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# Corrosion Performance of Carbon Steel in Acid Medium by *Solanum Nigrum* Leaf Extract

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**ABSTRACT :** Corrosion inhibition effect of *Solanum Nigrum* (SN) leaf extract was investigated for carbon steel corrosion in Sulphuric acid solution with different concentrations. The inhibition mechanism is discussed considering weight loss study and electrochemical techniques. It was observed from the results that in all the systems the IE increases with the concentration of SN increases. The maximum inhibition efficiency 99% is acknowledged at the inhibitor concentration of 300 ppm. SEM studies confirmed the formation of a protective film on the surface of the carbon steel.

**KEYWORDS:** Corrosion inhibition, Carbon steel, *Solanum Nigrum*, Weight loss study, electrochemical techniques

## I. INTRODUCTION

Corrosion is referred to as metallic deterioration by chemical attack or reaction of a metal with its environment (1). It is difficult to eliminate completely. Prevention would be more practical and achievable than elimination (2). Corrosion process, being surface reactions, can be controlled by inhibitors (i.e.) Plant extract which absorb on the reacting metal surface. Extract of plant with Organic compounds containing hetero atoms like O, N, S and P have been widely used as a potential Corrosion inhibitor in acid solutions. These compounds assist in Corrosion inhibition to reduce Corrosion of carbon steel (2-3). Carbon steel is widely used for mechanical and structural engineering purpose, boiler, plates, steam engine parts and automobile etc., (4). The corrosion of carbon steel storage tanks and pipes by sulphuric acid is a great concern (5). *Solanum nigrum* (Solanaceae) commonly known as Makoi or black nightshade, usually grows as a weed in most habitats in different kinds of soils. The juice of the plant is used on ulcers and other skin diseases. The fruits are used as a tonic, laxative, appetite stimulant, and for treating asthma (6). Thus the present study is an effort to use Ethanol extract of *Solanum nigrum* leaf as a green Corrosion inhibitor for the carbon steel in acid solutions in different concentrations.

## II. EXPERIMENTAL

### 2.1 Preparation of *Solanum nigrum* leaf extract:

Ethanol extract of *Solanum nigrum* leaf was prepared by refluxing 10g of the leaf powder with 100 ml of ethanol for 3 hours. The refluxed solution was filtered, and the liquor was evaporated. 1g of the sample was accurately weighed and dissolved in 1000 ml of double distilled water made in 1000 ml standard flask. The thousand fold dilution of stock solution is 1000 ppm. This extract was used as corrosion inhibitor in the present study. The major constituent of the ethanol extract is Solasodine.



## 2.2 Preparation of carbon steel specimens:

Carbon steel specimens of dimensions 1.0 cm × 4.0 cm × 0.2 cm (surface area 10cm<sup>2</sup>) and the density 7.87 g/cm<sup>3</sup>, were polished to a mirror finish and degreased with acetone and used for the weight loss method and surface examination studies. Carbon steel rod encapsulated in Teflon with an exposed cross section of 1 cm<sup>2</sup> area was used as the working electrode for AC impedance studies.

## 2.3 Weight loss Method:

The weight loss techniques are the conventional and simplest of all corrosion techniques. Carbon steels were completely immersed in 100 ml of the solution of acid media of normality (0.1 N H<sub>2</sub>SO<sub>4</sub>) containing various concentrations of the inhibitor (SN) for a period of 1, 3 and 5 hours. After the hours of immersion the specimens were taken out, washed in running water, dried and weighed. The corrosion inhibition efficiency (IE) was then calculated using the equation

$$IE = 100 \left[ 1 - \left( \frac{W_2}{W_1} \right) \right] \%$$

Where,  $W_1$  is the corrosion rate in the absence of the inhibitor

$W_2$  is the corrosion rate in the presence of the inhibitor.

Corrosion rates (CR) are calculated from weight loss method using the formula

$$CR = \frac{534 W}{DAT} \text{ Mils per year (mpy)}$$

Where,

$W$  = weight loss in milligrams

$D$  = density of specimen g/c = 2.70 gm/cm<sup>3</sup>

$A$  = area of specimen in square inches = 1.395

$T$  = exposure in hours = 3 hours

## 2.4 AC impedance spectra

The instrument used for polarization study was to record AC impedance spectra also. The real part ( $Z'$ ) and imaginary part ( $Z''$ ) of the cell impedance were measured in ohms at various frequencies. Values of charge transfer resistance ( $R_t$ ) and the double layer capacitance ( $C_{dl}$ ) were calculated.

$$R_t = (R_s + R_t) - R_s$$

Where,

$R_t$  = solution resistance

$C_{dl}$  values were calculated using the relationship

$$C_{dl} = \frac{1}{2 \times 3.14 \times R_t \times f_{max}}$$

where,

$f_{max}$  = frequency at maximum impedance

## 2.5 Surface examination study:

The carbon steel specimens were immersed in various test solution for a period of 3 hours. After 3 hours the specimens were taken out and dried. The nature of film formed on the surface of the metal specimens was analyzed by various surface analysis techniques

## 2.6 Scanning Electron Microscopy (SEM)

The effect of inhibitor on corrosion process of carbon steel was examined using SEM. The surface analysis of the carbon steel for fresh, inhibited and uninhibited systems was investigated. The carbon steel immersed in blank and in the inhibitor solutions for a period of 3 hours was removed, rinsed with double distilled water, dried and observed



under scanning electron microscopy to examine the surface morphology. The morphology measurements of carbon steel were examined using a JEOL model 6390 computer controlled SEM.

**2.7 Weight loss study**

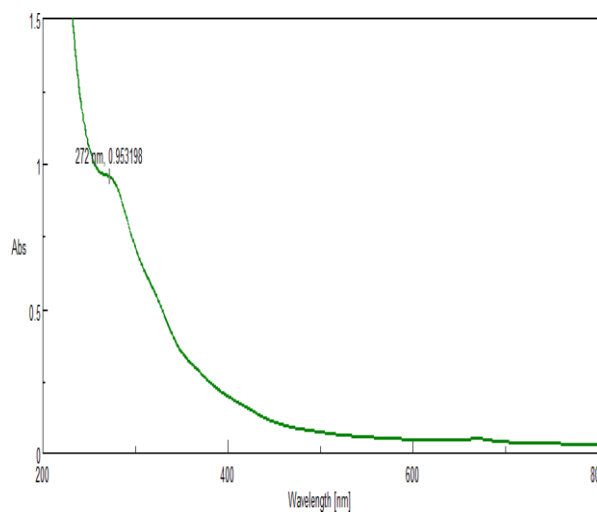
The weight - loss method was done for carbon steel in 0.1N H<sub>2</sub>SO<sub>4</sub> with various concentrations of SN leaf extract ranging from 50 ppm to 300 ppm and the corresponding values of IE and CR are given in Table 3.1. It was observed that in all the systems the IE increased up to 300 ppm . It was observed from the table 1, that the CR decreased and thus IE increases with increasing concentration of SN. The maximum IE of about 99% was achieved at 300 ppm . This result indicated that SN leaf extract could act as potent corrosion inhibitor (7,8).

**TABLE 3.1: CORROSION IE% AND CORRESPONDING (CR) IN (MILLS PER YEAR) OF PLANT SYSTEM IN 0.1 N SULPHURIC ACID**

Conc. of SN in ppm	0.1 N H <sub>2</sub> SO <sub>4</sub>				
	1hour		3hour		5hour
	CR (mpy)	IE %	CR (mpy)	IE %	CR (mpy)
0	0	0	0	0	0
50	1.9423	36	2.5803	21	2.9574
100	1.4035	74	1.0727	37	1.4716
150	1.0491	80	0.8270	59	1.5283
200	0.8081	87	0.5151	94	0.2126
250	0.6663	94	0.2315	91	0.3345
300	0.6238	99	0.0472	84	0.3714

**2.8 Analysis of UV Spectra**

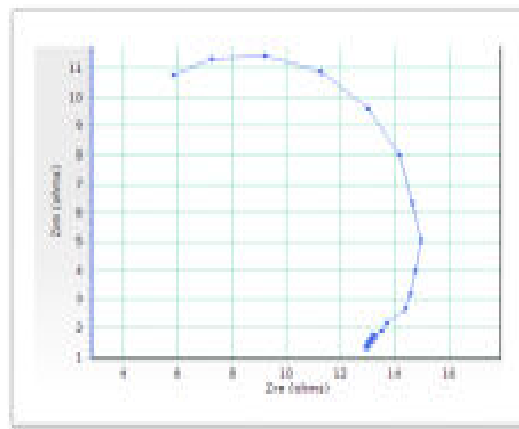
UV visible spectrum of the SN extract was recorded using water as the solvent in JASCO V-730 spectrophotometer. UV visible spectrum of the aqueous SN extract was shown in Figure. It shows absorbance at 272 nm. A peak between 200- 400 nm shows the presence of hetero atoms inSN [9].



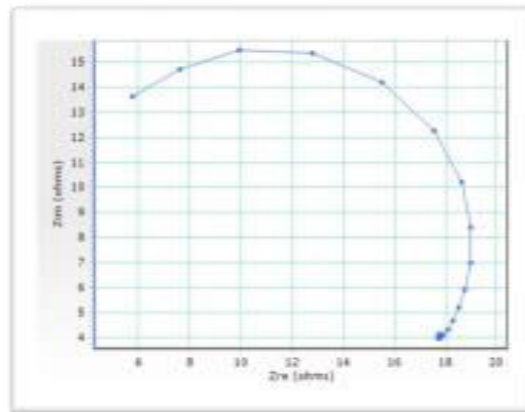
**Figure.2.1. UV spectrum of pure SN**

**2.9 Analysis of AC Impedance Spectra:**

AC impedance spectra can be used to detect the formation of protective film on the metal surface. Figure 2.2(a) & (b) shows the plots for acidic solution in the absence and presence of 300 ppm concentration of SN leaf extract and their corresponding impedance parameter. It was observed that the plots are approximately elliptical in nature. The elliptical nature of the plot was due to the formation of oxide film on carbon surface (10). The impedance parameters such as charge transfer resistance ( $R_t$ ) and double layer capacitance ( $C_{dl}$ ) are given in table. When carbon metal was immersed in acid solution and to the 300 ppm inhibitor,  $R_t$  value was rises from 7.1 to 12 Ohm  $cm^2$  at 0.1N  $H_2SO_4$ . Again decrease in  $C_{dl}$  value from  $1.2574 \times 10^{-6}$  to  $7.5464 \times 10^{-7} F/cm^2$  with the increase in  $R_t$  value suggest the formation of protective film on the surface of the carbon metal (11-13).



**Figure.2.2.a AC impedance of spectra of Carbon steel in 0.1 N  $H_2SO_4$**

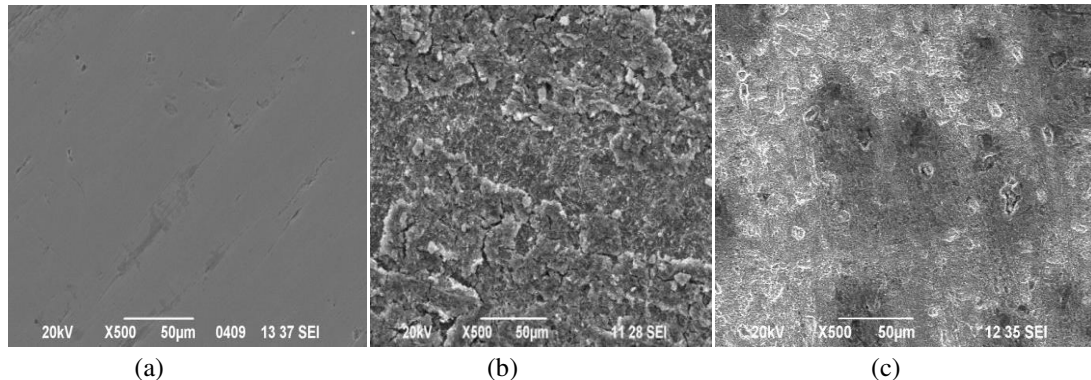


**Figure.2.2.b.AC impedance of spectra of Carbon steel in 0.1 N  $H_2SO_4$  and 300 ppm SN**

**2.10SEM Analysis of metal surface**

SEM provides a pictorial representation of the surface. SEM photographs were taken to show that the corrosion inhibition is owing to the formation of an adsorptive film on the steel surface. The SEM micrograph of polished carbon steel surface (control) in Figure.2.3(a) illustrates the smooth surface of the metal. The SEM micrograph of the carbon steel surface immersed in 0.1N  $H_2SO_4$  was represented in Figure.2.3 (b), revealed that the surface was severely corroded due to the aggressive attack by Acid medium. Figure.2.3(c) confirms that in the presence of 300 ppm of SN in 0.1 N  $H_2SO_4$ , the rate of corrosion is suppressed, as can be seen from the decrease in corroded areas. This is a result of the formation of insoluble complex on the surface of the carbon steel ( $Fe^{2+}$ -inhibitor complex) [14- 16].





**Figure.2.3 SEM micrographs of a. polished carbon steel ( control), b. Carbon steel immersed in 0.1N H<sub>2</sub>SO<sub>4</sub>. c. Carbon steel immersed in 0.1N H<sub>2</sub>SO<sub>4</sub> containing 300 ppm of SN**

### III. CONCLUSION

Solanumnigrum leaf (SN) extract was found to be an effective inhibitor to prevent the corrosion of carbon steel in 0.1N H<sub>2</sub>SO<sub>4</sub> solution. The formulation consisting of 300 ppm of SN shows 99 % IE. The protective film formed on the carbon steel surface was able to withstand for 3 hours of immersion period. AC impedance spectra reveals that a protective film is formed on the carbon steel surface. SEM studies showed the formation of protective film on the inhibited carbon steel surface by SN inhibitor

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