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Corrosion inhibitive effect of extract of seeds of *Momordica dioica* for Iron (Fe) in HNO_3

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Abstract

This study is majorly conducted to investigate the corrosion effectiveness of spiny gourd's seed on the iron suspended in HNO_3. Therefore, the major aim of this experiment lies on the evaluation of biodegradable and non-pollutant green natural compound for corrosion hindrance in the iron material which came contact with the nitric acid. The chemical constituent of the *Momordica dioica* has also been highlighted in this study. Appropriate calculation has also been done in this study to analyse the effectiveness of the seeds. The seeds are used for preventing eczema and different skin problems in different regions of India, Pakistan, and Sri Lanka. In has been seen that the efficiency of the seed increased at a specific temperature and after that it decreased. On the other hand, this efficiency was also dependent on the strength of HNO_3 and the concentration of the seed extract. In order to analyse the effectiveness, two methods that were the weight loss and thermometric method were used in this research.

1. Introduction

Corrosion is natural but an electrochemical effect that occurs within the metals or alloys when these metals or alloys are fabricated due to coming in contact with moist air or water. The effect of corrosion is as harsh as it produces detruded metals and declines its properties. Corrosion has majorly shown in the iron substances and makes it less commercial. Iron is a metal and a chemical element that is considered one of the most common and essential metals of the earth. Additionally, it is the most common metal that is used across the world for commercial purposes. This is the metal that is available in the market with the cheapest price and strongest property. The iron is mainly used in the steel products. On the other hand, it is also used to construct many objects such as machine parts, tools, machines, building parts and automobile parts.

Therefore, rusting is commercial damage for iron industries as oxidation of iron occurs in the acid solutions that lead to the evolution of hydrogen gas. There are many acids present in the air which can dotoid the metals

as well as the iron and alloys. On the other hand, industries also utilize various acids for manufacture along with using metallic instruments and machines. Therefore, industries need corrosion inhibitors that can hinder the effect of rusting and slow down the corrosion process. There are many corrosion inhibitors available in the market that is used by the industries such as heterocyclic elements and their derivatives. Additionally, a variety of N and S ligands reuse as corrosion inhibitors. A current report says that ***Cefaclor*** and ***Clindamycin*** are the safest for iron coating and effective for corrosion inhibition. In addition to this ***Mannich*** based inhibitors are also proven as effective corrosion inhibitors for iron material. ***Antibacterial Drug*** based corrosion inhibitors are also effective for inhibiting the corrosion of mild steel.

However, all these above products are best to hinder the corrosion effect on the iron metal but are too costly and not eco-friendly. Sometimes They are proved toxic as the iron coating therefore, the industries need less costly and eco-friendly corrosion inhibitors for commercial purposes. In addition to this, if the corrosion inhibitors are organic then both the cost and the toxicity after coating the metals with corrosion inhibitors will decline. This research is conducted to identify where natural compounds work as corrosion inhibitors and reduce the corrosion effectiveness in the metals. On that content, there are a huge number of green natural extracts that can be used as medicine for not only the lining object but also for the non-lining objects. Plant extract of *Holy basil, Ocimum sanctum*, seed extract of *Mucuna pruriens* are used for medical purposes and the exact effect in the corrosion inhibition is still not clear. Therefore, in this study, ***Momordica dioica*** is chosen and its extract from the seed is used to investigate the corridor inhibition effect on the iron metals in the sulphuric acid solution. In the end, the effectiveness of this study relates to the identification of less toxic, eco-friendly, cheaper and non-polluting natural corrosion inhibitors for the iron material suspended in the HNO3.

2. Methods and material

Plant Description

The chemical elements that are present in *Momordica dioica* include flavonoids, glycosides, ursolic acid, triterpenoid, glycosides, steroids, saponin, and alkaloids. The common name of this plant is balsam pear or spine gourd or spiny gourd[1]. This flowering plant is under the Cucurbitaceae family and is used for different medicinal purposes such as snake bites, fever, and inflammation treatment. This plant is also effective to treat the disease diabetes. The Fruits of this plant are short-beaked, obtuse, densely echinate having a soft spine, and become green coloured at maturity. The seeds are rounded and irregular. The seeds of this plant are commercially important for the local regional people for their high nutritional value. It is used as an edible vegetable in India, Sri Lanka, and Pakistan.

7.7 g of carbohydrate is present in the fruits and it also contains protein, fruit, and fibres. Vitamins and minerals are also present in this vegetable. The seeds of this plant are capable of preventing the free radicals and in the mixture of acidic concentrations; the seeds prevent the formation of O_2. It also has different

[1]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.

activities such as neuroprotective activity, nephroprotective activity, and analgesic activity. From September to November the fruits are observed in the plants.

Figure 1: Seeds of *Momordica dioica*

(Source: Erdoğan *et al.* 2017)

There are many benefits of this plant such as preventing cancer, improving digestion, controlling high blood pressure, and controlling sugar. Consumption of this vegetable also improves the immune system. It increases eyesight and helps in removing kidney stones. It is also known as Karol, Kankro, teasel gourd, Bhat Korola, and Agakara[2]. The root part of this plant is cut into small pieces to prepare medicine for fever, snake bites, and eye disease.

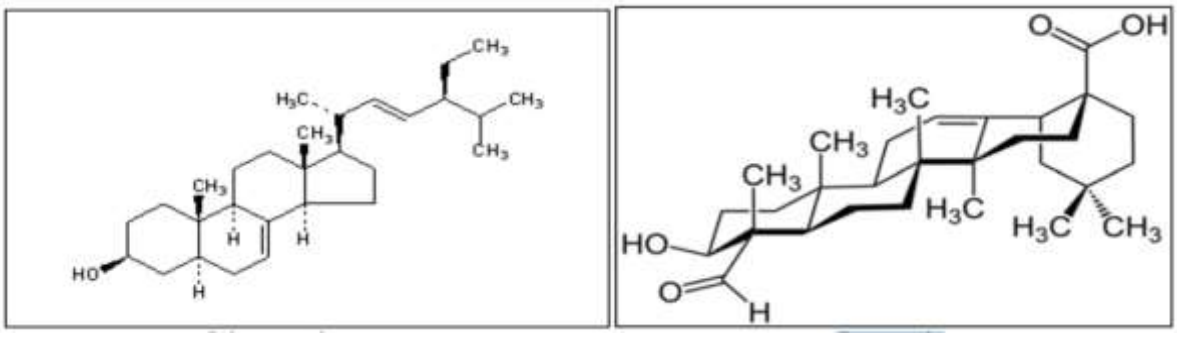

Figure 2: Chemical composition of *Momordica dioica* seeds (Spiranosterol and Gypsogenin)

(Source: Erdoğan *et al.* 2017)

The seeds of *Momordica dioica* are made up of the alkaloid groups, Spiranosterol and Gypsogenin. Anti-H lectin is also found in the seeds of this plant and these seeds are used for preventing eczema and different skin

[2]Miralrio, Alan, and Araceli Espinoza Vázquez. "Plant extracts as green corrosion inhibitors for different metal surfaces and corrosive media: A review." *Processes* 8, no. 8 (2020): 942.

problems. Different research has also revealed that the seeds of this plant act as effective insecticides[3]. The seed alkaloid is known as momordicin whereas root alkaloid is known as *Momordica foetida*.

Experimental

Two different methods were used in this research to analyse the corrosion rate and the effectiveness of the inhibitors. In this case, the inhibitor was *Momordica dioica* seed extract. In the weight-loss method, the iron pieces were exposed in the 1N, 2N, and 3N HNO_3 solution respectively. After a specific time period that was 23 hr 5 min in the case of 1N HNO_3, 8Hr 14 Min in the case of 2N HNO_3, and 1 Hr 22 Min in the case of 3N HNO_3, the iron pieces were taken out, washed, and soaked. The inhibitor's concentration used in this research was 0.1%, 0.3%, 0.5% and 0.7% in different strengths of the HNO_3 solution. In order to analyse the effectiveness of the inhibitors that are the seed extract of *Momordica dioica*, the final weight of the Fe was observed. Below is the seed extract efficiency calculating formula in which seed extract was used as a corrosion inhibitor.

DWu - DWi

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

DWu = weight loss of Fe in HNO_3 without seed extract

DWi = weight loss of Fe in HNO_3 with seed extract

The calculation for the 1N HNO_3 solution

Time:23 Hr 5 Min

The effectiveness of stem extract has been calculated using the below formula.

$$\eta\% = (\Delta Wu - \Delta Wi/ \Delta Wi) * 100$$

Final wight of Fe in different concentration of the inhibitors have been described below for 1N, 2N, and 3N HNO3.

Inhibitor concentration	**The final weight of Fe after applying concentrated stem extract**
In the case of blank concentration	72%

[3]Umoren, Saviour A., Moses M. Solomon, Ime B. Obot, and Rami K. Suleiman. "A critical review on the recent studies on plant biomaterials as corrosion inhibitors for industrial metals." *Journal of Industrial and Engineering Chemistry* 76 (2019): 91-115.

In the case of 0.1% inhibitor concentration	76%
In the case of 0.3% inhibitor concentration	84%
In the case of 0.5% inhibitor concentration	90%
In the case of 0.7% inhibitor concentration	94%

Table 1: final weight of Fe in 1N HNO_3

(Source: Self-created)

It has been seen in the experimenter that the efficiency of corrosion inhibition was 16.67% in 0.1%inhibitor concentration. In the case of 0.3% inhibitor concentration, the corrosion efficiency was 75%. 0.5%inhibitor concentration the efficiency was 180% and in 0.7%inhibitor concentration the efficiency was 366.67%.

The calculation for the 2N HNO_3 solution

Time4: 8Hr 14 Min

Inhibitor concentration	**The final weight of Fe after applying concentrated stem extract**
In the case of blank concentration	75%
In the case of 0.1% inhibitor concentration	79%
In the case of 0.3% inhibitor concentration	86%
In the case of 0.5% inhibitor concentration	91%
In the case of 0.7% inhibitor concentration	95%

Table2: final weight of Fe in 2N HNO_3

(Source: Self-created)

The table has shown that the efficiency of the seed extract was 19.04% in *the case of* 0.1%inhibitor concentration. In 0.3%inhibitor concentration the efficiency rate was 78.57% and in 0.5% concentration the efficiency rate was 177.77%. In 0.7% concentration, the efficiency rate was 400%.

The calculation for the 3N HNO_3 solution

Time: 1 Hr 22 Min

Inhibitor concentration	**The final weight of Fe after applying concentrated stem extract**
In the case of blank concentration	77%
In the case of 0.1% inhibitor concentration	81%
In the case of 0.3% inhibitor concentration	89%
In the case of 0.5% inhibitor concentration	93%
In the case of 0.7% inhibitor concentration	98%

Table 3: final weight of Fe in 3N HNO_3

(Source: Self-created)

The table has shown that the efficiency of the seed extract was 21.05% in the case of0.1%inhibitor concentration. In 0.3%inhibitor concentration the efficiency rate was 109.09% and in 0.5% concentration the efficiency rate was 228.57%. In 0.7% concentration, the efficiency rate was 1050%.

In the thermometric process, the Fe pieces were immersed in the mixture of HNO_3 and seed extract that was the inhibitor. A thermometric bulb was also present in the beaker containing the mixed solution and it was also immersed in the Dewar Flask. The formula to calculate the reaction number is given below.

Reaction Number = (Tm – Ti)/t

Here, Tm represented the Maximum Temperature

'Ti' represented the Initial Temperature

't' denoted the required time to attain the maximum temperature

3. Discussion and result

In this section discussion of the effectiveness of *Momordica dioica* seed extract as a corrosion inhibitor has been done. This section has also shed light on the results gained from the experiments. The data findings are4 presented in the below table and through the graphical representation.

Strengths of HNO3	**Seed extract concentrations**	**The final weight of Fe after applying concentrated Seed extract**
1N	Blank	72%
	0.1%	76%
	0.3%	84%
	0.5%	90%
	0.7%	94%

2N	Blank	75%
	0.1%	79%
	0.3%	86%
	0.5%	91%
	0.7%	95%
3N	Blank	77%
	0.1%	81%
	0.3%	89%
	0.5%	93%
	0.7%	98%

Table 4: Final metal weigh in different HNO_3 strength and different concentrated seed extract

(Source: Self-created)

In the above table the final weight of Fe in 1N, 2N, and 3N solution along with 0.1%, 0.3%, and 0.5% concentrated seed extract were represented. It has been cleared from the table that the final weight of Fe was highest in the case of 3N and 0.7% seed extract concentrated solution. Similarly, Popoola *et al.* in this research shown that with the increasing rate of extract concentration the rate of weight loss decreased[4].

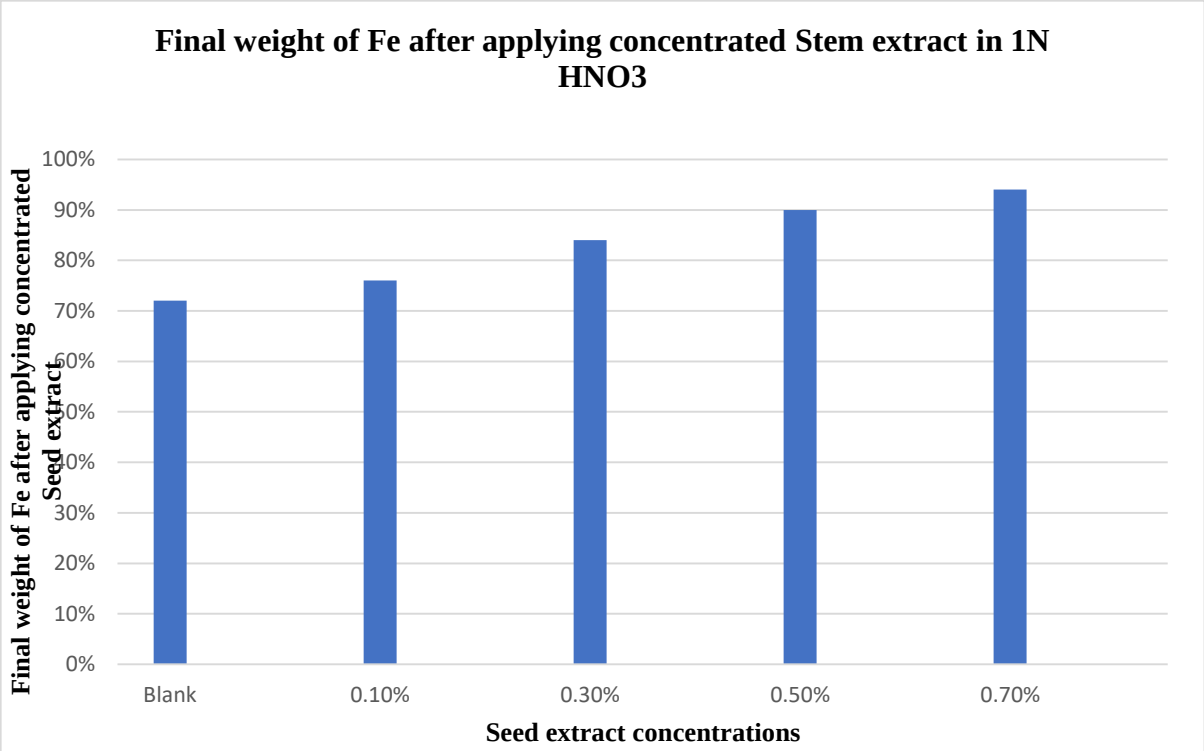

Figure 3: Final weight of Fe after applying concentrated Stem extract in 1N HNO_3

(Source: Self-created)

The graphical data of the weight of Fe in different concentration of the stem extract in 1N HNO_3 has been represented. The weight of Fe in the absence of stem extract was 72% which is given for accurate comparisons. In 0.1% concentration, the weight of Fe was 76%, in 0.3% was 84%, in 0.5% was 90%, and in 0.7% was 94%.

The highest rate of inhibition efficiency observed in the case of 1N HNO_3 solution was in 0.7% concentrated seed extract. The loss of weight, in this case, was 6% as the final weight of Fe was 94%.

[4]Popoola, Lekan Taofeek. "Organic green corrosion inhibitors (OGCIs): a critical review." *Corrosion Reviews* 37, no. 2 (2019): 71-102.

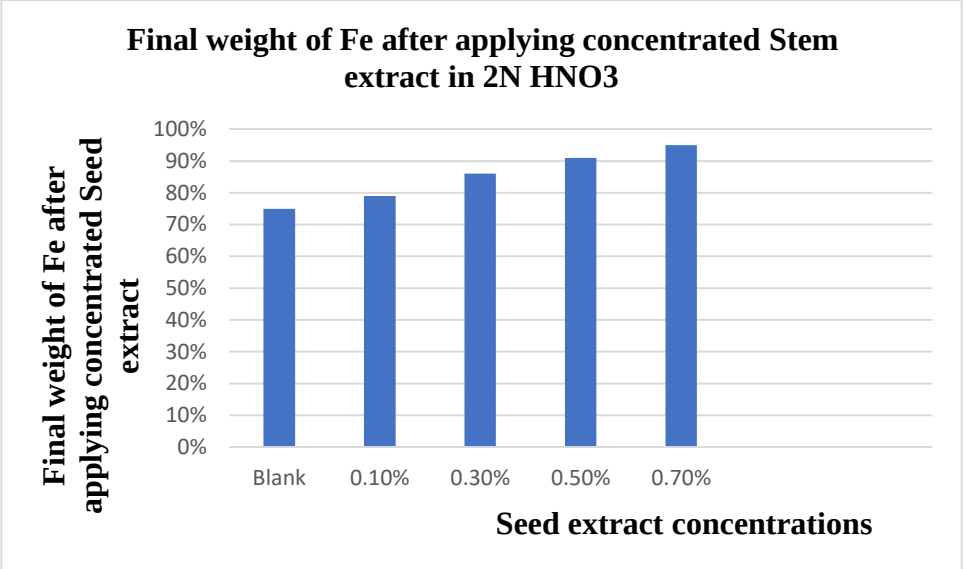

Figure4: Final weight of Fe after applying concentrated Stem extract in 2N HNO_3

(Source: Self-created)

The graphical data of the weight of Fe in different concentration of the stem extract in 2N HNO_3 has been represented. The weight of Fe in the absence of stem extract was 75% which is given for accurate comparisons. In 0.1% concentration, the weight of Fe was 79%, in 0.3% was 86%, in 0.5% was 91%, and in 0.7% was 95%. The above figure represents the efficiency of the inhibitor was higher in the case of 0.7% in which the final weight of Fe was 95% and the loss of weight was reduced by 5%. El-Hashemy *et al.* in their research showed that the maximum percentage of inhibition was observed with the highest seed extract concentration[5].

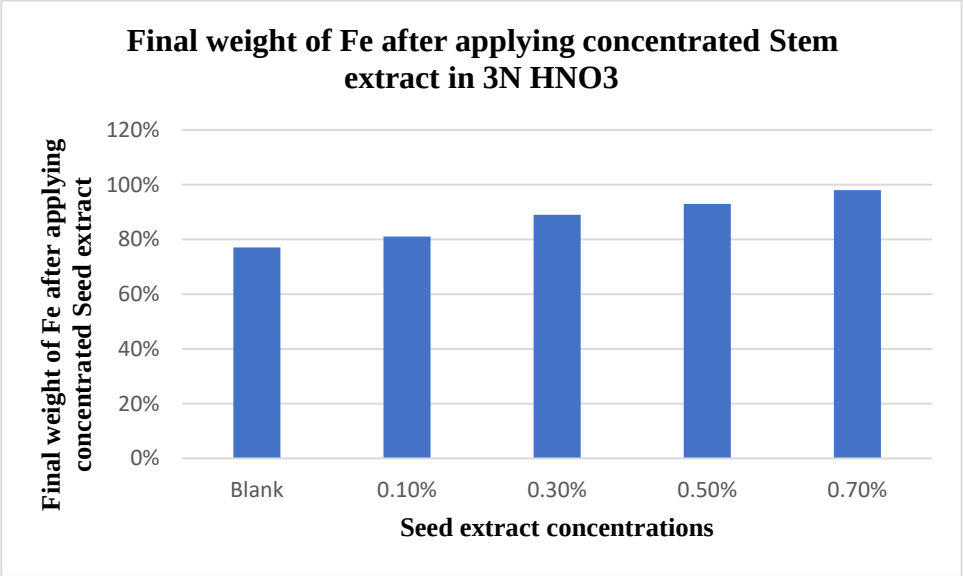

Figure 5: Final weight of Fe after applying concentrated Stem extract in 3N HNO_3

(Source: Self-created)

[5] El-Hashemy, Mohammed A., and Amal Sallam. "The inhibitive action of Calendula officinalis flower heads extract for mild steel corrosion in 1 M HCl solution." *Journal of Materials Research and Technology* 9, no. 6 (2020): 13509-13523. https://www.sciencedirect.com/science/article/pii/S2238785420318032

The graphical data of the weight of Fe in different concentration of the stem extract in 3N HNO_3 has been represented. The weight of Fe in the absence of stem extract was 77% which is given for accurate comparisons. In 0.1% concentration, the weight of Fe was 81%, in 0.3% was 89%, in 0.5% was 93%, and in 0.7% was 98%. The highest rate of inhibitory action was observed in the case of 0.7% concentrated seed extract in 3 N HNO_3. The loss of metallic weight was 2% for which the efficiency of corrosion inhibition increased to 1050%. El-Hashemy*et al.* has shown that the effectiveness of the inhibitor is also dependent on the temperature. The corrosion inhibition efficiency increases with increased temperature[6].

The efficiency of seed as a corrosion inhibitor

Different studies have revealed that the efficiency of the seed extract is lower than the leave extract to act as an inhibitor for corrosion. The seed extract is able to block the corrosion inhibition sites of the metals. The adsorption of the Fe extract increases with the increase in temperature. The efficiency of the seed extract is also dependent on the phytochemical constituents of the seeds. The rate of efficiency of the ethanolic solution increases with the increase in temperature. On the other hand, the efficiency rate of the extract decreases with increased temperature.

Different depending factors for corrosion inhibition

The rate of corrosion is dependent on different factors such as the concentration, dispersion rate, velocity, temperature, fluid composition, and instability presence. The major sources of corrosion in the oil industry are HCl. The other source also includes H_2SO_4, H_2S, and HNO_3. Hydrogen sulphide is a dangerous substance to cause damage to different materials. It is more soluble than water, O_2, and CO_2. Chloride also corrodes in the presence of high temperatures those results in the production of liquid hydrocarbons and methane. The effects can also be perceived with the use of spectrometer.

Thermometric and weight loss method

The thermometric and weight loss methods are effective methods to identify the effectiveness of the inhibitors in different concentrations and in different temperatures. The thermometric test shows the effect of increased and decreased temperature on the performance of the plant extract. On the other hand, the loss of metallic weight denotes the corrosion rate of the metals. In this research, it has been seen that the rate of loss of weight decreased within the increased concentration. The least weight loss was observed in the case of 3N HNO_3 with 0.7% seed extract. The efficiency of the seed extract was also higher in this case.

4. Conclusion

Based on the above discussion it can be concluded that the efficiency of the seed extract increased at the highest HNO3 concentration. On the other hand, the efficiency was also dependent on the concentration of the seed extract. The efficiency was increased with the increase of acidic strength and extract concentration. The

[6]Popoola, Lekan Taofeek. "Progress on pharmaceutical drugs, plant extracts and ionic liquids as corrosion inhibitors." *Heliyon* 5, no. 2 (2019): e01143. https://www.sciencedirect.com/science/article/pii/S2405844018334261

rate of Fe weight loss decreased with the increased extract concentration. It has also been highlighted in the study that the efficiency of the seed extract is also dependent on the temperature. The efficiency increased up to a certain temperature but after that, the seed extract's efficiency decreased that shows a feedback loop effect in the reaction

The process of experiment has been deceived in this study efficiently. This study has also shed light on the chemical composition of Momordica *dioica*. It has also been highlighted in the study that the efficiency of the seed extract is also dependent on the phytochemical constituents of the plant extracts. A brief illustration has been given about the dependent factors for corrosion. It has been stated that temperature and fluid concentration have a significant impact on the extract's efficiency. Through the weight-loss method, the efficiency of the seed extract in different HNO_3 strengths has been highlighted. Thus, it can be stated that the seed extracts are efficient to prevent Fe metals from corrosion.

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