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Investigation on the Role of Various Eco-Friendly Materials which acts as a Corrosion Inhibitor for Mild Steel and HYSD Bars

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Abstract:** This study was carried out to investigate the role of natural materials as corrosion inhibitors for Mild Steel (MS) and High Yield Strength Deformed Bars (HYSD). The results obtained using various materials on MS and HYSD were compared to find out the highest inhibition efficiency. Green corrosion inhibitors are eco-friendly and do not produce any toxic wastes compared to commercial synthetic inhibitors. Synthetic materials which are used as corrosion inhibitors like chromates, pectin, sulphates, etc., produce toxic wastes which affect the environment and other living organisms. While using extracts of planet friendly materials, no harm to the environment occurs due to their bio-degradability nature. In this work, extracts from various plant species such as Musa paradisiaca, Azadiratcha indica, Citrullus lanatus were investigated by altering parameters such as concentration and time for its corrosion inhibition efficiency for Mild steel and HYSD bars under 0.5M Sulphuric acid medium. The investigation was carried out by using weight loss method and comparison was done to find the most effective inhibitor. The results obtained for different extracts on different specimens at different time periods proved that these natural products can be effectively used as corrosion inhibitors replacing the synthetic ones on active usage.
Keywords:** Corrosion inhibitors, Musa paradisiaca, Azadiratcha indica, Citrullus lanatu, Weight Loss.

I. INTRODUCTION

Traditionally, reduction of corrosion has been managed by various methods including cathodic protection, process control, reduction of the metal impurity content, and application of surface treatment techniques, as well as incorporation of suitable alloys. However, the use of corrosion inhibitors has proven to be the easiest and cheapest method for corrosion protection and prevention in acidic media. Many researchers have recently focused on corrosion prevention methods using green inhibitors for mild steel in acidic solutions to mimic industrial processes. Industrial processes such as acid cleaning, pickling, descaling, and drilling operations in oil and gas exploration use acidic solutions extensively and as such iron and steel vessels or surfaces used in these environments are prone to corrosion. Natural products such as plant extract, amino acids, proteins, and biopolymers have been reported to be efficient corrosion inhibitors [1]. Corrosion is a phenomenon where chemistry helps to explain its mechanism and role of ions and energy behind it. Corrosion attack can be prevented by various methods such as materials improvement, combination of production fluids, process control, and chemical inhibition [4].The study of corrosion inhibition using inhibitor in acidic media is one of the most challenging areas in the current research. The majority of well-known inhibitors are organic compounds containing heteroatoms, such as O, N, S and multiple bonds. Although many synthetic compounds show good anticorrosive properties, most of them are highly toxic to both human beings and environments. The natural product extracts are viewed as an incredibly rich source of naturally synthesized chemical compounds that can be extracted by simple procedures with low cost, and are biodegradable in nature [2].

Sanjay k. Sharma et al., (2015) studied on "Potential of Azadirachta indica as a green corrosion inhibition against mild steel, aluminium and tin: a review". It aims at application of A.indica extract for metallic corrosion inhibition especially for mild steel, aluminium and tin. From the results obtained, it is quite obvious that Azadirachta indica is an effective green corrosion inhibition against various metals especially for mild steel, aluminium and tin [4].

Also, Jeetendra bhaswar et al., (2015) conducted a study on corrosion inhibition of mild steel in 2M H2SO4 solution by Nicotiana extract using weight loss method. The percentage of inhibition efficiency and corrosion resistance of mild steel increases with increase in concentration and decreases at increase in temperature. The N.tabacum extract can be considered as a source of eco-

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friendly biodegradable and effective corrosion acid inhibitors [8]. Anees A. Khadam et al., (2017) conducted a study on Xanthium strumarium leaves extract as a friendly corrosion inhibition of low carbon steel in HCl: Kinetics and mathematical studies. This study deals with corrosion inhibition of low carbon steel in 1M HCl using weight loss method. The results show that acidic extraction of Xanthium strumarium act as a good and efficient anti-corrosion material for low carbon steel in HCl medium. Inhibition efficiency increases with inhibition concentration and maximum inhibition efficiency of the extract was found to be 98.82 at opt concentration of 10mL/L [15]. Likewise, many researchers have conducted their experiments using natural materials to prove their efficiency in corrosion inhibition. Therefore, in this study, three different natural species are selected and tested individually on MS and HYSD bars, for determining the naturally effective corrosion resistive species.

II. MATERIALS AND METHOD

A. Mild Steel

The mild steel used for this investigation is cut into rectangular steel plates of size 30mm x 20mm and of thickness 2mm. Each specimen was degreased by washing with acetone, dried at room temperature and preserved in a moisture-free desiccator. All chemicals and reagents were of analar grade.



Fig. 1 Mild steel specimens of rectangular shape.

B. HYSD

The HYSD bars used for this investigation is of grade Fe 500 and its size is 50mm and of 8mm diameter.



Fig. 2 HYSD bar specimen

C. Preparation of Musa paradisiaca

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In this process, initially the dry leaves were collected and washed thoroughly with distilled water. The leaves are then oven-dried at 40ºC for 2 hrs. The dried leaves were ground into powder. This powdered extract was then directly added to the acid test media where the specimen is immersed at different concentrations of 3, 6, 9, 12 and 15 g respectively.



Fig.3 Leaves of Musa *paradisiacal (Banana*

D. Preparation of Azadirachta Indica

The Neem leaves collected were washed with distilled water. The leaves are then allowed to dry in shade for few hours. The dried leaves were ground into powder. Different concentrations of 3, 6, 9, 12 and 15 g of the powder were taken. They were then added to the test media with specimen directly.



Fig.4 Leaves of Azadirachta *indica (Neem leaves)*

E. Preparation of Citrullus lanatus

In case of watermelons, the waste products were effectively used as corrosion inhibitors. Watermelon rind and peel were collected and washed with distilled water. They were then allowed to dry for few days. The dried rind and peel were ground into powder. The powder was taken at different concentrations of 3, 6, 9, 12 and 15 g and added to the test media along with the specimen respectively.

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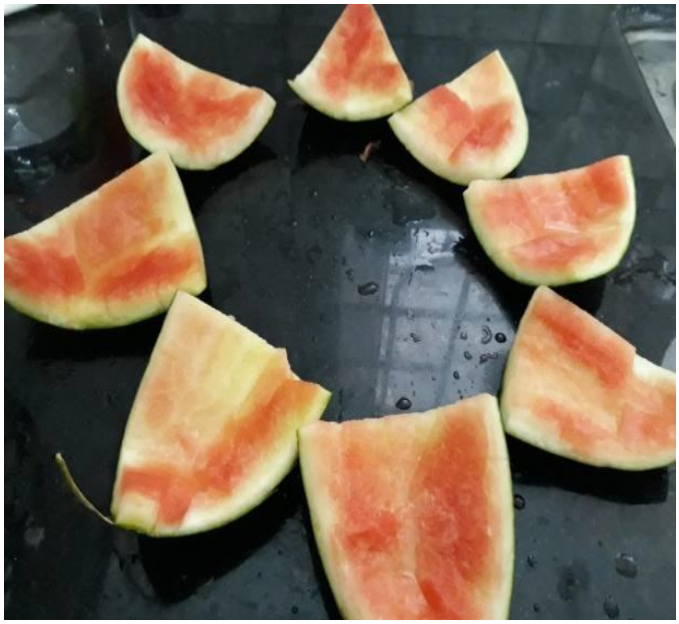


Fig.5Watermelon rind

F. Weight Loss Method

In this study, the corrosion inhibition efficiency of various eco-friendly materials is determined by the weight loss method. In this method, the test specimens were initially weighed after thorough cleaning with distilled water, followed by drying. The specimens were immersed in each of the test media kept in a crucible. Experiments were done in the acid test media with addition of some extract. The specimens were taken out of the media at regular intervals of 2, 4 and 24 hours, washed with distilled water, air – dried and weighed again. The difference in weight of the specimens before and after the immersion is recorded. The inhibition efficiencies of the extracts were calculated using the formula,

$$\%I.E = (1- W_1/W_2) \times 100$$

Where W_1 and W_2 are the weight losses in grams for specimens in the presence and absence of the extract of 0.5M dilute Sulphuric acid (H_2SO_4) solution in room temperature.

III. RESULTS AND DISCUSSION

A. Effect of Banana leaves on MS

Different concentrations of Banana leaves extract are being used as corrosion inhibitors and the results are tabulated as follows.

Table 1 Inhibition efficiency of Banana Leaf extract in Mild Steel.

Concentration of the extract (g)	Inhibition efficiency in %		
	After 2hrs	After 4hrs	After 24hrs
3	45.32	44.74	52.11
6	51.80	55.26	53.86
9	62.59	67.92	57.21
12	63.31	68.73	60.70
15	80.94	58.76	65.05

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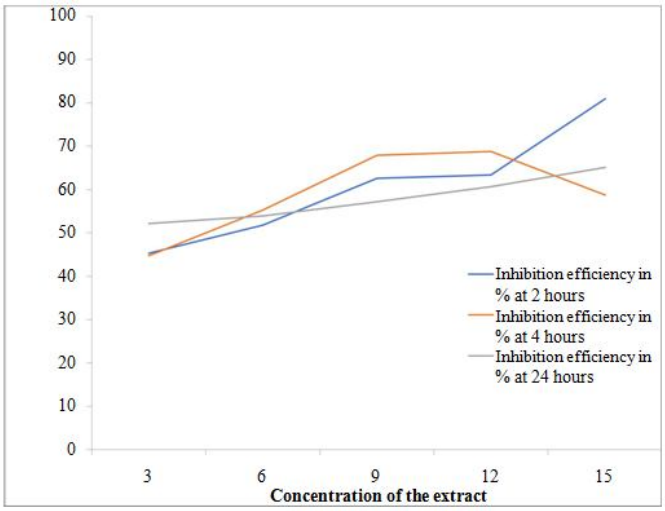


Fig.6 Comparison of Inhibition Efficiency of Banana leaf extract in Mild Steel.

From the above results, it is evident that the inhibition efficiency is (68.73%) maximum when the concentration of the Banana Leaves extract is 12 grams for a time period of 4 hours.

B. Effect of Neem leaves on MS

The following are the results when extracts of Neem leaves are used as corrosion inhibitors for mild steel and the results for varied concentrations and time are tabulated below:

Table 2 Inhibition efficiency of Neem Leaf extract in Mild Steel.

Concentration of the extract (g)	Inhibition efficiency in %		
	After 2hrs	After 4hrs	After 24hrs
3	93.88	90.67	98.01
6	95.92	89.33	98.56
9	95.92	93.33	98.23
12	79.59	70.67	90.61
15	83.67	82.67	95.80

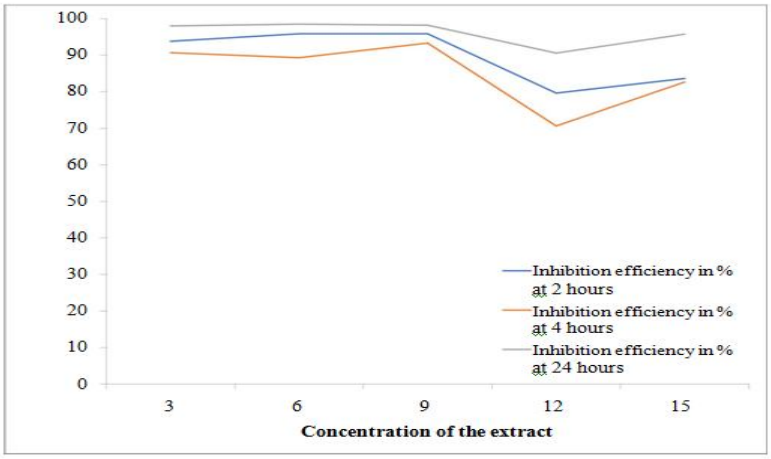


Fig.7 Comparison of Inhibition Efficiency of Neem leaves extract in Mild Steel.

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From the above graph, it is clear that when a concentration of 15 grams of Neem leaves are used, the inhibition efficiency increases over time comparatively, however a maximum inhibition efficiency of 98.56 % is obtained at a concentration of 6 grams after keeping for 24 hours.

C. Effect of Watermelon extract on MS

When the extracts of peel and rind of Watermelon fruit are used as corrosion inhibitors for mild steel in 0.5 M sulphuric acid medium, the following results are obtained at various time periods and concentrations.

Table 3 Inhibition efficiency of Watermelon Peel and Rind extract in Mild Steel.

Concentration of the extract (g)	Inhibition efficiency in %		
	After 2hrs	After 4hrs	After 24hrs
3	86.52	90.56	71.20
6	91.01	91.67	74.36
9	91.01	93.33	77.12
12	92.13	93.33	81.26
15	93.26	93.89	94.08

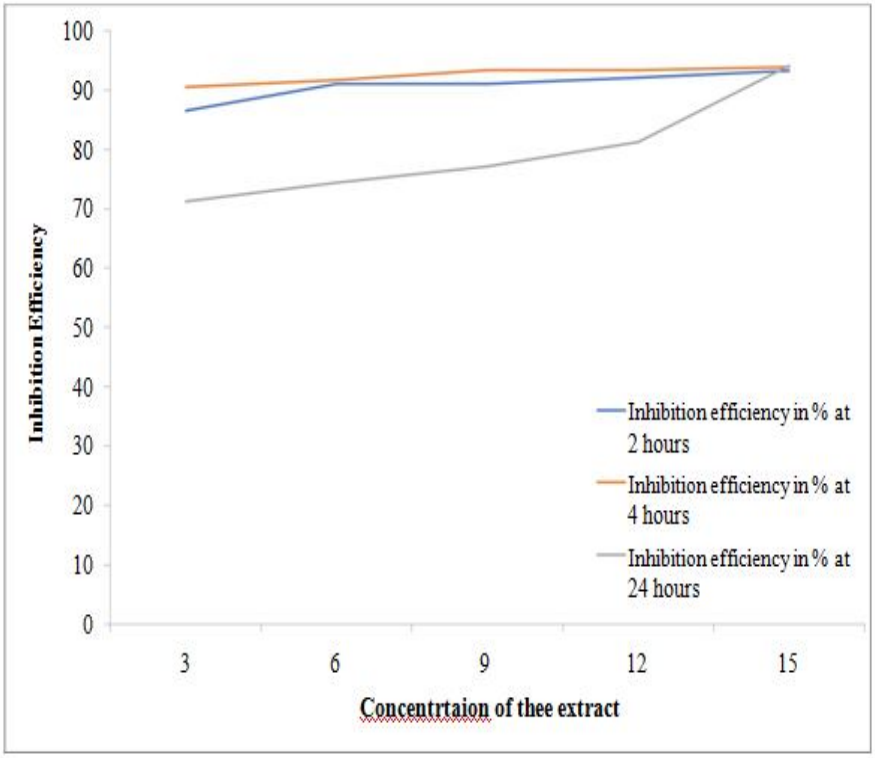


Fig. 8 Comparison of Inhibition Efficiency of Watermelon Peel and Rind extract in Mild Steel.

From the above inferences it is evident that the inhibition efficiency increases with respect to time showing a maximum inhibition efficiency of 94.08% on using 15 grams of extract.

D. Effect of Banana leaves on HYSD bars

The powdered extract of Banana leaves are used as green corrosion inhibitors for HYSD bars and the results are tabulated as below:

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Table 4 Inhibition efficiency of Banana Leaf extract in HYSD bars.

Concentration of the extract (g)	Inhibition efficiency in %		
	After 2hrs	After 4hrs	After 24hrs
3	86.52	90.56	71.20
6	91.01	91.67	74.36
9	91.01	93.33	77.12
12	92.13	93.33	81.26
15	93.26	93.89	94.08

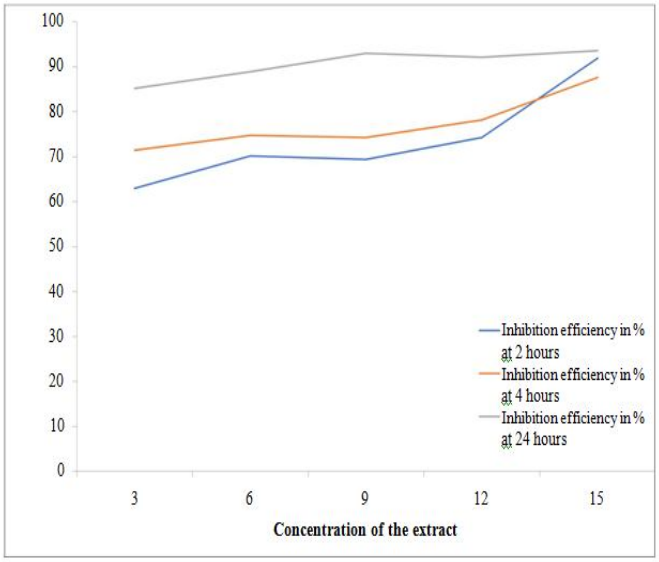


Fig. 9 Comparison of Inhibition Efficiency of Banana leaf extract in HYSD bar.

From the above results it can be seen that the maximum inhibition efficiency of 93.59 % is achieved on using 15 grams of powdered leaf and shows a constant increase in efficiency beyond that extract.

E. Effect of Neem leaves on HYSD bars

The following are the results when extracts of Neem leaves are used as corrosion inhibitors for HYSD bars in sulphuric acid medium. Weight loss tests were conducted at different time period for different concentrations.

Table 5 Inhibition efficiency of Neem leaf extract in HYSD bars.

Concentration of the extract (g)	Inhibition efficiency in %		
	After 2hrs	After 4hrs	After 24hrs
3	62.86	65.63	82.25
6	48.57	58.33	87.68
9	87.14	61.98	88.21
12	94.29	54.69	88.21
15	64.29	62.50	88.61

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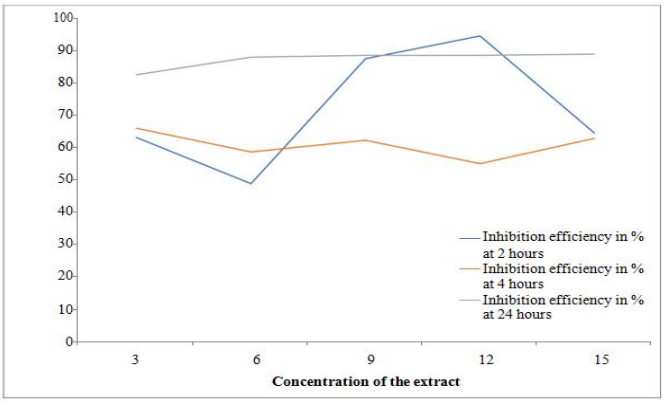


Fig. 10 Comparison of Inhibition Efficiency of Neem leaves extract in HYSD bar.

From the above inferences, it is observed that when 15 grams of Neem leaf extract is used, the inhibition efficiency increases from 64.29% to 88.61% constantly over time, however 94.29 % IE is obtained for 12 grams of extract at 2 hours of contact period.

F. Effect of Watermelon extract on HYSD bars

The rind and seed extracts of the watermelon are used to resist corrosion in High Yield Strength Deformed bars and the results obtained for varied time and concentration are tabulated below:

Table 6 Inhibition efficiency of Watermelon Peel and Rind extract in HYSD bars.

Concentration of the extract (g)	Inhibition efficiency in %		
	After 2hrs	After 4hrs	After 24hrs
3	55.26	67.06	86.20
6	58.55	69.05	90.38
9	78.95	66.67	88.44
12	53.29	67.86	89.50
15	61.84	69.84	91.16

From the recorded observations the results show that 91.156% is the maximum inhibition efficiency attained at 24 hours on using 15 grams of extract.

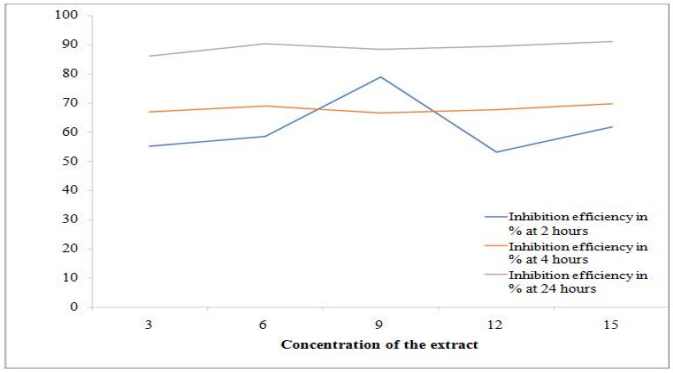


Fig.11 Comparison of Inhibition Efficiency of Watermelon Peel and Rind extract in HYSD bars.

From the recorded observations the results show that 91.156% is the maximum inhibition efficiency attained at 24 hours on using 15 grams of extract.

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IV. CONCLUSION

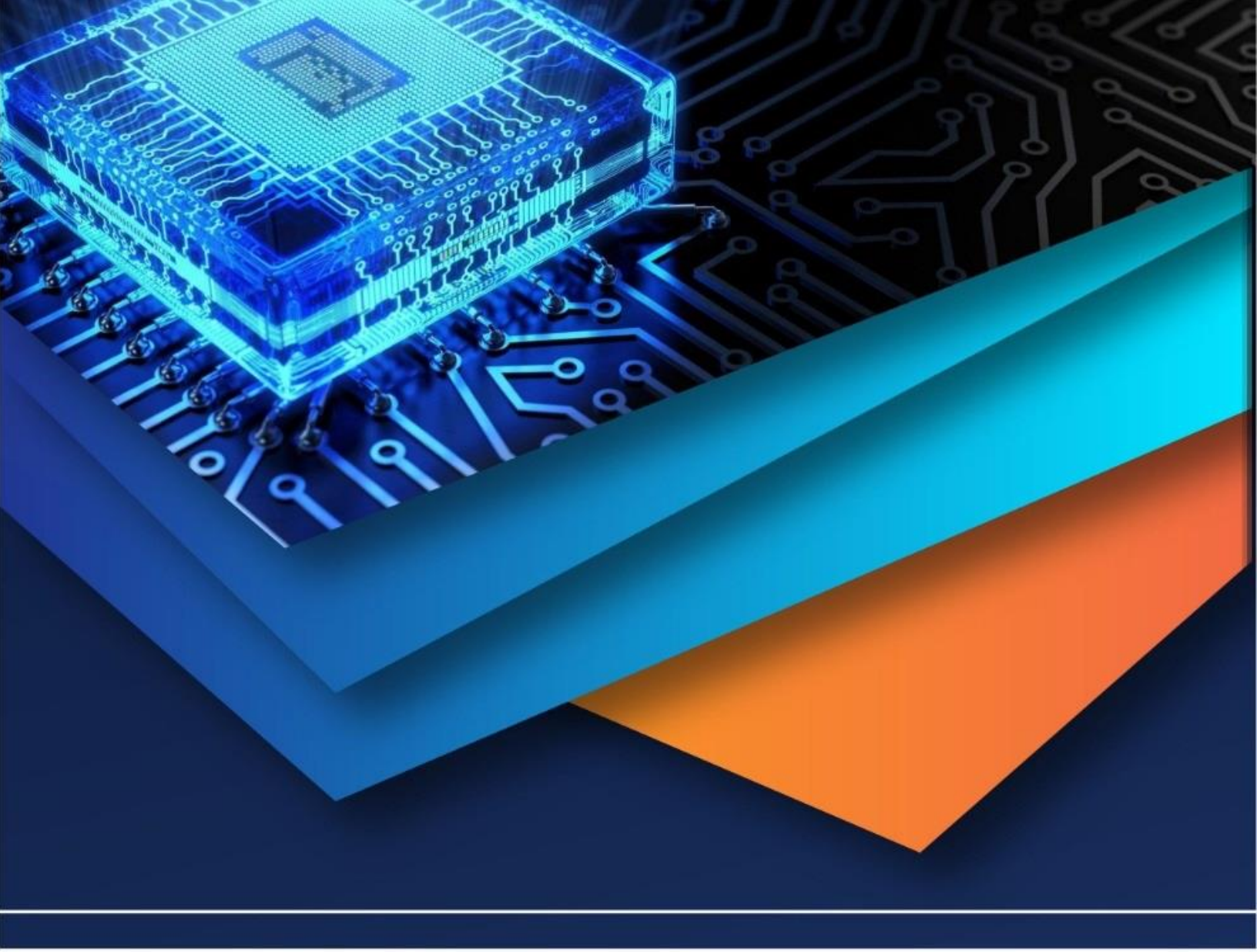
For Mild steel, the extracts of Neem leaf has the highest inhibition efficiency of 98.56 % whereas the extracts of watermelon rind and peel; and Banana peel has an inhibition efficiency of 94.08 % and 68.73 % respectively. Thus, extracts of Neem leaf which has a higher inhibition efficiency can be effectively used as an eco-friendly corrosion inhibitors. Since, Neem leaves are abundantly available in the country, it can be used economically without endangering the environment. For HYSD bars, the extracts of Banana leaves shows a maximum inhibition efficiency of 93.59 % than the Watermelon Rind extract and Watermelon Peel Extract; and Neem extract which has an inhibition efficiency of 91.16 % and 88.61 % respectively. Thus, extracts of Banana leaf can be used as an effective corrosion inhibitors for High Yield Strength Deformed Bars compared to the other natural materials used.

From this experimental study, it is clear that eco-friendly materials can be used effectively as corrosion inhibitors for Mild steel and HYSD bars replacing the commercial synthetic ones. In future, these green inhibitors can be further modified without producing any harm to the environment for commercial purpose.

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