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Withania somnifera Extract as Green Inhibitor for Mild Steel in 8 % H_2SO_4

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By using polarization measurements, UV, IR and weight loss study, it has been detected that the extract of *Withania somnifera* leaves can act as corrosion inhibitor for mild steel in 8 % H_2SO_4 solution. This plant shows good corrosion inhibition efficiency at particular concentrations of the acid. It is observed that plant extract acts as better inhibitor on increasing its concentration. Here we have focused on the corrosion inhibition action of plant extract in H_2SO_4 medium.

Keywords: *Withania somnifera,* Mild Steel, SEM, UV, IR, Polarization measurements.

INTRODUCTION

From last few decades corrosion inhibitor has been an emerging field of research. Acids are being used widely in the field of mild steel machinery in industries for different applications *e.g.* cleaning, descaling, pickling *etc.* [1]. A number of organic inhibitors are dynamically used to prevent corrosion and it is the most provident method. The inhibition action of organic inhibitors relies on their adsorption capability on metal by replacing water molecules [2]. Organic compounds also show corrosion inhibition efficiency and there are several organic compounds which are notified to prevent corrosion [3-7]. But the problem with them is that they are extremely poisonous to both human being as well as surroundings. Because of the poisonous effects of these organic inhibitors, natural non-toxic inhibitors are the requirement of our environment [1]. Compounds which contain oxygen and nitrogen inhibit the corrosion of mild steel most effectually [8]. To prevent the corrosion of mild steel by using plant extracts is one of the most enterprising methods. In green inhibitors secondary metabolize O and N are usually present and they are the active centers for adsorption [9].The adsorption of green inhibitors on the steel surface can be either in the form of physisorption or chemisorptions or it may also be as a combined effect of both [10].Therefore to overcome the toxic effects of commercial inhibitors, the development of natural non-toxic inhibitors to prevent the metallic corrosion is necessary and seductive [11]. Extract of naturalistic products contain many compounds which are biodegradable in nature. In the present study we have used the extract of *Withania somnifera* saturated with H_2SO_4 which plays an effective role to inhibit corrosion of mild steel. This plant extract consists of isopelletierine alkaloid which is rich in heteroatoms hence we can use this plant extract to prevent corrosion. The inhibition effect of this plant extract on the corrosion rate of mild steel in 8 % H_2SO_4 was studied by using weight loss study, IR, UV and polarization measurements.

EXPERIMENTAL

Preparation of plant extract: We have collected the *Withania somnifera* for present study and then dried and powered. The powder was soaked to 500 mL deionized water and then refluxed for 3 h. In this manner we obtained the aqueous solution which was then filtered and concentrated. Then we prepared the solutions of particular concentrations by diluting this concentrated solution.

Weight loss measurements: With the help of weight loss study we measured the loss in weight of mild steel strips when they were immersed in saturated solution of H_2SO_4 with extract. For this purpose, we took rectangular pieces of mild steel which composed of (wt %) Fe 97.60 %, C 0.083 %, Si 0.39 %, Mn 0.43 %, P 0.12 %,Cr 0.45 %, Ni 0.27 % and Cu 0.43 %. These strips were then squeezed with fine grade emery paper (120, 600, 800 and 1000), washed with distilled water and dried. Then the mild steel strips were weighted accurately before inserting them into the saturated solution of H_2SO_4 with plant extract. The mild steel strips were then immersed into H_2SO_4 without plant extract and saturated with varied concentrations of extract. Then we left the set up for 3 h and after the elapsed time, the mild steel strips were excluded, cleansed, drained and weighed. A difference in weight is noted between the mild steel strips dipped in H_2SO_4 solution without plant extract and with varied concentrations of plant extract. Here we have used 8 % H_2SO_4 in the experiment. All the concentrations of inhibitors for weight loss are taken in mgL^{-1} by weight. The inhibition efficiency (I.E.) and surface coverage (θ) can be determined by using following equation:

$$\theta = \frac{w_0 - w_i}{w_0} \quad (1)$$

$$\text{I.E.}\ (\%) = \frac{w_0 - w_i}{w_0} \times 100 \quad (2)$$

where w_i and w_0 are the weight loss values in presence and absence of inhibitor respectively.

Electrochemical measurements: Electrochemical studies were conducted by using a Gamry interface Potentiostat/Galvanostate/ZRA03007. Polarization with potentiostat measures current while on the other hand polarization with Galvanostate measures potential. The corrosion cell consists of three electrodes. We use a saturated calomel electrode in the form of reference electrode, a platinum foil in the form of counter electrode and mild steel is used in the form of a working electrode. Here we immerse the working electrode in the test solution and stabilize it for 0.5 h. With the help of such studies we obtain Tafel polarization curves which help us to get information about corrosion inhibition of mild steel. These slopes provide us the value of corrosion current densities (I_{corr}), we use this value in the following formula and find the inhibition efficiency.

$$\eta\ (\%) = \frac{I_{0corr} - I_{icorr}}{I_{0corr}} \times 100 \quad (3)$$

where I_{0corr} and I_{icorr} represent the corrosion current density values in the absence and presence of inhibitor, respectively.

UV-visible spectroscopy: We subjected the acidic solution of extract before and after the immersion of mild steel strips to UV-visible spectrophotometer and then compared the spectra in both cases. The spectra of plant extract before the immersion of mild steel strip shows some smaller peaks which are not found in the spectra of plant extract after the immersion of mild steel strip. It means that when we dip mild steel strip in the plant extract then some molecules adsorbed on the mild steel surface, they forms a protective film on the surface and prevent the corrosion of mild steel.

IR spectroscopy: The IR spectroscopy identify the different types of functional groups, heteroatoms present in the extract.

Surface analysis: The mild steel strips were immersed in 8 % H_2SO_4 solution for 3 h in the absence and presence of *Withania somnifera* extract. Here we obtained the effect of corrosion and inhibition on mild steel surface. The mild steel strips were then dried and micrographs of their surfaces were taken by using SEM model.

RESULTS AND DISCUSSION

From IR spectra of *Withania somnifera* extract, the peak at 3412 cm^{-1} suggests aromatic O-H stretching. Further peak at 1631 cm^{-1} suggests C=O stretching of amide group. The peak at 1055 cm^{-1} suggests C-O stretching of alcohol.

The UV-visible spectroscopy the formation of a metal complex. Here we obtained the UV-visible absorption spectra for different concentrations of *Withania somnifera* extract before and after the immersion of mild steel strip. The electronic absorption spectrum of *Withania somnifera* extract before the immersion of mild steel strip is shown by black coloured line. These bands may arise due to π-π* and n-π* transitions with a considerable charge transfer character. The UV spectra of extract after the immersion of mild steel strips is shown by green coloured line which shows that the position of absorption maximum changes or value of absorbance changes which indicates that a complex is formed between two species in the solution. The UV spectra of *Withania somnifera* extract saturated with 8 % H_2SO_4 before and after immersing the mild steel strips are shown in Fig. 1.

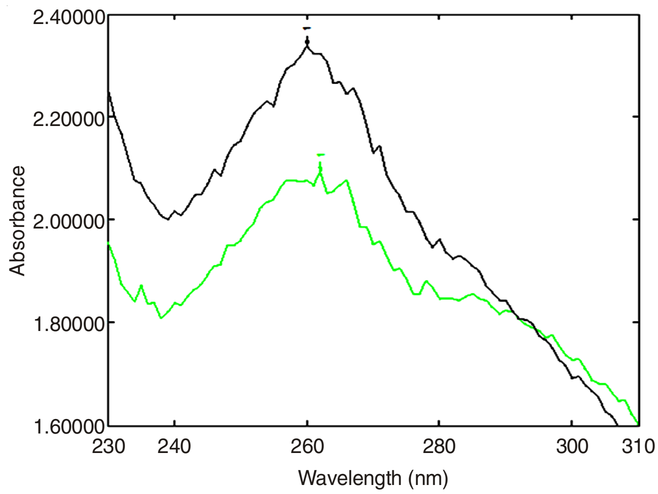

Fig. 1. UV spectra of *Withania somnifera extract* before and after the immersion of mild steel strip

Weight loss study

Effect of concentration: For mild steel, the weight loss results in the absence and presence of different concentration of plant extract saturated with H_2SO_4 are summarized in Table-1. Table-1 clearly indicates that when concentrations of the *Withania somnifera* extract increases, the inhibition efficiency also enhances. The extract of *Withania somnifera* consists of heteroatoms (O, N) which form the metal complex bond with the metal surface thereby reducing corrosion. Hence it proves that the *Withania somnifera* extract can be treated effectively to prevent the corrosion of mild steel.

Polarization measurements: Weight loss study is verified by polarization measurement. The polarization measurement

TABLE-1
CORROSION PARAMETERS FOR MILD STEEL IN 8 % H_2SO_4 WITHOUT AND WITH DIFFERENT CONCENTRATIONS OF *Withania somnifera* EXTRACT

Inhibitor concentration (ppm)	Weight loss (mg cm^{-2})	η (%)	θ
0	36.06	00.00	0.0000
30	20.42	43.37	0.4337
90	18.20	49.53	0.4953
180	04.15	88.49	0.8849
300	03.45	90.43	0.9043

TABLE-2
POTENTIODYNAMIC POLARIZATION PARAMETERS FOR THE CORROSION OF MILD STEEL IN 8 % H_2SO_4 WITHOUT AND WITH DIFFERENT CONCENTRATIONS OF *Withania somnifera* EXTRACT

Conc. (ppm)	E_{corr} (V)	I_{corr} (A)	β_a (V/decade)	β_b (V/decade)	CR (mpy)	E (%)
0	-0.44	0.0355	0.2742	0.7565	20687	–
90	-0.42	0.0126	0.1481	0.4345	7357	64
180	-0.43	0.0038	0.1062	0.2436	2212	89
300	-0.42	0.0033	0.0979	0.224	1924	91

for *Withania somnifera* provides the values of corrosion current density (I_{corr}) which has been shown in Table-2.

We use these values in the following formula and will find inhibition efficiency using formula (3).

Figs. 2 and 3 represents the polarization curves of mild steel in 8 % H_2SO_4 without and with various concentrations of *Withania somnifera* extract.

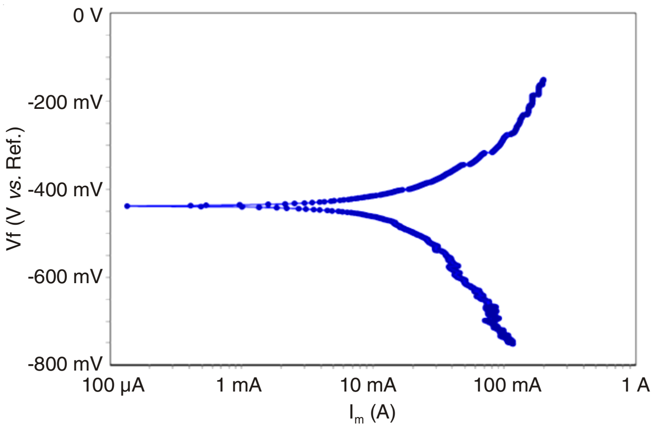

Fig. 2. Tafel polarization curve for mild steel in 8 % H_2SO_4 without *Withania somnifera* extract

Surface analysis: Fig. 4 shows the SEM micrographs of polished mild steel and mild steel strips immersed in 8 % H_2SO_4 without and with *Withania somnifera* inhibitor. A rough surface can be seen for the mild steel immersed in H_2SO_4 without inhibitor which indicates the corrosion on mild steel surface in acidic medium. In the presence of inhibitor a smooth surface can be observed, which indicates that the mild steel surface is covered by inhibitor.

Mechanism of action: In the present study the plant extract we are using contains alkaloids which are explained above. These alkaloids are rich in heteroatoms like N and O. From the IR study of plant extract it has been shown that they contain functional groups like hydroxyl group, amide group,

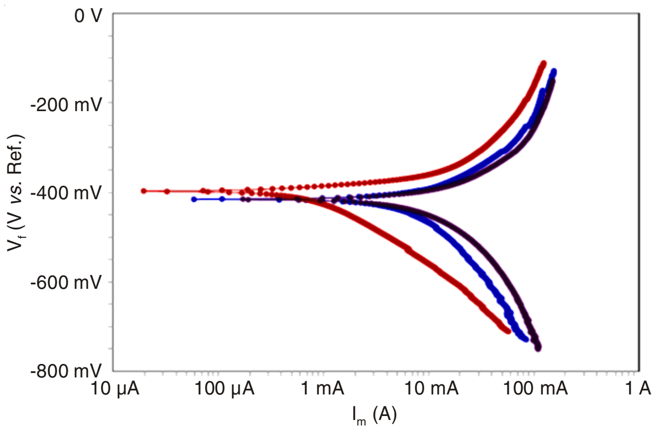

Fig. 3. Tafel polarization curve for mild steel in 8 % H_2SO_4 with different concentrations of *Withania somnifera* extract

carbonyl group *etc*. Hence the IR study also verifies the presence of heteroatoms N, O in the extract. These heteroatoms donate their lone pair of electron to the empty *d*-orbital of Fe. Similarly there is also the interaction between the π-electrons of C=O and empty *d*-orbital of Fe. In such a way the inhibitor adsorb on the mild steel surface and forms a protective thin film by the combination between inhibitor and mild steel surface. This protective film prevents the corrosion of mild steel. The mechanism of corrosion inhibition action of plant extract is diagrammatically shown in the Fig. 5.

Conclusions

In the present study we have considered the plant extract of *Withania somnifera* as inhibitor for mild steel. Here we have determined the corrosion inhibition rate of plant extract for mild steel in 8 % H_2SO_4. From the results results, it is concluded that

• The examined plant extract prevents the corrosion of mild steel in 8 % H_2SO_4 by adsorbing on the mild steel surface.

• We have observed maximum 91 % inhibition efficiency for *Withania somnifera* plant extract at 300 ppm inhibitor concentration with 8 % H_2SO_4.

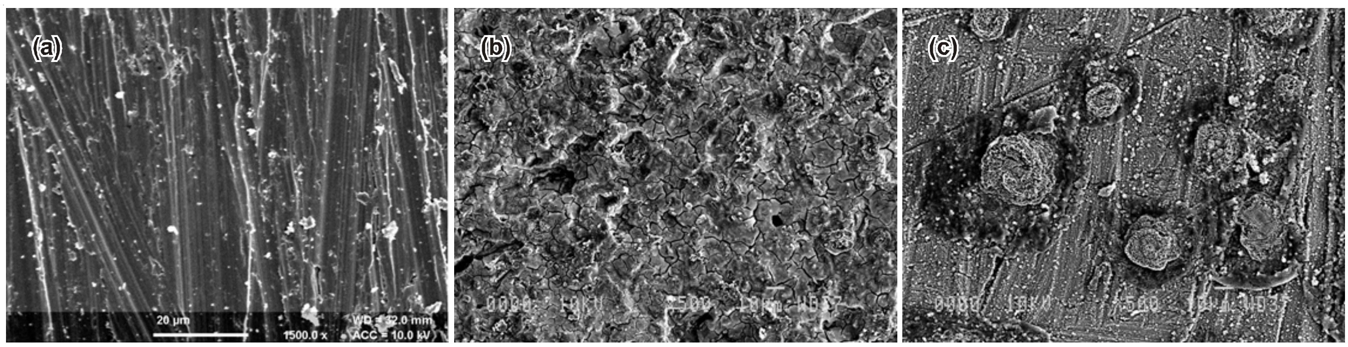

Fig. 4. SEM images of polished mild steel (a), mild steel immersed in 8 % H_2SO_4 without inhibitor (b) and mild steel immersed in 8 % H_2SO_4 saturated with *Withania somnifera* inhibitor (c)

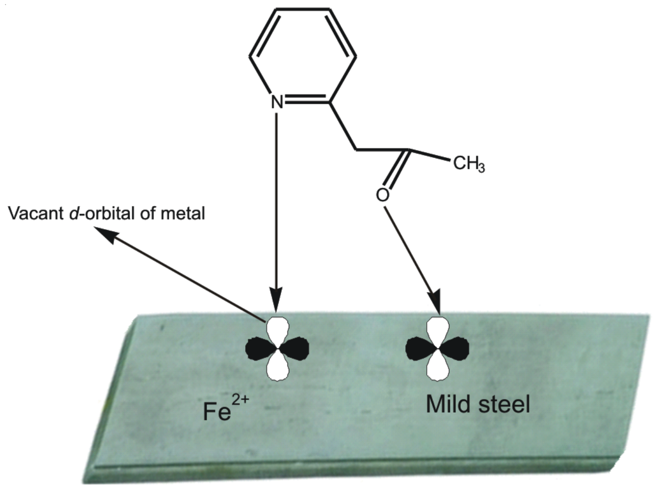

Fig. 5. Mechanism of corrosion inhibition

• It has been seen that corrosion inhibition efficiency increases on increasing the concentration of inhibitor.

Present study may be useful for all those areas where mild steel comes in contact with acidic medium or wherever mild steel corrosion occurs.

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REFERENCES

1. M.A. Quraishi, A. Singh, V.K. Singh, D.K. Yadav and A.K. Singh, *Mater. Chem. Phys.*, **122**, 114 (2010).
2. A.S. Fouda and A.S. Ellithy, *Corros. Sci.*, **51**, 868 (2009).
3. M.A. Quraishi and R. Sardar, *Corros.*, **58**, 103 (2002).
4. H.M. Abd El-Lateef, L.I. Aliyeva, V.M. Abbasov and T.I. Ismayilov, *Adv. Appl. Sci. Res.*, **3**, 1185 (2012).
5. M. Lebrini, M. Lagrenee, H. Vezin, L. Gengembre and F. Bentiss, *Corros. Sci.*, **47**, 485 (2005).
6. F. Bentiss, M. Bouanis, B. Mernari, M. Traisnel, H. Vezin and M. Lagrenée, *Appl. Surf. Sci.*, **253**, 3696 (2007).
7. G. Husnu and S.H. Ibrahim, *Ind. Eng. Chem. Res.*, **51**, 785 (2012).
8. D.K. Yadav, D.S. Chauhan, I. Ahamad and M.A. Quraishi, *RSC Adv.*, **3**, 632 (2013).
9. G. Ji, P. Dwivedi, S. Sundaram and R. Prakash, *Ind. Eng. Chem. Res.*, **52**, 10673 (2013).
10. J. Aljourani, K. Raeissi and M.A. Golozar, *Corros. Sci.*, **51**, 1836 (2009).
11. H. Ashassi-Sorkhabi, D. Seifzadeh and M.G. Hosseini, *Corros. Sci.*, **50**, 3363 (2008).