BIOMASS GASIFIER WASTE FOR CORROSION INHIBITOR APPLICATION

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Abstract: Mild steel is widely used in construction, nuclear power and oil and gas industries because of its incredibly low cost. The biggest drawback of it is that it is poor corrosion resistant when exposed to corrosive environments. Use of corrosion inhibitor is one efficient and affordable way to reduce the excessive amount of corrosion in acidic and saline environment. This has necessitated the present trend of searching for and developing green inhibitors that are environmentally benign, non-toxic, biodegradable, and low in cost. In this work green inhibitor made of waste of biomass gasifier was investigated by waste loss and electrochemical method. The results show that waste of biomass gasifier extract possesses good inhibition properties. The inhibition efficiency was found to increase with concentration and corrosion rate is decrease. The highest inhibition efficiency obtained was above 60% in NaCl environment on the surface of low carbon steel, which shows that Low carbon steel in NaCl environment provides an excellent corrosion resistance. The inhibition efficiency obtained is mainly due to the presence of Alkaloids, flavonoids, tannins and phenols in the inhibitor.

Keywords: *Waste of biomass gasifier, Corrosion inhibitor, Weight loss method, Electrochemical measurement and Phytochemical analysis*.

1. Introduction

Acids are used in various industrial procedures such as oil well acidizing, pickling, cleaning, and descaling, which expose the metals and their alloys to the action of acids[1]. The most typical kind of steel is mild steel, commonly referred to as low carbon steel. Due to its exceptionally low cost when compared to other types of steel and the features it offers, mild steel has a wide range of uses, including building, nuclear power, energy consumption, and especially the oil and gas industries[2]. The biggest drawback is that it has poor corrosion resistance when exposed to corrosive environments like acidic environments. Due to its poor corrosion resistance, only the oil and gas industries experience around 60% of corrosion failures. Additionally, corrosion has a significant impact on every industry, making it a problem that must be overcome. The easy and cost-effective, and widely used method for reducing corrosion and acid usage has been adopted the application of corrosion inhibitors, mainly in the oil and gas industry[3].

Additionally, the equipment used in these processes is frequently mainly of steel materials, which corrodes when it comes into contact with the environment[4]. Inhibitors are frequently used to prevent metal corrosion, reduce acid usage, and inhibits harmful metal attack. Inhibitors are available in many different types[5]. However unfortunately, most corrosion inhibitors are expensive synthetic materials which have a negative impact on the environments[6]. Therefore, it is essential to choose an inhibitor that can be both inexpensive and environmentally friendly[7]. That's why natural, non-toxic, environmentally friendly inhibitors are preferred for metals[8]. In order to accomplish sustainable development goals, researchers are diligently looking for naturally occurring organic compounds that can be used as inhibitors and which are inexpensive, biodegradable, and environmentally friendly[9]. Therefore, animal excrement contains a group of organic chemicals that are suitable for this usage[10]. Furthermore, it is inexpensive and naturally occurring. It is mainly made up of Cellulose, Hemicelluloses, and Lignin[11]. In addition, it has trace amounts of Sulfur, Iron, Magnesium, Copper, Cobalt, Manganese, and Nitrogen, Potassium, and twenty-four other minerals. Many other naturally occurring inhibitors such as Aloe Vera extract[12]. falcaria vulgaris leave extract[13], Guar gum seeds [14] And soya bean oil[15] etc. has been reported as corrosion inhibitor.

By extracting the biomass gasifier waste in 3.5% of NaCl solution, the present research will investigate how to prevent low carbon steel from corrosion attack[16]. This research will accomplish its work by using a variety of techniques, including weight loss, electrochemical, phytochemical analysis.

2. MATERIAL AND METHODOLOGY

Preparation of extract

The waste of biomass gasifier was collected from biomass gasifier plants located near Hyderabad. Ensuring that it is free of pesticides and contaminants. The collected residue of biomass gasifier is spread out in open area to dry by exposure to air. The organic material is thereby concentrated, and further moisture is taken out. An extraction procedure was carried out on after being dried by using on a suitable solvent and dried residue of biomass gasifier, which was then crushed to make a powder of it. 5g of the powdered feces were mixed into with 500ml of distilled water. Mixing process is carried out for 30 minutes in a 100°C temperature

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of water bath. Then mixture was cooled after filtering with What man filter paper.

Sample preparation and solution

The study of mild steel (Low carbon steel) used to determine the chemical composition indicated in Table 1; this information was obtained using a Spark Spectrometer (BURKER Q2 ION). The dimensions of coupons 20 x 10 cm which were subsequently polished and grinded with different grades of emery paper of silicon carbide having mesh number (80, 120, 200,400, 600,1000, 1200) an order to remove corroded portion. The test environment was prepared in 3.5% of NaCl We took 500ml of beaker take 300ml of DI water add 10.5 gram of NaCl to make a solution. Different concentrations, Blank, 2ml, 4ml, and 6ml of residue of biomass gasifier as inhibitor were added in 3.5% of NaCl solution

% Of Elements					
C	**Si**	**P**	**S**	**Mn**	**Fe**
0.235	0279	<0.0030	<0.0030	0.636	98.41

Table 1: Chemical Composition of Low Carbon Steel

Phytochemical Analysis

Phytochemical analysis of the extract of residue biomass gasifier was carried out accordion to method of[17]. Phytochemical analysis of residue of biomass gasifier extract shows the presence of Alkaloids through tannic acid test. Ferric chloride test analysis the presence of tannin and phenols. Lead acetate test identify the presence of Flavonoids. The presence of these compounds improve the inhibition efficiency in aggressive medium.

Weight loss method

The corrosion rate (CR) in the presence and absence of waste of biomass gasifier extract in an environment NaCl was measured using the weight loss method[18]. Using an analytical weight balance, the dried samples were prepared and then immersed in different 300ml solutions. The sample were immersed in NaCl solution containing different concentrations, Blank, 20ml, 40ml, 60ml for different exposure time. After the exposing samples were taken out from the environment and sonicated in acetone to remove residual corrosion product after a certain amount of time. After the removing of the corrosion products, the samples were accurately weighed. The difference between the initial weight (Wi) and the final weight (Wf) was used to calculate the weight loss. Equation 1 was used to calculate the corrosion rate (CR).[19]

$$\boldsymbol{C_R = \frac{\Delta W}{A \times t}} \qquad \text{equation. 1}$$

where ΔW is the weight loss (g). t is the immersion time (hours), A is the surface area of the coupons (cm^2). Equations 2, 3 were used to calculate the inhibition efficiency (%Ƞ) and surface coverage (θ).

$$\%\boldsymbol{\eta} = \left[\frac{C_R{}^{bare} - C_R{}^{inh}}{C_R{}^{bare}}\right] \times \mathbf{100} \qquad \text{equation .2}$$

$$\boldsymbol{\theta} = \frac{C_R{}^{bare} - C_R{}^{inh}}{C_R{}^{bare}} \qquad \text{equation. 3}$$

Where CR^{Blank} and CR^{inh} represent the corrosion rates of low carbon steel respectively, in the presence and absence of a corrosion inhibitor.

Electrochemical measurement

Electrochemical experiments were performed computer-controlled VersaSTAT4 Potentiostat/Galvanostat three-electrode electrochemical system. A 15 cm diameter carbon steel and mild steel was fixed as the working electrode (WE), a platinum mesh was used as the counter electrode (CE), and a saturated calomel electrode (SCE) was used as the reference electrode (RE). Before the electrochemical study, the working electrode was placed in the solution for 60 min at open circuit potential (OCP) to reach a steady state[20].

An effective quantitative method for rapidly evaluating an inhibitor's anti-corrosion efficiency is electrochemical impedance spectroscopy (EIS)[21]. EIS tests were measured at OCP with an amplitude of 10mV peak to peak throughout a frequency range of 10 KHz to 0.1 Hz. Additionally, a similar circuit was used in Z-view software to fit and simulate the EIS graphs. The Ƞ% was determined form charge transfer resistance (Rct) by following equation 4.

$$\%\boldsymbol{\eta} = \left[\frac{Rct^{o} - Rct^{i}}{Rct^{o}}\right] \times \mathbf{100} \qquad \text{equation.4}$$

Where Rct^0 and Rct^i are charge transfer resistances with and without inhibitor, respectively. Podentiodynamic polarization tests were performed over a potential range of -0.4 V to +0.4 V with a scan rate of 1 $mVsec^{-1}$ at 25 ^0C. Anodic (β_a), cathodic (βc) and current density (Icorr) were calculated by extrapolating the obtained Tafel curves using EC-LAB software. %η was calculated using Equation 5.

$$\%\boldsymbol{\eta} = \frac{Icorr - Icorr^{inh}}{Icorr} \times \mathbf{100} \qquad \text{equation.5}$$

Where Icorr and $Icorr^{inh}$ are denoting the corrosion current densities in absence and presence of corrosion inhibitor.

4. Results and Discussion

Phytochemical analysis of extract

Phytochemical analysis of waste of biomass gasifier extracts is presented in following table 2. That show the presence of Alkaloids, flavonoids, tannins, phenols. The presence of these compounds improve the inhibition efficiency of low carbon steel in aggressive medium.

Table:2 Phytochemical analysis of waste of biomass gasifier extract.

Phytochemical Analysis	Carbohydrates	Alkaloids	Flavonoids	Tannins	Phenols
EXTRACT	-	+	+	+	+

Key: (+) and (-) shows the presence and absence of compounds.

Weight loss method results

Corrosion resistance behavior of low carbon steel shown in Fig: 4.1 respectively in 3.5% NaCl environment. The sample having no inhibitor shows highest weight loss in case of low carbon steel as well as medium carbon steel. It is found that low carbon steel is corrosion resistant may be due to the presence of more pearlite phase. It is also evident that by the addition of inhibitor the weight loss is decreased in both steels. By considering the corrosion rate it is also confirmed that corrosion rate is decreasing by the addition of inhibitor and the rate is almost constant for whole one month in case of NaCl environment.

The inhibition efficiency of waste of biomass gasifier extract (at higher concentration) is higher in case of low carbon steel (>60%). It is also evident that by the addition of inhibitor the weight loss is decreased by increasing the concentration of inhibitor and the corrosion rate also decreases by the addition of inhibitor.

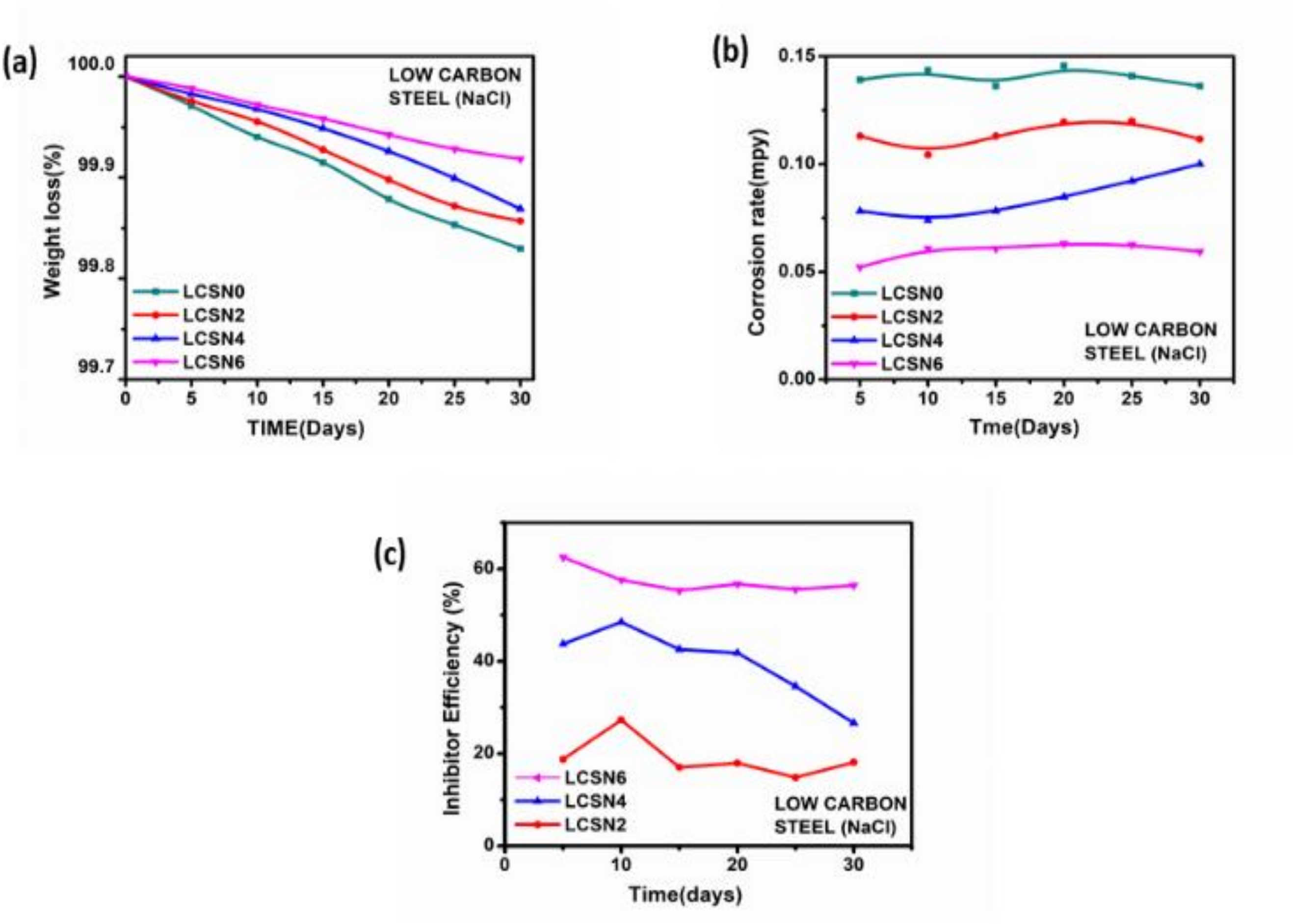

Fig4.1: Low Carbon steel in NaCl solution 3.5% with different concentration of extracts

Table 3: Polarization parameters for the corrosion of Low carbon steel in 3.5% NaCl solution with different concentration of corrosion inhibitors.

Electrochemical measurement results

In 3.5% NaCl solution, potentiodynamic polarization measurements conducted on low carbon steel at various inhibitor concentrations, i.e: Blank, 2ml, 4ml, and 6ml. Figure displays the polarization curves that were produced. The Figures 4.2, illustrates how the addition of biomass gasifier extract waste adjusts the anodic (βa) and cathodic (βc) slopes by slowing down the hydrogen evolution process and reducing anodic dissolution.Tafel plots show that by reducing the corrosion current density (Icorr), the residue from the addition of biomass gasifier extract significantly decreases the corrosion reaction. According to Icorr analysis, increasing the extract concentration achieved the maximum inhibitor efficiency.

The anodic, cathodic, and mixed types of inhibitors are indicated by the shift in polarization curves. The significant shift in polarization curves observed in this instance indicates the biomass gasifier extract waste acts as a mixed type inhibitor.

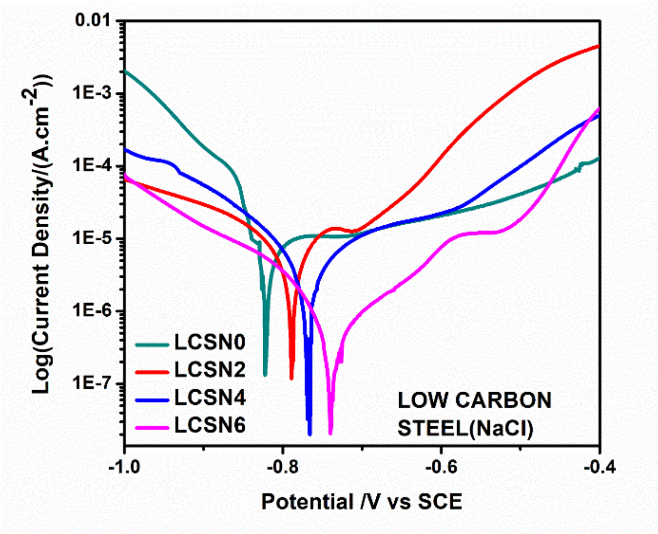

Fig 4.2: Tafel Curve of Low carbon steel in 3.5% NaCl solution

Inhibitor concentration (ml)	Ecorr (mV vs SCE)	Icorr (uA/cm^2)	βa (mV/dec)	βc (mV/dec)	(CR) (mpy)	Surface Coverage (θ)	Inhibition efficiency (%η)
BLANK	714.88	0.005	35.6	43.3	0.000083	-	-
2	705.11	0.002	32.6	80.1	0.000033	0.602	60
4	66.49	0.00071	24.1	54.	0.000029	0.650	65
6	619.79	0.00065	20.3	44	0.000010	0.87	87

5. Conclusion

Considering the obtained results of present study, we concluded that the waste of biomass gasifier was found to be an excellent corrosion inhibitor for low carbon steel in 3.5% of NaCl solution. The inhibitor performance was increasing with addition of extract concentration. The maximum efficiency of low carbon steel in 3.5% NaCl is above 60%. Phytochemical analysis confirms the organic compounds present in waste of biomass gasifier extract may inherent the inhibition property in it. Moreover, the time has also little effect on inhibition efficiency, suggesting that extract is able to protect corrosion for longer exposure time

References

[1] S. J. Olusegun, O. O. Oluwasina, K. K. Alaneme, and P. A. Olubambi, "Corrosion inhibition of mild steel in acidic solution by cow dung extract as an eco-friendly inhibitor," 2016.

[2] L. Popoola, A. Grema, G. Latinwo, B. Gutti, and A. Balogun, "Corrosion problems during oil and gas production and its mitigation," *Int J Ind Chem*, vol. 4, no. 1, p. 35, 2013, doi: 10.1186/2228-5547-4-35.

[3] B. Su, Y. Zhang, G. Huang, Z. Wang, and R. Liu, "Corrosion Failure Cause Analysis of Buried Pipelines in Oil and Gas Stations," *E3S Web Conf.*, vol. 213, p. 02021, 2020, doi: 10.1051/e3sconf/202021302021.

[4] R. O. Medupin, K. O. Ukoba, K. O. Yoro, and T.-C. Jen, "Sustainable approach for corrosion control in mild steel using plant-based inhibitors: a review," *Materials Today Sustainability*, vol. 22, p. 100373, Jun. 2023, doi: 10.1016/j.mtsust.2023.100373.

[5] S. Tanwer and S. K. Shukla, "Recent advances in the applicability of drugs as corrosion inhibitor on metal surface: A review," *Current Research in Green and Sustainable Chemistry*, vol. 5, p. 100227, 2022, doi: 10.1016/j.crgsc.2021.100227.

[6] Z. Javed, G. D. Tripathi, M. Mishra, M. Gattupalli, and K. Dashora, "Cow dung extract mediated green synthesis of zinc oxide nanoparticles for agricultural applications," *Sci Rep*, vol. 12, no. 1, p. 20371, Nov. 2022, doi: 10.1038/s41598-022-22099-y.

[7] N. Soltani, N. Tavakkoli, M. Khayatkashani, M. R. Jalali, and A. Mosavizade, "Green approach to corrosion inhibition of 304 stainless steel in hydrochloric acid solution by the extract of Salvia officinalis leaves," *Corrosion Science*, vol. 62, pp. 122–135, Sep. 2012, doi: 10.1016/j.corsci.2012.05.003.

[8] C. C. Aralu, H. O. Chukwuemeka-Okorie, and K. G. Akpomie, "Inhibition and adsorption potentials of mild steel corrosion using methanol extract of Gongronema latifoliuim," *Appl Water Sci*, vol. 11, no. 2, p. 22, Feb. 2021, doi: 10.1007/s13201-020-01351-8.

[9] J. J. Hernández, M. Lapuerta, and E. Monedero, "Characterisation of residual char from biomass gasification: effect of the gasifier operating conditions," *Journal of Cleaner Production*, vol. 138, pp. 83–93, Dec. 2016, doi: 10.1016/j.jclepro.2016.05.120.

[10] N. Prays and M. Kaupenjohann, "Initial Effects of Differently Treated Biogas Residues from Municipal and Industrial Wastes on Spring Barley Yield Formation," *PLoS ONE*, vol. 11, no. 4, p. e0154232, Apr. 2016, doi: 10.1371/journal.pone.0154232.

[11] S. Puri, S. Sharma, A. Kumari, M. Sharma, U. Sharma, and S. Kumar, "Extraction of lignocellulosic constituents from cow dung: preparation and characterisation of nanocellulose," *Biomass Conv. Bioref.*, vol.

13, no. 1, pp. 311–320, Jan. 2023, doi: 10.1007/s13399-020-01119-9.

[12] S. M. Odhano, M. Kumar, and I. N. Unar, “Effect of Aloe Vera Extract as Green Corrosion Inhibitor on Medium Carbon Steel in Sulphuric Acid Environment,” *Pak J Anal Environ Chem*, vol. 23, no. 1, pp. 70–78, Jun. 2022, doi: 10.21743/pjaec/2022.01.07.

[13] M. Alimohammadi, M. Ghaderi, A. Ramazani S.A., and M. Mahdavian, “Falcaria vulgaris leaves extract as an eco-friendly corrosion inhibitor for mild steel in hydrochloric acid media,” *Sci Rep*, vol. 13, no. 1, p. 3737, Mar. 2023, doi: 10.1038/s41598-023-30571-6.

[14] G. Palumbo, K. Berent, E. Proniewicz, and J. Banaś, “Guar Gum as an Eco-Friendly Corrosion Inhibitor for Pure Aluminium in 1-M HCl Solution,” *Materials*, vol. 12, no. 16, p. 2620, Aug. 2019, doi: 10.3390/ma12162620.

[15] V. Eswaramoorthi, S. Jagadeesan, S. Palanisamy, P. Kandhasamy, and S. Chitra, “Soya bean oil based polyurethanes for corrosion inhibition of mild steel in acid medium,” *Journal of Adhesion Science and Technology*, vol. 30, no. 5, pp. 468–493, Mar. 2016, doi: 10.1080/01694243.2015.1108951.

[16] S. A. Umoren, E. I. Inam, A. A. Udoidiong, I. B. Obot, U. M. Eduok, and K.-W. Kim, “Humic Acid from Livestock Dung: Ecofriendly Corrosion Inhibitor for 3SR Aluminum Alloy in Alkaline Medium,” *Chemical Engineering Communications*, vol. 202, no. 2, pp. 206–216, Feb. 2015, doi: 10.1080/00986445.2013.836635.

[17] S. Rajeswari, E. Poongothai, and N. Hemalatha, “ANTIMICROBIAL ACTIVITES OF COW DUNG EXTRACTS AGAINST HUMAN PATHOGENS,” *Int J Curr Pharm Sci*, vol. 8, no. 4, p. 9, Oct. 2016, doi: 10.22159/ijcpr.2016v8i4.15268.

[18] N. Ali and M. A. Fulazzaky, “The empirical prediction of weight change and corrosion rate of low-carbon steel,” *Heliyon*, vol. 6, no. 9, p. e05050, Sep. 2020, doi: 10.1016/j.heliyon.2020.e05050.

[19] F. Malaret, “Exact calculation of corrosion rates by the weight-loss method,” *Exp Results*, vol. 3, p. e13, 2022, doi: 10.1017/exp.2022.5.

[20] A. A. Al-Amiery, A. B. Mohamad, A. A. H. Kadhum, L. M. Shaker, W. N. R. W. Isahak, and M. S. Takriff, “Experimental and theoretical study on the corrosion inhibition of mild steel by nonanedioic acid derivative in hydrochloric acid solution,” *Sci Rep*, vol. 12, no. 1, p. 4705, Mar. 2022, doi: 10.1038/s41598-022-08146-8.

[21] A. Paul, S. K.O., A. R. Prasad, and A. Joseph, “Electroanalytical and surface studies on the protective action of a coating of PVA@3WGO on mild steel in acidic and saline environment,” *Results in Surfaces and Interfaces*, vol. 4, p. 100018, Aug. 2021, doi: 10.1016/j.rsurfi.2021.100018.