Natural Plants: An Efficient Inhibitors of Mild Steel Corrosion in H_2SO_4 Acid

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Introduction: Corrosion is a natural occurring process where it can be defined as the deterioration of a material's properties due to its interaction with its environment. Corrosion can lead to failures in plant infrastructure and machines which are usually costly to repair, in terms of loss of contaminated products, environmental damage and possibly costly in terms of human health. Mild steel being the important alloy of iron has found a wide application in industries, constructional materials and machines due to its low cost and excellent mechanical properties despite of its tendency to corrosion in aqueous solution, especially in acidic media. Acid solutions are often used in the industry for industrial acid cleaning, pickling, descaling, oil well acidizing and petrochemical processes which are normally accompanied by considerable dissolution of metal. The use of corrosion inhibitor is usually the most promising, effective, flexible and cost attractive method to reduce the corrosive attack of acid solutions. Many organic compounds prepared in laboratories are used as inhibitors to protect metals from corrosion, but most of them are considered high toxic either to humans or the environment as well as they are expensive and difficult to decompose. At present, it has become a growing need to produce non-toxic inhibitors which are non-toxic for human beings and are environmentally safe, known as green Inhibitors. Green inhibitors consist of non-toxic organic compounds, biodegradable, highly effective and low cost. The extracts of plant parts such as leaves, peels, seeds, fruits, and roots have been reported as effective corrosion inhibitors for metals in different aggressive environments. Therefore, the use of natural products extracted from plants as corrosion inhibitors has become a key area of research as they are extremely rich sources of naturally synthesized chemical compounds that are biodegradable, renewable, and cost-effective as well as can be extracted by simple methods. Plant extracts generally contains mixtures of organic compounds including hetero atoms, multiple bonds, and aromatic rings.

Aim: water extracts of three plants were used as inhibitors for mild steel corrosion in 1.0 N H_2SO_4

Materials and Methods: Mild steel: The study was conducted using mild steel (MS) specimens with composition (weight %) P = 0.02 %, Mn = 0.35 %, S = 0.03 %, Mo = 0.01 %, Ni = 0.04 %, C = 0.21 % and the rest up to 100 % Fe.

Preparation of plants extracts: were prepared by boiling 50 g of each dry grounded *Tribulus Terrestris* (TTAE) (Inh. 1), *Vachellia Nilotica* (VNAE) (Inh. 2) and *Cymbopogeon Schoenanthus* (CSAE) (Inh. 3) in 500 mL of de-ionized water for 2 hrs using a boiling water bath. The resulting solutions (the extracts) were cooled and then filtered to remove suspended impurities. After filtration, water was evaporated from the extracts in an oven at controlled temperature (50-60ºC) to yield a crystalline precipitate. The concentration of the extracts was expressed as w/v.

Preparation of solutions: An aggressive solution (1.0 N H_2SO_4) was prepared using analytical grade reagent and de-ionized water.

Chemical Measurements: The mass loss measurements of mild steel samples in the investigated solutions were determined over a 70-min immersion period. The corrosion rate (RC_{ML}) was calculated in g cm^{-2} min^{-1} using the following equation:

- $$CR_{ML} = \frac{m_i - m_f}{At_\infty} \quad (1)$$

where m_i and m_f are the masses of mild steel before and after immersion, A is the surface area and t_∞ is the immersion time. The percentage of inhibition efficiency (η%) obtained from ML measurements can be calculated as follows:

- $$\eta\% = (1 - \frac{CR_{ML}}{CR^o{}_{ML}}) \times 100 \quad (2)$$

where CR^o_{ML} and CR_{ML} are the corrosion rates obtained from ML measurements without and with a certain concentration of inhibitors, respectively.

Results:

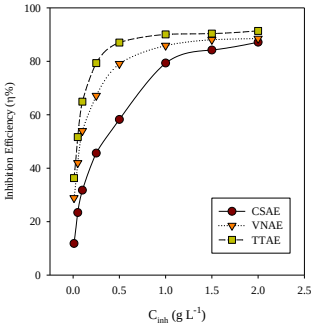


Fig. 1. Relation between η% and concentration of inhibitors.

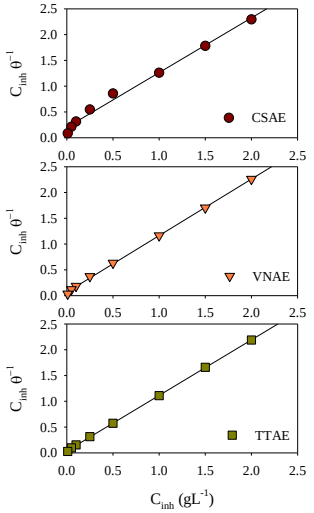


Fig. 2. Fitting of the results obtained by chemical measurements to Langmuir adsorption.

Table 1. Inhibition efficiency obtained from ML measurements for MS in 1.0 N H_2SO_4 in the presence of different concentrations of inhibitors

C_{inh} (g L^{-1})	Inhibition Efficiency (η%)		
	CSAE	VNAE	TTAE
0.01	11.82	28.86	36.31
0.05	23.51	41.97	51.64
0.10	31.77	53.95	64.90
0.25	45.65	67.13	79.39
0.50	58.23	79.09	87.02
1.00	79.36	85.88	90.07
1.50	84.12	88.08	90.39
2.00	87.14	88.51	91.37

Table 2. Langmuir isotherm parameters and activation energy obtained from ML measurements for inhibitors adsorption on MS surface in 1.0 N H_2SO_4.

Inhibitor	slope	K (Lg^{-1})	R^2	$-\Delta G$ ($kJmol^{-1}$)	$E_{app.}$ ($kJmol^{-1}$)
Free acid	-	-	-	-	40.18
CSAE	1.06	4.957	0.991	21.44	62.15
VNAE	1.10	14.916	0.999	24.21	60.60
TTAE	1.08	26.961	0.999	25.71	80.76

Table 3. Inhibition efficiency obtained for MS in 1.0 N H_2SO_4 in the presence of 2.0 g L^{-1} of inhibitors at different temperatures

T (K)	Inhibition Efficiency (η%)		
	CSAE	VNAE	TTAE
303	87.14	88.51	91.37
313	74.58	82.54	86.67
323	62.10	79.41	83.20
333	41.17	76.43	80.99

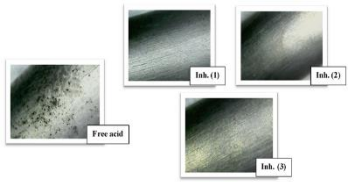


Fig. 3. Macroscopic images for MS specimen in the absence and presence of 2.0 g L^{-1} of inhibitors

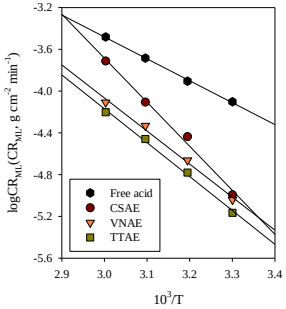


Fig. 4. Arrhenius plots for MS corrosion in 1 N of H_2SO_4 in the absence and presence of 2.0 gL^{-1} of inhibitors

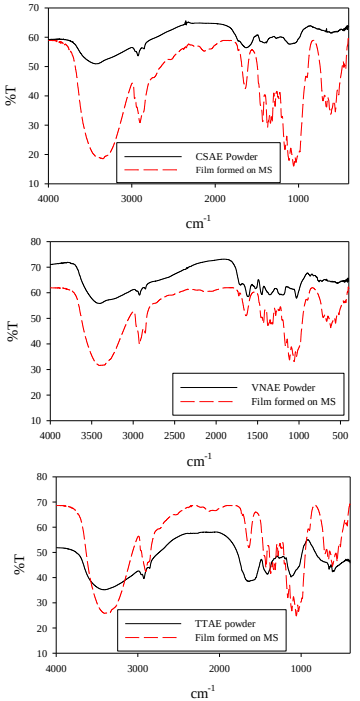


Fig. 5. FTIR spectra of inhibitor powder and film formed on the MS surface.