness of structure is the main requirement in modern wireless communication systems. A very compact asymmetric coplanar strip fed monopole structure for dual frequency bands presented in [13]. Another compact design presented in [14] which has L-shaped radiating element, a modified inverted-F-shaped stub and a C-shaped parasitic radiating element for WLAN and WI-MAX application. Triple bands obtained by applying a pair of inverted-L slots etched on the ground plane and a split-ring resonator (SRR) in [15]. A tapered printed structure attached to U-slot reported in [16] to achieve WLAN dual frequency bands. In [17], a directional dual band performance obtained by tuning the lengths of the inner symmetrical trapezoidal slots and the outer trapezoidal arms.

The main objectives of this communication to obtain a single structure which has compactness, high gain, multiple operation bands and circular polarization. Rectangular and circular configurations are the most common configuration. In this communication, a new U-shaped design has offered which has a compact size compared to other configurations and provides circular polarization that desires in several wireless communications. Broadband performance and circular polarization have achieved through U-shaped monopole structure with an eight shape ring slot in the patch geometry and an eight shape ring in the ground plane. The gain of the antenna has improved through application of a metallic reflector placed beneath the radiating structure. The CST Microwave Studio 2014 has used for the simulation analysis of antennas while measurement has performed by