

## Research Article

# CORROSION INHIBITION EFFECT OF LEAVES OF MOMORDICADIOICA FOR COPPER (CU) IN HNO<sub>3</sub>

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### ABSTRACT

This research work is performed to find out the effects of aerial part that is leaves of Momordicadioica as corrosion inhibitor on copper (Cu) in nitric acid medium. This plant is angiosperm of the family of Cucurbitaceae and this is well-known in India and other peripheral regions of South Asia. The plants are believed as rich in phytochemicals that have much good potential. Through this research it is obtained that leaves extract of this spiny gourd is very useful to hinder the corrosion effect on copper in nitric acid contamination. Hence, a cheap and eco-friendly inhibitor of corrosion is found for copper coating through this study. Therefore, the materials and methods are presented in this research paper to demonstrate the process of experiment, and final observation indicates the efficacy of the leaf extract of Momordicadioica as the corrosion inhibitor green product.

**Keywords:** corrosion, copper, inhibitors, metal

### INTRODUCTION

Corrosion is an electrochemical process that degrades the myrtles and their alloys in that situation where the actual properties of the metal and alloys vanish. Corrosion is not only impacted on the iron materials but also generates an asteroid effect on the copper material. Copper is a metal and chemical element that has 29<sup>th</sup> position in the atomic number table. This element is considered as one of the malleable, soft and ductile compounds used widely in industrial purposes. The major use of copper is related to electricity conduction as it has a high electrical and thermal conductivity. In addition to this, it is the only metal that is available in nature is ready to use the metallic form. Majorly it is a red-orange metal and has lustre highly. It is believed that copper is the only metal that is used by humans along with gold and iron. On that content, copper can easily be alloyed with other metals and due to its high conductivity property; it is highly used in the industry and good commercial metal. Therefore, two common alloys of copper denote **brass** and **bronze**. Apart from industrial use copper is an essential part of human nutrition as this mineral is found essential for the formation of blood cells. In addition to this, copper was also appraised to have antibacterial properties along with proven toxicity for the invertebrates. These two properties are highly used to coat the door handles used by the public and to coat the ships in order to avoid the clutching of barnacles and mussels. Another use of copper is sometimes seen to control the algae involvement. On the other hand, as copper is used in the industries where many acids are also used for manufacturing purposes corrosion happens and as a result, huge amounts of loss can be faced by the industries. There are many acids present in nature that can hamper copper and its properties. Among all the acids nitric is considered as one of the effective solutions to make copper rust that is called patina. Therefore, industries need the best quality inhibitors to coat the copper and hinder the corrosion effect. Chemical compounds such as **Azole** and **amines** are proven best for copper coating. Additionally, **amino base drugs** and **Schiff base** compounds are highly used for the inhibitor purpose in copper corrosion. However, the majority of the above inhibitors are costly and

non-eco-friendly. Therefore, green naturals are investigated in this experiment to conclude the effectiveness of organic compounds. Polymers such as **deoxyribonucleic acid** and **chitosan** are widely used as organic inhibitors for copper coating. Hence, the detection of these polymers in the chosen plant is aimed in this study. Here, **Momordicadioica** is subjected to investigating its corrosion efficiency regarding the leaf's extraction of this plant. In the end, the study was majorly conducted to find an ecologically beneficial, eco-friendly, non-toxic and cheaper organic compound that can act as a corrosion inhibitor.

### METHODS AND MATERIAL

#### Plant Description

**Momordicadioica** is an angiosperm plant of the Cucurbitaceae family. This plant is generally found in India and other regions of South Asia. The fruit of this plant is used as vegetables in those parts of South Asia and is commonly known as Spine Gourd. The underground tuber of this plant is used for propagation purposes. There are small leaves, yellow-coloured small flowers, and small, green and oval-shaped fruits, but this type of plant has two separate plants: female and male<sup>1</sup>. Hence, the dry weight and nutritions are more in the aerial parts or leaves of the male individual. There is 84.1% of water content in 100 g of fruit and 7.7 g of carbohydrate. There are also 3.1 g protein, 3.1 g fat, 3 g of fiber, and 1.1 g of minerals in the parts of Momordicadioica. There are some essential vitamins in this plant like riboflavin, thiamin, niacin, carotene, ascorbic acid etc. In different parts of Momordicadioica, different organic elements are present that have many medicinal values<sup>2</sup>. This is used as the traditional natural remedy for type 2 diabetes that is increasing

<sup>1</sup>Chung, Ill-Min, Kaliyaperumal Rekha, Govindasamy Rajakumar, and Muthu Thiruvengadam. "Jasmonic and salicylic acids enhanced phytochemical production and biological activities in cell suspension cultures of spine gourd (*Momordica dioica* Roxb)." *Acta Biologica Hungarica* 68, no. 1 (2017): 88-100.

<sup>2</sup>Du, Junqiao, Lai Yue Chan, Aaron G. Poth, and David J. Craik. "Discovery and characterization of cyclic and acyclic trypsin inhibitors from *momordica dioica*." *Journal of natural products* 82, no. 2 (2019): 293-300.

daily. Besides this, this plant has antioxidant properties, antimicrobial properties and it is believed that this plant has corrosion inhibition factors. Therefore, this plant with such medicinal values is also exported to many parts of the world and the fruits of this plant have a slight bitterness in taste. These completely edible fruits are a part of regular food habits in India and other parts of South Asia. For this, the fruits and all over plants are commercially beneficial to the local people and for better growth, many people cultivate these with special care.



Figure 1: Momordicadioica<sup>3</sup>

The extracts of the body parts of Momordicadioica are non-toxic and natural products. That is why this is used for several experiments in medicinal and other purposes. In the same way, the experiment is very much useful to establish the corrosion inhibition effects of the aerial parts, that is leaves of Momordicadioica. Corrosion is a decaying process of metals that can take place naturally to form more stable oxides or any other form of that metal. This can cause a loss of mass of the metal, which is a threat to the economical sides of that metal<sup>4</sup>. Here the experiment is to identify the corrosion inhibition effects of leaf extract of Spine Gourd plant on copper (Cu) in the medium of HNO<sub>3</sub>.

## Experimental

The experiment of finding out the effects of leaves of Momordicadioica as the corrosion inhibitor on copper in the acidic medium of Nitric acid is performed in this research work. This is to utilise natural products as the inhibition factor so that the costs will be decreased for coating the metals and the process will be environmentally friendly. For this experimental process, the solutions of nitric acid should be prepared at the initial point as this is the main medium. The solution has to be prepared by using double distilled water to ensure that there is no unwanted material in the solution. Here the acid medium is used as the electrolytic solution, henceforth; there should not be any other chemicals in that solution<sup>5</sup>. The reagents are prepared as per the instructions of standard measurements. There are three different strengths of acid solutions that are 1N, 2N, and 3N. In the meantime, the leaves of Momordicadioica are dipped into ethanol for plenty of time to extract the chemicals, and ethanol prohibits other impurities or microbial growth in the extract. After the preparation of acid solutions and leaf extract, different beakers are taken to make different corrosion inhibitor solutions. There are three different sets of solutions for 1N,

2N, and 3N solutions respectively. In each group, there is one blank solution, and the other four parts containing 0.1%, 0.3%, 0.5%, and 0.7% of the leaf extracts. The copper pieces are suspended in each solution by a V-shaped glass hook. This is to evaluate in which concentration the efficiency of corrosion inhibition is the highest. The copper pieces are suspended in the solution set of 1N HNO<sub>3</sub> medium for 54 hours 32 min, 36 hours 2 min for the solution set of 2N HNO<sub>3</sub> medium, and 23 hours 24 min for the solution set of 3N HNO<sub>3</sub> medium. After the end of these processes, the suspended copper pieces are brought out of the solution and washed thoroughly with tap water. After drying those pieces in air final weights are measured for each piece of copper and the differences are found by subtracting these measurements from the initial ones.

The percentage of inhibition efficiency are calculated with the formula as,

$$n\% = [(DWu - DWi) / DWi] * 100$$

### Calculation for 1N HNO<sub>3</sub> medium:

Amount of Extract in Solution	Rate of Inhibition in Acid Solution Without Leaf Extract (%)	Rate of Inhibition after adding Leaf Extract (%)
0.1%	68	76
0.3%	68	82
0.5%	68	89
0.7%	68	95

Table 1: Calculation of effectiveness in 1N Nitric Acid Medium

(Source: Self-created)

### Calculation for 2N HNO<sub>3</sub> medium:

Amount of Extract in Solution	Rate of Inhibition in Acid Solution Without Leaf Extract (%)	Rate of Inhibition after adding Leaf Extract (%)
0.1%	74	80
0.3%	74	86
0.5%	74	91
0.7%	74	96

Table 2: Calculation of effectiveness in 2N Nitric Acid Medium

(Source: Self-created)

### Calculation for 3N HNO<sub>3</sub> medium:

Amount of Extract in Solution	Rate of Inhibition in Acid Solution Without Leaf Extract (%)	Rate of Inhibition after adding Leaf Extract (%)
0.1%	76	83
0.3%	76	89
0.5%	76	92
0.7%	76	97

Table 3: Calculation of effectiveness in 3N Nitric Acid Medium

(Source: Self-created)

## DISCUSSION AND RESULT

This experiment is performed to see the efficiency of the corrosion inhibition effect of the leaf extract of **Momordicadioica** on copper (Cu) through an HNO<sub>3</sub> medium. Corrosion is a natural process that causes the decaying of metals by forming a more stable form of compounds of that metal. This reaction is a permanent chemical reaction so that if this occurs, there is no way to recover from it. In the case of copper, if this metal remains open in the environment it reacts with oxygen of the air, which turns the bright copper colour to tarnish,

<sup>3</sup>b4fn.org". *momordica-dioica*. 2021. <http://www.b4fn.org/resources/species-database/detail/momordica-dioica/> (Accessed on 8 July 2021)

<sup>4</sup>Navarro, Ignacio J., Víctor Yepes, José V. Martí, and Fernando González-Vidosa. "Life cycle impact assessment of corrosion preventive designs applied to prestressed concrete bridge decks." *Journal of Cleaner Production* 196 (2018): 698-713.

<sup>5</sup>Lgaz, H., R. Salghi, and Ismat H. Ali. "Corrosion inhibition behavior of 9-hydroxyrisperidone as a green corrosion inhibitor for mild steel in hydrochloric acid: electrochemical, DFT and MD simulations studies." *Int. J. Electrochem. Sci* 13 (2018): 250-264.

and gradually that can be dark brown or black<sup>6</sup>. The preliminary reaction is  $4\text{Cu} + \text{O}_2 = 2\text{Cu}_2\text{O}$ .

The results of corrosion affect the economics as this takes place in metals like copper, iron, aluminum, etc. that are commercially beneficial. If the metals decayed naturally it results in a great loss and that is why the initiative should be there to coat the metals with corrosion inhibitors. Here the experiment is focused on the extraction of chemicals from the aerial parts of the Momordicadioica or Spine Gourd to inhibit the corrosion process that is a natural product. The importance of using natural products or phytochemicals is, this is non-toxic and easily available<sup>7</sup>. Previous research work shows that green products have good effects on corrosion inhibitors as these are rich in oxygen, nitrogen, carbon, and other necessary chemicals. These chemicals can make a protective film on the metal so that air cannot react with that metal directly. The coating of natural products is environmentally friendly. Additionally, the leaves of Spine Gourd are wasted in a vast amount in India and other parts of South Asia. Therefore, this is very cost-effective to collect the materials and methods can be cost-effective. This can help the industries to make more profit if they can save the useful metals from corrosion by using cheap natural materials. The body parts of Momordicadioica are rich in different phytochemicals and these are well-known all over India and the peripheral regions of South Asia. For the beneficial chemical constituents of this plant, the people of those regions, intake fruits in their regular diet<sup>8</sup>. The local people believe that this slightly bitter vegetable is good for diabetic patients and the researchers also work on this to find out its proteins and other chemicals to treat diabetes mellitus patients, cancerous problems, microbial infections, etc.

In this experimental work, there is a need to bring out the extract of the leaves of Spine Gourd to make a solution of the chemicals of those aerial parts. For this, the extraction has been performed with ethanol to prevent other impurities. The acidic solutions of nitric acid of different strengths have been prepared with double distilled water so that any unwanted minerals cannot interrupt the calculation<sup>9</sup>. The acid solutions have been prepared in 1N, 2N, and 3N strengths and the extracts have been added in each set according to four different concentrations, 0.1%, 0.3%, 0.5%, and 0.7% respectively. The copper pieces have been suspended in the solutions for a quality time to get an adequate surface coat and the time duration is different for three different sets of the inhibitor solutions. For 1N HNO<sub>3</sub> medium, duration is 54 hours 32 min, for 2N HNO<sub>3</sub> medium duration is 36 hours 2 min and for 3N HNO<sub>3</sub> medium, duration is 23 hours 24 min. These different strengths of the acid medium and different concentrations of leaf extract have been prepared to identify the optimum concentrations and strengths to receive the optimum level of efficacy. Every solution has been taken in equal to 50ml amount so that there is no other discrimination except different concentrations of leaf extract and different strengths of nitric acid. The weights of copper pieces have been collected at the initial stage and after the completion of the process. Therefore, the efficacy has been calculated with the formula,  $n\% = \frac{[DWu - DWi]}{DWi} * 100$ . Here, DWu is the initial weight loss in the acid solution when the leaf extract has not been added and the DWi is the weight loss at the end of the process where the leaf extract has been added to the solution.

<sup>6</sup>"copper.org". Protection. 2021. <https://www.copper.org/resources/properties/protection/underground.html> (Accessed on 9 July 2021)

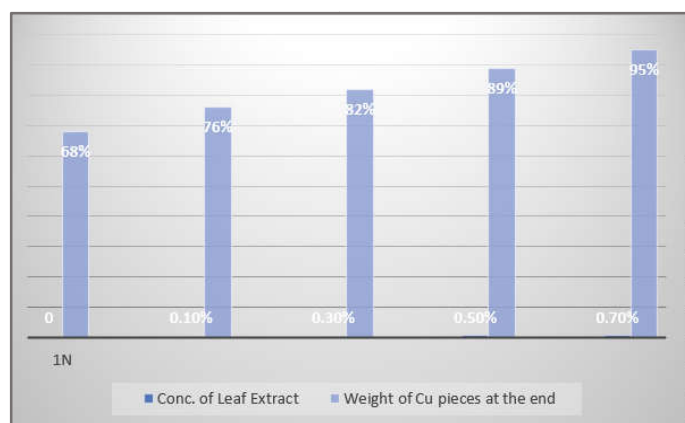
<sup>7</sup>Hamilton-Amachree, Akens, and Nkem Bartholomew Iroha. "Corrosion inhibition of API 5L X80 pipeline steel in acidic environment using aqueous extract of Thevetia peruviana." *Chem. Int.* 6, no. 3 (2020): 110-121.

<sup>8</sup>Poovitha, Sundar, Muddineni Siva Sai, and Madasamy Parani. "Protein extract from the fruit pulp of Momordica dioica shows anti-diabetic, anti-lipidemic and antioxidant activity in diabetic rats." *Journal of Functional Foods* 33 (2017): 181-187.

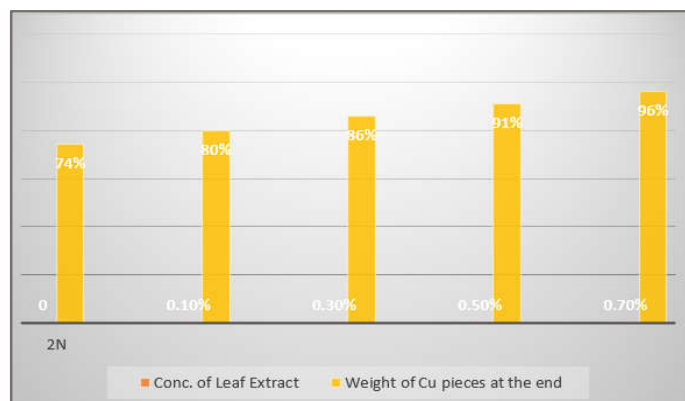
<sup>9</sup>Lgaz, H., R. Salghi, and Ismat H. Ali. "Corrosion inhibition behavior of 9-hydroxyrisperidone as a green corrosion inhibitor for mild steel in hydrochloric acid: electrochemical, DFT and MD simulations studies." *Int. J. Electrochem. Sci* 13 (2018): 250-264.

Strengths of HNO <sub>3</sub> Medium	Conc. of Leaf Extract	Weight of Cu pieces at the end
1N	Blank (0%)	68%
	0.1%	76%
	0.3%	82%
	0.5%	89%
2N	0.7%	95%
	Blank (0%)	74%
	0.1%	80%
	0.3%	86%
3N	0.5%	91%
	0.7%	96%
	Blank (0%)	76%
	0.1%	83%
	0.3%	89%
	0.5%	92%
	0.7%	97%

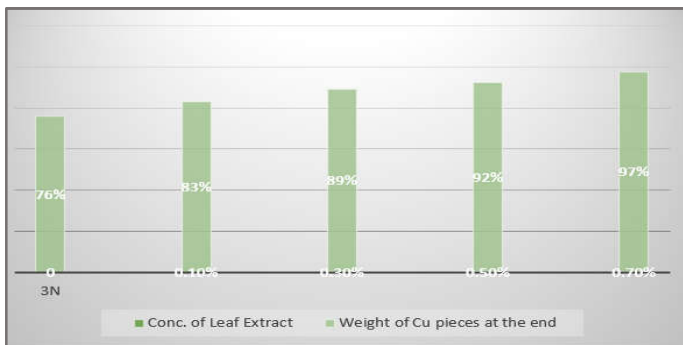
**Table 4: Observation of the Experiment**  
(Source: Self-created)



**Figure 2: Graph of values of 1N HNO<sub>3</sub> medium**  
(Source: Self-created)



**Figure 3: Graph of the values of 2N HNO<sub>3</sub> medium**  
(Source: Self-created)



**Figure 4: Graph of the values of 3N HNO<sub>3</sub> medium**  
(Source: Self-created)

From the above observation this can be concluded that the final findings of the effects of the leaf extract as corrosion inhibitor are 68%, 74%, 76% respectively for 1N, 2N and 3N HNO<sub>3</sub> solutions without adding the leaf extract. In 1N acid solutions the rates have increased as 76%, 82%, 89% and 95% with addition of 0.1%, 0.3%, 0.5% and 0.7% leaf extract respectively. In the same method it has been observed that the inhibition efficiency has increased gradually in the 2N and 3N acid solutions also. 80%, 86%, 91% and 96% inhibition rates have been noticed with the addition of 0.1%, 0.3%, 0.5% and 0.7% leaf extracts respectively in 2N HNO<sub>3</sub> solution. In 3N HNO<sub>3</sub> solution, addition of 0.1%, 0.3%, 0.5% and 0.7% of the leaf extracts have shown the increasing inhibition rates as 83%, 89%, 92% and 97% respectively. The highest amount of surface coating has been formed in the case of 3N HNO<sub>3</sub> medium with 0.7% concentration of leaf extract as the efficiency rate indicates as 97% as per calculation, and the copper pieces have been suspended in this set of 3N HNO<sub>3</sub> medium for the shortest duration, that is 23 hour 24 mins. Therefore, this is effective for the corrosion inhibition on copper in the medium of nitric acid.

## CONCLUSION

This research work is to find out the effects of aerial parts or leaves of Momordicadioica or Spine Gourd on copper (Cu) through the nitric acid medium. The fruits of this plant are used as vegetables in India and other parts of South Asia and have a little bitter taste. It is also believed that this plant has many useful phytochemicals and is used as the health protector for diabetic patients in their regular diet. Here the leaves of this plant are used to observe the potential of natural green products to inhibit the corrosion process. Hence, this will be beneficial as the natural products are cost-effective, easily available, and non-toxic. The observations of the experiment have demonstrated that 0.7% of this leaf extract can perform the highest efficacy level in 3N HNO<sub>3</sub> medium within 23 hours 24 min.

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