Chapter 3 Evaluation of the inhibition efficiency of the Coccoloba Uvífera extract, through weight loss in 1M HCl and 3.5% NaCl media

Capítulo 3 Evaluación de la eficiencia de inhibición del extracto de la Coccoloba Uvífera, mediante la pérdida de peso en los medios de 1M HCl y 3.5% NaCl

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Abstract

In the present investigation, the leaf extract of Coccoloba Uvifera (CU) is obtained with the help of the ethanol solvent through the maceration process; It is implemented as a green corrosion inhibitor for 1018 steel in acid and saline solutions. The percentage of corrosion efficiency was evaluated by the weight loss method, which was carried out in two media: 1 M HCl and 3.5% NaCl at times of 27 and 258 h at room temperature. The results indicate that CU can act as an efficient corrosion inhibitor, the maximum inhibition efficiency was achieved at the concentration of 600 ppm after 27 h of immersion in both media (1 M HCl and 3.5% NaCl). The formation of the protective film retards the invasion of aggressive ions and inhibits the corrosion of carbon steel in acidic and saline environments.

Acero 1018, *Coccoloba uvifera*, Inhibition efficiency, Extracts, Weight loss

Resumen

En la presente investigación, se obtiene el extracto de la hoja *de Coccoloba Uvifera (CU)*, con ayuda del solvente de etanol por medio del proceso de maceración; se implementa como inhibidor verde de corrosión para el acero 1018 en soluciones ácidas y salinas. El porcentaje de eficiencia de corrosión fue evaluado por el método de pérdida de peso, el cual se realizó en dos medios: 1 M HCl y 3.5% NaCl en los tiempos de 27 y 258 h a temperatura ambiente. Los resultados indican que *CU* puede actuar como un eficiente inhibidor de corrosión, la máxima eficiencia de inhibición se alcanzó en la concentración de 600 ppm después de 27 h de inmersión en ambos medios (1 M HCl y 3.5% NaCl). La formación de la película protectora retarda la invasión de iones agresivos e inhibir la corrosión del acero al carbono en medios ácidos y salinos.

Acero 1018, *Coccoloba uvifera*, Eficiencia de inhibición, Extractos, Pérdida de peso

1. Introduccion

90% of the pipelines, furnaces and distillation towers that make up the structural area of the oil and gas industry, are constituted by 1018 steel (Li Pubo, 2023)which is singularized by its low maintenance and acquisition costs (Haddadi Seyyed Arash, 2019). In our environment these buildings are fickle to suffer the effect of corrosion; being an impacting factor in the industrial area. Corrosion is a phenomenon that damages the internal or external conformation of metals; it occurs due to electrochemical interaction that is generated in the environment naturally or artificially (Chaubey Namrata, 2021). The impact it has on steel leads to the degradation of the quality of the metal and the safety of structures (Salleh Siti Zuliana, 2021). Corrosion currently causes economic losses in the industrial area, damaging safety measures, environment and health. Therefore, it is necessary to implement alternatives or anti-corrosion treatments for metal that is exposed to this type of media.

Inhibitors have become known as one of the methods for the coating of metals to prevent corrosion and are classified into inorganic and organic (Zhou Zongyi, 2023); among the characteristics of inorganic inhibitors is known the high potential for inhibition in corrosive media and its composition, derived from chemicals, which generate environmental impact, health and the high cost of acquisition that maintain, prompting the search for another method that is more feasible (Zhang Yanli, 2022).

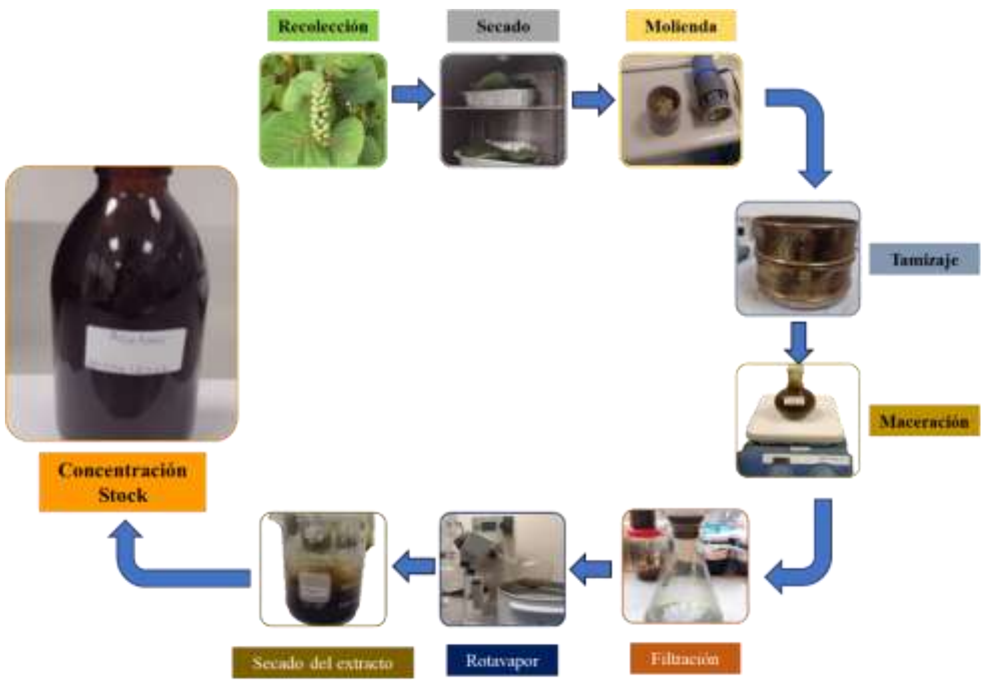
On the other hand, in recent years researchers have focused on implementing organic or green corrosion inhibitors, derived from plant extracts that are a complete mixture of various organic compounds (flavonoids, alkaloids, catechins, terpenoids, and coenzymes) that adhere and protect the metal from the effect of corrosion; In addition, they are biodegradable and have a lower acquisition cost (Oyewole Olamide, 2022) In the Gulf of Mexico there is a wide biodiversity of flora, mainly the Coccoloba Uvífera plant is identified, which is colloquially known as sea grape, this species has been used as food, ornamental and part of its stem as fuel; it is also a plant that can be found at any time of the year, facilitating its acquisition.. For this reason, in the present work, Coccoloba Uvifera (CU) extract, which is produced by the maceration process and used as a green corrosion inhibitor on 1018 steel in two media: 1 M HCl and 3.5% NaCl, is studied. The corrosion inhibition efficiency is evaluated by the weight loss technique in different exposure periods at 27 and 258 hours at room temperature.

2. Methodology to develop

2.1. Obtaining the extract from leaves

The leaves of Coccoloba Uvifera plant were collected in Playa Norte, Ciudad del Carmen, Campeche, cleaned with tap water, distilled water and left to dry. Then, they are cut into small fractions and placed in the oven at 70 °C for 4 days; later they are crushed in a mill and sieved with mesh No. 60. The extract is obtained by the maceration method; using 25 g of leaf powder and as a solvent (ethanol), it is left in agitation for 72 hours. The extract is placed in the rotary evaporator at 40 rpm and 60 °C. Finally, the extract is concentrated in the oven at 50°C for 3 days. The stock solution is prepared from the dried extract, ethanol and distilled water. Figure 1.1 shows the process for obtaining the extract from Coccoloba Uvifera leaves.

Figure 1.1 Process for obtaining Coccoloba Uvifera leaf extract



Source of Consultation: Own Elaboration.

2.2. Specimen preparation

From a cylindrical bar of AISI 1018 steel (diameter 1 inch) the specimens are obtained, which are cut to a height of 2 cm. They are then drilled with a 1/32 drill bit, this space will allow the wire to pass through, for the development of the weight loss technique. Finally, the specimens are polished with silicon carbide sandpaper numbered 60-600 and cleaned with distilled water and acetone. The specimens are stored in a desiccator so that they do not oxidize in the environment.

2.3. Weight loss method

Considering the ASTM G1 standard, weight loss is performed. The corrosion rate of the specimens was determined using 1 M HCl and 3.5% NaCl as corrosive medium and different concentrations of the inhibitor (200, 400, 600, 800 and 1000 ppm). The immersion time was 27 hours and 258 hours at room temperature. The test was performed in triplicate.

The corrosion rate is obtained by means of the following equation:

$$Velocidad\ de\ corrosión \left(\frac{mm}{año}\right) = K\,\frac{\Delta W}{DAT} \qquad (1)$$

Where: K= constant 8.76□104, ΔW= initial weight-final weight (g), A= the exposure area (cm2), D= density of the material (g/cm3) and T= the exposure time (h).

To calculate the inhibitor efficiency:

$$\%Eficiencia\ del\ inhibidor = \frac{Vcorr - Vinh}{Vcorr}\ x\ 100 \quad (2)$$

In which Vcorr corresponds to the corrosion rate of the specimen in acid and saline media, i.e. without inhibitor (blank) and Vinh refers to the corrosion rate of the specimen when inhibitor is present

Figure 1.2 1018 steel specimens subjected to weight loss analysis

Source Of Consultation: Own Elaboration

3. Results and discussions

3.1. Evaluation of the extract using the weight loss technique

Table 1.1 shows the comparison of the corrosion rate results (mm/year) obtained on 1018 steel using different concentrations of the inhibitor in 1 M HCl and immersion times. In both times, it is observed that as the inhibitor concentration increases, the corrosion rate decreases; it is important to note that this behavior is observed up to a concentration of 600 ppm, at higher concentrations the rate increases due to the fact that corrosion is promoted on the material. It is also observed that the longer the exposure time, the higher the corrosion rate

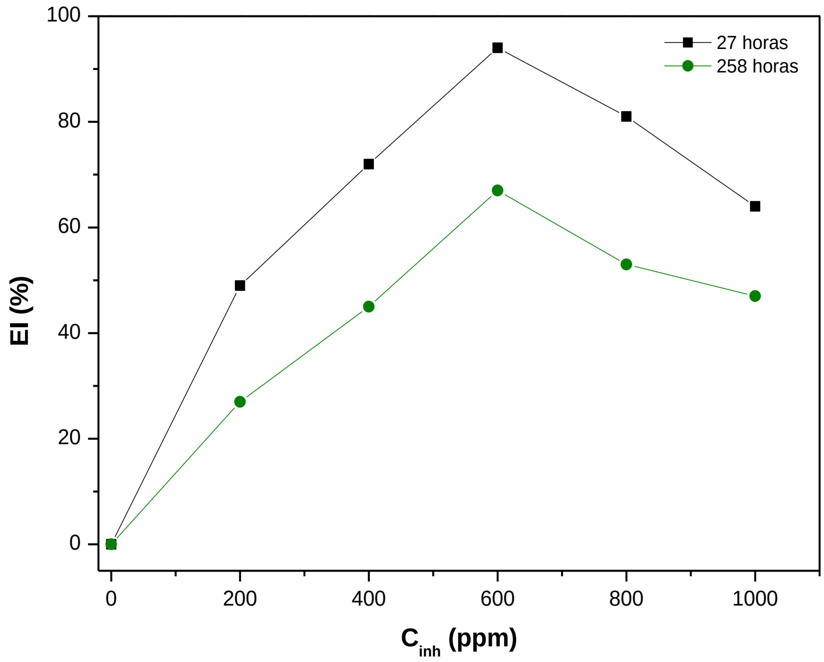
Table 1.1 Corrosion rate values obtained on 1018 steel at different concentrations of the inhibitor in 1 M HCl medium at different exposure times

Concentration (ppm)	Corrosion rate (mm/year)	
	27 horas	258 horas
0	1.49	1.26
200	0.76	0.96
400	0.42	0.67
600	0.09	0.43
800	0.28	0.58
1000	0.54	0.64

Source of Consultation: Own elaboration

Graph 1.1 shows the percentages of inhibition efficiency for 1 M HCl reveals that the percentage of efficiency for the time of 27 hours increases proportionally until reaching the concentration of 600 ppm where it obtains 93%, then it tends to decay until concluding with a percentage similar to that of the concentration of 400 ppm. On the other hand, for the exposure period of 258 h, it is perceived that the displacement takes place proportionally; being the concentration of 600 ppm the one that acquires a percentage of 67% of inhibition and begins to decrease.

Graph 1.1 Inhibitor efficiency values obtained on 1018 steel with different inhibitor concentrations in 1 M HCl



Source of Consultation: Own elaboration

On the other hand, Table 1.2 shows the results obtained in the 3.5% NaCl medium. A similar behavior to the previous case is observed, where the 600 ppm concentration shows low corrosion rate values. Comparing the results in both exposure times, lower values are observed at longer exposure times. This behavior is due to the interaction of the saline medium with the inhibitor.

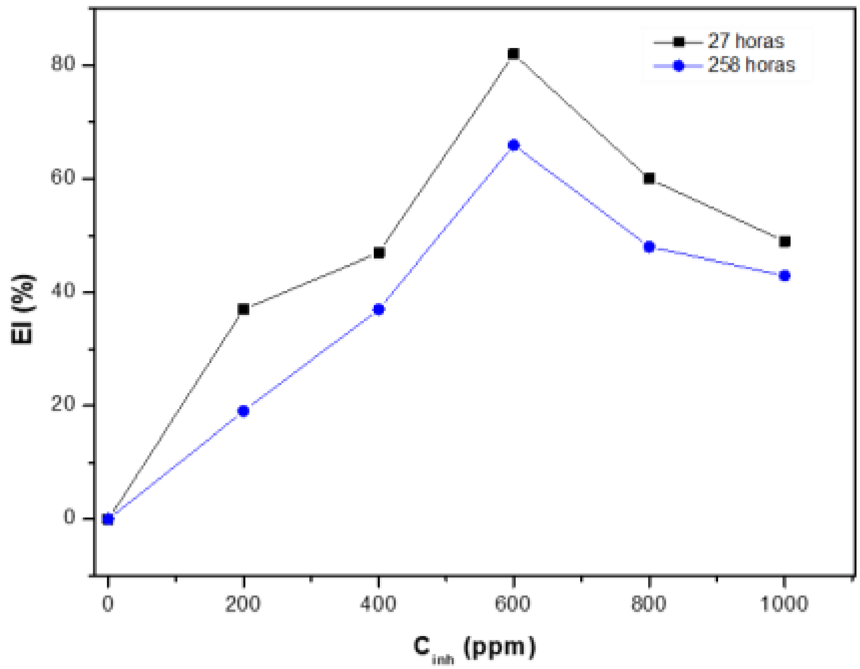
Table 1.2 Corrosion rate values obtained on 1018 steel at different concentrations of the inhibitor in 3.5% NaCl medium at different exposure times

C_{inh} (ppm)	Corrosion rate (mm/year)	
	27 hours	258 hours
0	3.37	0.20
200	2.11	0.17
400	1.77	0.13
600	0.60	0.07
800	1.31	0.11
1000	1.99	0.12

Source of Consultation: Own elaboration

Graph 1.2 shows the inhibition efficiency percentages of steel 1018 in 3.5% NaCl. The behavior is very similar to the acid medium; however, in the chloride medium, slightly lower efficiencies are obtained, but the current inhibitor lasts longer, presenting values around 60% for 258 hours of exposure.

Graph 1.2 Inhibitor efficiency values obtained on 1018 steel with different inhibitor concentrations in 3.5% NaCl



Source of Consultation: Own Elaboration

In order to compare the results obtained in this study with the literature, Table 1.3 shows the inhibitor, material and the percentage of inhibition efficiencies of green extracts. It is observed that the results of the Coccoloba Uvifera extract present similar percentages to the reported extracts; therefore, it can be deduced that the ECU works as a good corrosion inhibitor for both study media.

Table 1.3 Comparison of the efficiency percentages of extracts from green inhibitors using different metals and corrosive media obtained by the weight loss technique

Inhibitor	Type of metal	Inhibition efficiency percentage (%)	
Medium: HCl			
Coccoloba Uvífera	Steel 1018	27 h	258 h
		93.6%	67.0%
Eleusine Indica (Vashishth Priya, 2022)	Iron	91.3%	
Ligularia Fischeri (Prabakaran Mayakrishnan, 2016)	Mild steel	92%	
Mentha Pulegium (Khadraoui A., 2016)	Carbon steel	81%	
Medium: NaCl			
Coccoloba Uvífera	Steel 1018	27 h	258 h
		82.0%	66.0%
Catharanthus Roseus (Palaniappan N, 2019)	Mild steel	84.0%	
Hojas de Anabasis aretioides (Berrani Assia, 2018)	Mild steel	86.0%	
Raíz de Anabasis (Berrani Assia, 2018)	Mild steel	87.0%	

Source of Consultation: Own Elaboration

4. Conclusions

According to the results obtained from the evaluation of the efficiency of the Coccoloba Uvifera extract by weight loss in the 1 M HCl and 3.5% NaCl media at exposure times of 27 and 258 h (at room temperature). In the acid medium, the concentration of 600 ppm presented at 27 hours of exposure an inhibition efficiency of 93%, consequently, a lower corrosion rate. At times greater than 258 hours, the efficiency was around 67%. In the saline medium, it is also observed that the 600 ppm concentration acts at a shorter exposure time; for the case of 27 hours, an inhibition efficiency of 88% is obtained and the corrosion rate of 0.60, for the case of 258 hours, an efficiency of 66% is observed; for this exposure cycle, the corrosion rate decreases. Comparing both media, it was observed that the inhibitor in chloride medium acts for a longer exposure time.

In general, it was observed that the concentration of 600 ppm is the one with the highest percentage of inhibition efficiency and minimum corrosion values in the evaluation of weight loss for these media. Likewise, it was determined that the inhibitor acts better in shorter exposure times, referring to the 27 h that were being worked, it is deduced that this is due to the fact that the evaluation was performed at laboratory level.

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