Spectroscopic and phytochemical characterization of green corrosion inhibitors from leaves of the *Morinda citrifolia* plant based on acetone and ethyl acetate

Caracterización espectroscópica y fitoquímica de inhibidores verdes de corrosión provenientes de hojas de la planta *Morinda citrifolia* a base de acetona y acetato de etilo

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Key Handbooks

In this work we present the obtaining and characterization of acetone and ethyl acetate extracts from the leaves of *Morinda citrifolia*, we study these extracts to know their potential as a candidate corrosion inhibitor, we obtained their spectra and phytochemical tests. To understand this work it is necessary to study the FTIR and UV-Vis spectra, to find the functional groups and compounds of the extracts and to check with the phytochemical tests. It is important to mention that these extracts will be further evaluated as green corrosion inhibitors, in order to have an effective, economical and environmentally friendly method to inhibit the corrosion of metals. The organic compounds of the plant are responsible for reducing the corrosion rate of metals, so their identification is crucial for further evaluation. The authors in order in this book chapter have the following number of citations 0, 4, 3 and 0. The author Sánchez-Martínez has a CONAHCYT scholarship, and the rest of the authors have a PRODEP desirable profile and belong to the National System of Researchers (SNI). All authors are from the Universidad Autónoma del Carmen (State Public Institution). The keywords most frequently used are: spectroscopy, phytochemical tests and *Morinda citrifolia*.

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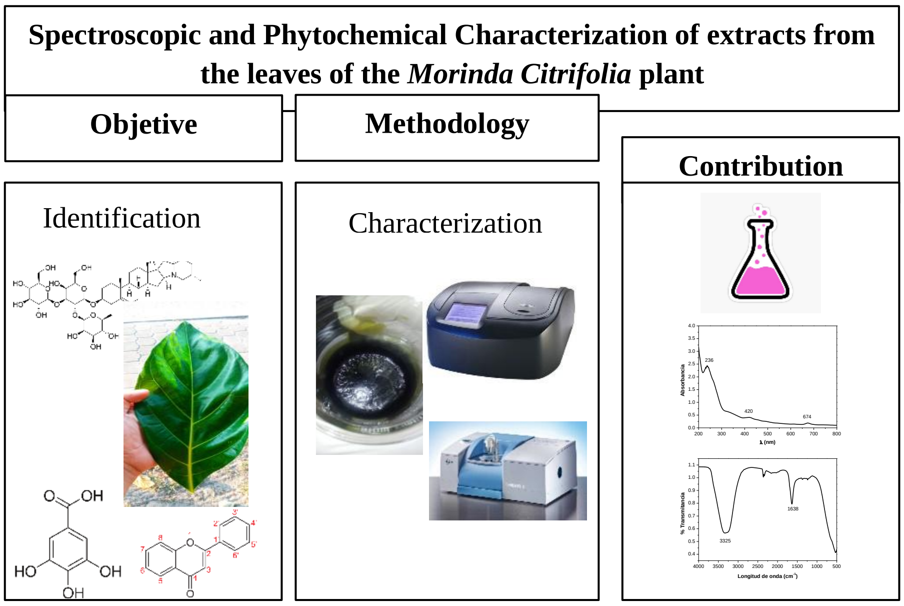
Abstract

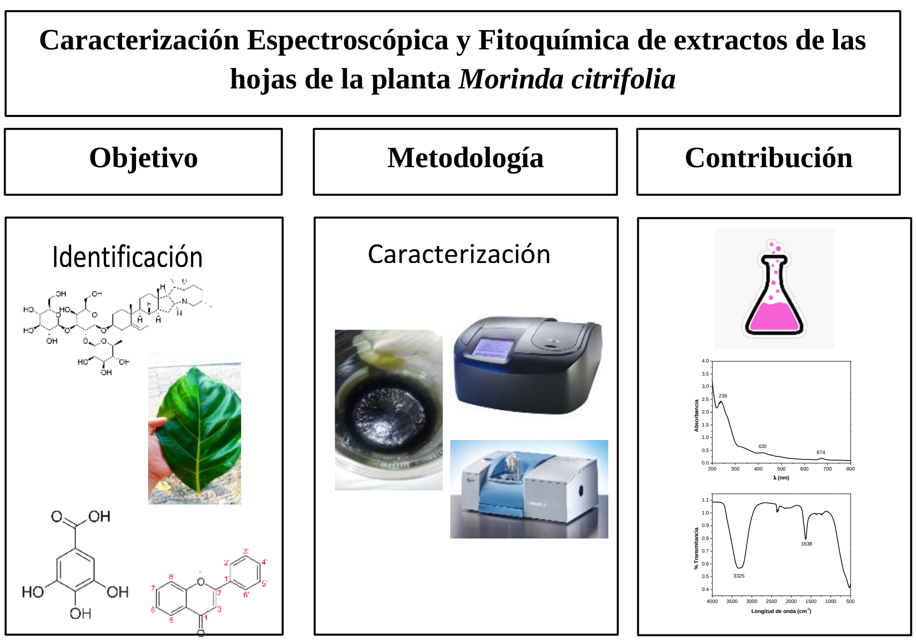
Metals suffer corrosion due to the presence of different corrosive media. One way to prevent corrosion is to develop and use corrosion inhibitors that are effective and environmentally friendly. Plant extracts are good candidates because they do not contain toxic substances. In the present work, extracts of *Morinda citrifolia* leaves were obtained and characterized in acetone and ethyl acetate. The extracts were obtained by maceration for 72 hours. Subsequently, they were characterized by spectroscopic and phytochemical techniques. The spectroscopic techniques showed the presence of anthocyanins and phenolic compounds and aromatic compounds. The phytochemical tests showed flavones, saponins and tannins. Studies showed that acetone and ethyl acetate extracts of *Morinda Citrifolia* leaves contain a mixture of organic compounds and their extraction depends on the solvent used.



Spectroscopy, Phytochemical Test, *Morinda citrifolia*

Resumen

Los metales sufren corrosión debido a la presencia de diferentes medios corrosivos. Una forma de prevenirla es desarrollando y empleando inhibidores de corrosión que sean eficaces y amigables con el mediante ambiente. Los extractos de plantas son buenos candidatos debido a que no contiene sustancias tóxicas. En presente trabajo se obtienen y caracterizan extractos de hojas de la *Morinda citrifolia* en acetona y acetato de etilo. La obtención de los extractos se realizó mediante el proceso de maceración durante 72 horas. Posteriormente, se caracterizaron mediante técnicas espectroscópicas y fitoquímicas. Las técnicas espectroscópicas mostraron la presencia de antocianinas y compuestos fenólicos y compuestos aromáticos. Las pruebas fitoquímicas flavonas, saponinas y taninos. Los estudios realizados mostraron que los extractos de acetona y acetato de etilo de las hojas de *Morinda citrifolia* contienen una mezcla de compuestos orgánicos y su extracción depende de disolvente empleado.



Espectroscopia, Pruebas Fitoquímicas, *Morinda citrifolia*

Introduction

Corrosion is one of the main problems affecting various industries, due to the use of metallic materials and alloys exposed to different aggressive media such as: acids (H_2SO_4), basic ($CaCO_3$, NaOH, $NaHCO_3$), gases (NH_4, H_2S, CH_2O), salts (NaCl) and chemicals. To mitigate this phenomenon, different methods have been developed, including protective coatings, cathodic and anodic protection, as well as corrosion inhibitors. The latter are a key alternative, as they can act through different mechanisms such as passivation, film formation and adsorption. However, the main problem with these inhibitors is that they have a high content of heavy metals and are therefore polluting and hazardous. Therefore, plants (leaf, stem, root, fruit) with high phytochemical content have started to be studied, which makes them promising candidates for the development of green corrosion inhibitors.

In southeastern Mexico, there is a great diversity of flora. In particular, the *Morinda citrifolia* tree , commonly known as Noni, belongs to the *Rubiaceae* family. This tree can reach a height of 5 m and its leaves are over 30 cm long, elliptical, large and shiny. In addition, it contains various organic compounds such as iridoids, terpenes, triterpenes, sterols, flavonoids, lignans, steroids, fatty acid esters with sugar, vitamins and minerals. The authors Franco and Ulloa have reported the use of this plant in the medical area. In addition, the fruit is consumed in the form of juice, the leaves are used in the form of tea for different ailments. Considering that *Morinda citrifolia* has antioxidant properties, it is a good candidate to be studied as a green corrosion inhibitor. For this reason, it is of interest to obtain and characterise the organic compounds present in the extracts of its leaves, using solvents such as acetone and ethyl acetate in the extraction process.

Methodology

Preparation and obtaining the extracts

The leaves of *Morinda citrifolia* were collected at the main campus of the Universidad Autónoma del Carmen (see **Figure 1)**. They were then rinsed with tap water, distilled water and drained for 1 hour. The leaves were then dried in a Hamilton Beach dehydrator at 60°C for 12 hr. At the end of this time, they were crushed in a Y series mill and sieved with an ELE International No. 60 sieve.

Box 1

Figure 1
Morinda citrifolia tree located on the main campus of the Universidad Autónoma del Carmen

Source: Own elaboration

Morinda citrifolia leaf extract was obtained by the maceration process. Acetone and ethyl acetate were used as solvent. Twenty-five g of leaf powder was used in 250 mL of solvent and the solution was left to stir for 72 hours. Subsequently, the extract was filtered and taken to the rotary evaporator at 60°C and 40 RPM. The concentrate obtained was placed in a convection oven at 60°C for 72 hours and finally the standard solution was prepared in 250 mL (see **Figure 2**).

Box 2

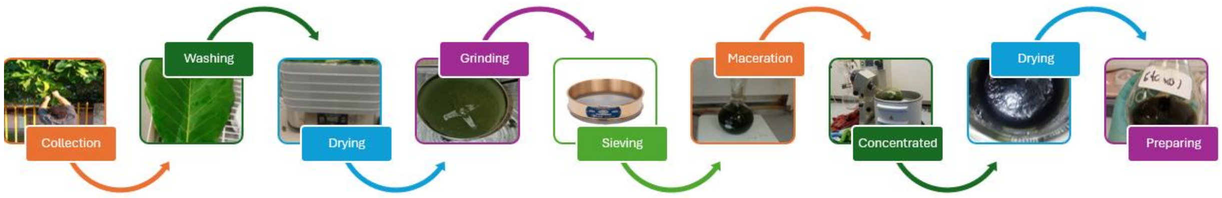


Figure 2
Obtaining and preparing *Morinda citrifolia* leaf extract

Source: *Own elaboration*

Characterisation of plant leaf extracts

The following techniques were used to identify the compounds contained in the *Morinda citrifolia* leaf extracts:

- Spectroscopic Techniques: The extracts were diluted in 10% water for subsequent measurement in UV-Vis spectrophotometer (HACH brand, model DR500). Measurements were made in the range of 200 to 800 nm. The samples were also measured in the FTIR spectrophotometer (Tensor II, Bruker brand) at a resolution of 4 $^{cm-1}$, 32 scans in the range 4000 to 500 $^{cm-1}$ using a diamond-tipped ATR.

- Phytochemical tests: The methodologies proposed by the authors were used to identify flavonoids, saponins and tannins present in the extract. The phytochemical tests used were: Shinoda reaction and reaction with 10% NaOH (flavonoids), reaction with ferric chloride, reaction with grenetin and lead acetate reaction (tannins) and the foam test (saponins). Figure 3 shows some images obtained from the phytochemical tests performed on the extracts.

Box 3

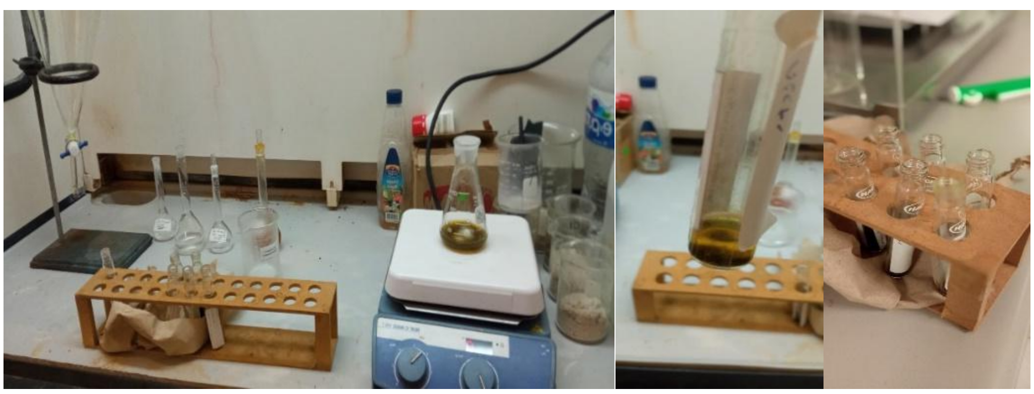


Figure 3
Images of phytochemical tests

Source: *Own elaboration*

Results

In order to know the extraction percentage of the organic compounds contained in the leaves of the *Morinda citrifolia* plant, the yield (% R) of the extract with acetone and ethyl acetate was calculated using the following equation:

$$\% R = \frac{P_s}{P_i} \times 100 \quad [1]$$

Where: P_s is the weight of dry extract of *Morinda citrifolia* leaves (g) and is the initial weight of leaves (g).

Table 1 shows the yields obtained with the two extracts. The extract with acetone had the highest yield. This means that the acetone extract was more efficient in extracting the compounds from the leaves of *Morinda Citrifolia citrifolia*.

Box 4

Table 1
Percentage yield values of *Morinda citrifolia* leaf extracts obtained with different solvents

Solvents	Dry extract (g)	% Performance
Acetone	3.60	14.4
Ethyl acetate	1.56	6.24

Source: own elaboration

Figure 4 shows the UV-VIS spectra obtained from the extract with acetone and ethyl acetate in the range from 200 to 800 nm. The spectrum corresponding to the extract with acetone presents two maximum peaks, the first at 236 nm which corresponds to flavonoids, since in this absorbance range the aromatic compounds are present and flavonoids belong to this group of chemical compounds. The peak at 420 nm and 674 nm is associated with anthocyanins, which belong to the group of flavonoids and provide the pigment (chlorophyll) to the leaves, flowers or fruits of plants. On the other hand, the response of the extract with ethyl acetate does not show the formation of a maximum peak. As can be seen, the solvent used in the extraction process has an effect on obtaining the components from the plant leaves.

Box 5

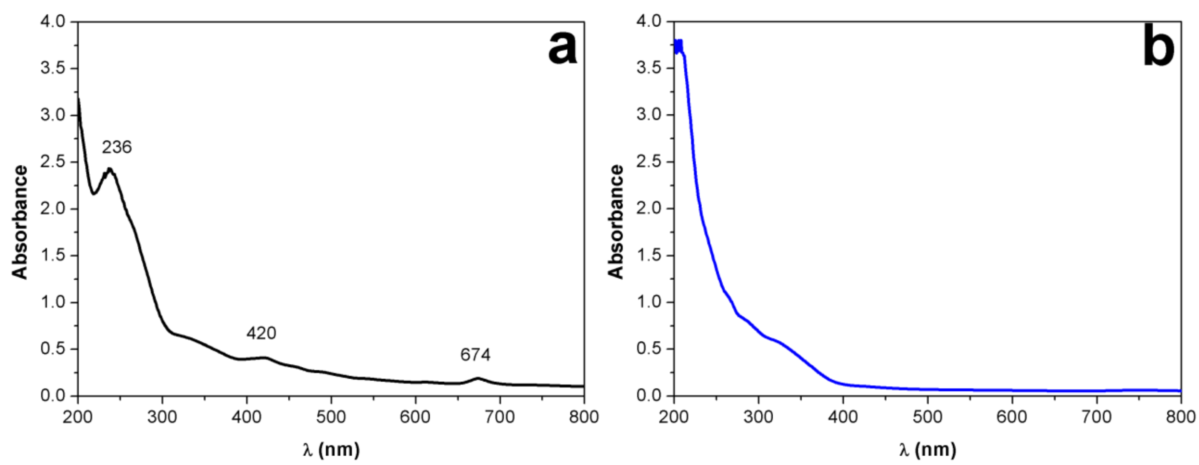


Figure 4
UV-Vis spectra obtained from (a) acetone and (b) ethyl acetate extract of *Morinda citrifolia* leaves

Source: Own elaboration

To identify the presence of organic compounds (secondary metabolites) in the extracts, the FTIR spectroscopy technique was used. **Figure 4** shows the FTIR spectra obtained from *Morinda Citrifolia* leaf extracts with different solvents in the range of 4000 to 500 $^{cm-1}$. In both cases, different adsorption peaks are observed. An adsorption peak is observed at 3325-3320 $^{cm-1}$ and 1638 $^{cm-1}$, which can be associated with the O-H and C-H bond of the phenolic group. The stretching vibration of the C=O bond is also observed at 1613 $^{cm-1}$. In addition, the stretching peak at 1044-1019 $^{cm-1}$ associated with the C-O bond is described

Box 6

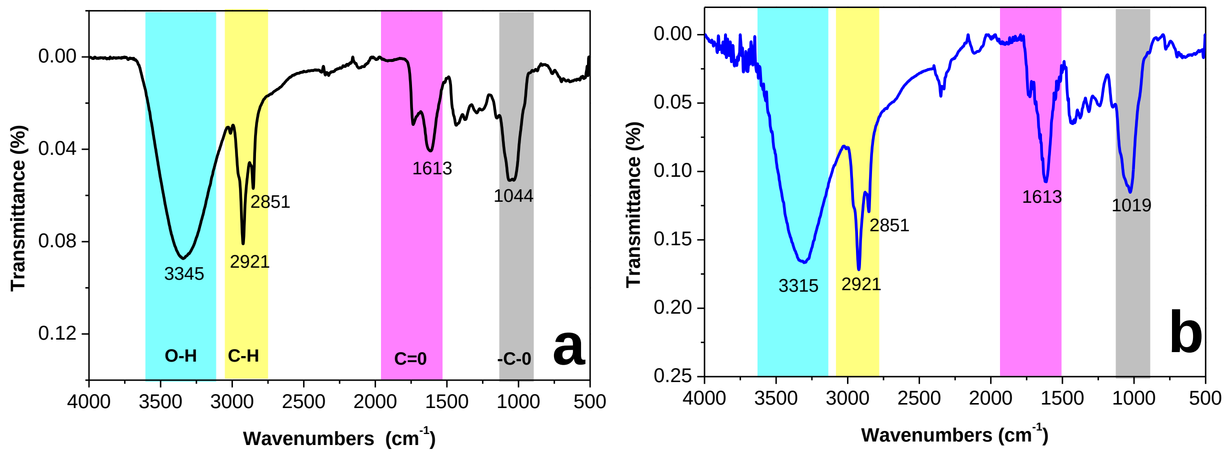


Figure 4
FTIR spectra obtained from (a) acetone and (b) ethyl acetate extract of *Morinda citrifolia* leaves

Source: *Own elaboration*

Table 2 shows the results obtained from the phytochemical tests used for the two extracts. It can be observed in both extracts the presence of tannins, saponins and flavonas.

Box 7

Table 2
Results of phytochemical tests obtained with extracts of *Morinda citrifolia* leaves with different solvents

Phytochemicals/solvents	Colouring	Acetone	Ethyl acetate
Flavonoids	Yellow precipitate	-	-
Tannins	Light yellow	+	+
Saponins	N/A	+	+
Flavones	Light green	+	+
Tannins Catechol	Dark green	-	-

Source: own elaboration

Conclusions

Acetone is widely recognised as an effective solvent for extracting phytochemicals from plant materials, and offers several advantages as well as certain disadvantages. Its ability to produce high concentrations of bioactive compounds makes it a popular choice in phytochemical research. The acetonitrile extract is a better candidate for use as a corrosion inhibitor, because a greater variety of phytochemicals were identified compared to the other extracts. The absorbance of these extracts is higher because it contains more compounds absorbing in the UV-Vis spectrum (420 nm and 674 nm), although the phytochemical tests showed the same results compared to the ethyl acetate inhibitor, its UV-Vis spectrum showed more peaks.

Declarations

Conflict of interest

The authors declare that they have no conflicts of interest. They have no financial interests or personal relationships that could have influenced this book.

Authors' contribution

Sánchez Martínez, Víctor Alberto: Supported the experimental development and writing of the paper.
Figueroa Ramírez, Sandra Jazmín: Contributed to the analysis of the results.
Benavides, Olena: Reviewed the work.
Sierra Grajeda, Juan Manuel: Contributed to the review of the results.

Availability of data and materials

Data are available on request at: sfigueroa@pampano.unacar.mx

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This research work was carried out with own resources.

Abbreviations

UV-Vis	Ultraviolet-visible
FTIR	Fourier Transform Infrared
ATR	Attenuated Total Reflectance

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References

Background

Cárdenas Pinzón, L. K., & López Cárdenas, D. (2020). *Analysis of the Use of Inhibitors to Mitigate Internal Corrosion in Oil Formation Water Pipelines* [Thesis]. Fundación Universidad de América.

Franco, M., Herrera-Hernández, H., García-Orozco, I., & Herrasti, P. (2018). Natural aqueous extract of Morinda Citrifolia as a corrosion inhibitor of AISI-1045 steel in acidic HCl environments. *Journal of Metallurgy*, *54*(4).

Madu, J. O., Ifeakachukwu, C., Okorodudu, U., Adams, F. V., & Joseph, I. V. (2019). Corrosion Inhibition Efficiency of Terminalia Catappa Leaves Extracts on Stainless Steel in Hydrochloric Acid. *Journal of Physics: Conference Series*, *1378*(2).

Razafimandimbison, S. G., McDowell, T. D., Halford, D. A., & Bremer, B. (2010). Origin of the pantropical and nutriceutical Morinda citrifolia L. (Rubiaceae): Comments on its distribution range and circumscription. *Journal of Biogeography*, *37*(3), 520-529.

Royani, A., Hanafi, M., Haldhar, R., & Manaf, A. (2024). Evaluation of Morinda citrifolia extract as sustainable inhibitor for mild steel in saline environment. *Journal of Engineering Research (Kuwait)*.

Ulloa, J. A., Rosas Ulloa, P., Carmen Ramírez Ramírez, J., Estela, B., & Rangel, U. (2012). Noni: properties, uses and potential applications. In *Revista Fuente Año (* Vol. 4, Issue 10). ISSN: 2007-7521.

Basics

C, R. U., & Mala Nair, V. (2013). Phytochemical analysis of successive reextracts of the leaves of moringa ISSN- 0975-1491. oleifera lam.

Royani, A., Hanafi, M., Haldhar, R., & Manaf, A. (2024). Evaluation of Morinda citrifolia extract as sustainable inhibitor for mild steel in saline environment. *Journal of Engineering Research (Kuwait)*.

Shaibu Auwal, M., Saka, S., Alhaji Mairiga, I., Abba Sanda, K., Shuaibu, A., Ibrahim, A., & Shaibu Auwal DVM, M. (2014). Preliminary phytochemical and elemental analysis of aqueous and fractionated pod extracts of Acacia nilotica (Thorn mimosa). In *ARTICLE Veterinary Research Forum* (Vol. 5, Issue 2).

Support

Benítez-Benítez, R., Sarria-Villa, R. A., Gallo-Corredor, J. A., Pérez Pacheco, N. O., Álvarez Sandoval, J. H., & Giraldo Aristizabal, C. I. (2020). Obtaining and yield of ethanolic extract of two medicinal plants. *Revista Facultad de Ciencias Básicas*, *15*(1), 31-40.

Fleming, I., & Williams, D. (2019). Ultraviolet and Visible Spectra. In *Spectroscopic Methods in Organic Chemistry* (pp. 55-83). Springer International Publishing.

Mamudu, U., Santos, J. H., Umoren, S. A., Alnarabiji, M. S., & Lim, R. C. (2024). Investigations of corrosion inhibition of ethanolic extract of Dillenia suffruticosa leaves as a green corrosion inhibitor of mild steel in hydrochloric acid medium. Corrosion Communications, 15, 52-62.