ISSN 2229-5518

Mitigation of Corrosion in Produced Water Pipeline Using Locally Produced Corrosion Inhibitor

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Abstract

Corrosion inhibitor was locally produced from orange peels and chrysophyllum albidum leaf using n-Hexane as solvent. Soxhlet extractor was used to extract the oils from the peels and leaves of the investigated plants. The extracted oil was characterized to determine their phytochemical properties and hence its suitability for corrosion inhibition. The characterized oils from the two species were blended to form a corrosion cocktail. The anti-corrosive effect of the cocktail was investigated for carbon steel in produced water at different concentration using weight loss method. The formulated cocktail showed a higher inhibition efficiency of 70.18% inhibition efficiency in produced water. Weight loss analysis was used to study the effect of time in order to evaluate the strength of the absorbed film for 168 hours at 40°C. The study generally, indicated that the combining effect of the extracts has the potential of inhibiting corrosion of carbon steel in produced oilfield water.

Index Terms— Produced water, Carbon Steel, Weight Loss, Cocktail and Inhibitor.

1 INTRODUCTION

Over the years, Corrosion of carbon steel in produced water is one of the leading problems facing the oil and gas industries Mayab (2016). Formation water which can also be referred to as produced oilfield water occurs in natural gas and crude oil reservoirs. It has a large amount of dissolved salts like sulfate and chloride Deyab & El-Rehim (2014). After a long period of time, this salts gradually attacks the pipe wall and increases the risk of corrosion.

The effect of corrosion influences man and his economy at large and if not taken care of could lead to dangerous and expensive damages in the process plant, shut down for repairs, loss of products, mechanical fractures, leakage and low efficiency of equipment's.

Corrosion inhibitor has been to be the most practical and economical method of preventing and controlling the deterioration of metal in the environment Akalezi et al, (2012).The prevention of corrosion in has played a pertinent role in various industries, especially in the chemical and petrochemical industries that employ the use for steel thus, several studies have been conducted to investigate effective methods for preventing corrosion Al-Amery et al,. (2014). Most of the synthetic organic corrosion inhibitors are very effective in protecting pipelines from corrosion but they are very toxic to both human and environment and are sometimes expensive. These concerns motivated researchers to find a natural means of producing an eco-friendly corrosion inhibitor that poses no side effect. Previous work has shown that plant extracts has the ability to inhibit corrosion in acidic media. The following are typical examples of works on by-product extracts that were used as corrosion inhibitors in acidic media: aqueous extracts of peels (oranges and mangoe) Janaina et al., (2014), leaves, seeds and roots.Orange peels are rich in antioxidants like carotenoids, phenolic compounds and ascorbic (Ajila et al (2007) & (Riberiro et al 2008). The extract of Chrysophyllum Albidum leaf has been proven to have the ability of inhibiting corrosion in acidic media and this was attributed to the presence of inherent phytochemical constituents like tannin, saponis and cardiac glycosides. Offurum and Offurum (2017). The purpose of this work is to study the combined extract effect of Chrysophyllum Albidum and orange peels as corrosion inhibitor on carbon steel in produced water using weight Loss method.

2 MATERIALS AND METHODS

2.1 Materials

In this present research, the carbon steel

ISSN 2229-5518

specimens used contains; Carbon,Maganese, Phosphorus, Silicone, Iron and chemical compositions (C=0.22%, Mn=0.34%, P=0.023, Si=0.004% and Fe=balance). The coupons were thoroughly cleaned with emery papers of different grades, degreased with acetone, properly washed with distilled water to remove any form of debris, weighed and stored in a desiccator.

Orange peels and leaf of chrysophyllum albidum which is popularly known in Nigeria as Udara was extracted using Soxhlet extractor.

The produced Oilfield water used in this work was collected from an oil well at Niger Delta Area in Nigeria.

2.2 Methods

2.2.1 Preparation of Powder

The orange peels and leave of chrysophyllum albidum were both thoroughly washed under a flowing water to remove debris and further dried in an oven at 103°C for about 7 hours. The dried peels and leave were separately weighted and grounded into a fine particle using electric grounding machine and stored in a closed container before use at room temperature. The grounded peels and leaves were added into Soxhlet apparatus and was successively extracted with n-Hexane until discoloration. Overheating of the sample was avoided using a minimum temperature during heating process. Afterwards, it was filtered, lyophilized and stored in a . Extract saturation was obtained using:

$$S = \frac{M_2 - M_1}{M_0} \quad (1)$$

Where, M_0 =Initial mass of the analyzed sample, M_1= Mass of the clean extraction flask, M_2 =Mass of the extraction flask containing the extracted liquid after solvent evaporation and cooled down to room temperature.
All masses are expressed in grams.

2.2.2 Density Determination

The pictometer was thoroughly washed with acetone to avoid contamination of the extract. The weight of the extracts in the pictometer and the empty pictometer was measured using a weighing machine. Density of the extracts were calculated using:

$$\rho = \frac{M}{V} \quad (2)$$

Where;
ϱ = density of the extract (g/ml), M = mass of sample (g), V = volume of picnometer (ml)

2.2.3 Determination of the phytochemical constituents

The phytochemical screening of the extracts was done to detect the main groups of active chemical constituents present in the peels and leaf extract by their colour reaction. The simple quantitative and qualitative methods of Okwu (2001), Rahilla et al., (1994), Sofowora (1993) and Odeja et al., (2015) were used to test for the presence of flavonoids, glycosides, saponins, alkaloids and tannins.

2.3.4 Produced Oilfield Water Analysis

The chemical and physical properties of the produced oilfield water was determined using a spectrophotometer.

2.3.5 Weight Loss Analysis

The carbon steel coupon used in this study have a Dimension of 7.6cm x 0.31cm x 0.75cm. This coupon which has already been cleaned and dried, was inserted into a 100ml beaker of produced oilfield water without and with the different concentration of the plant extract. This extract used as corrosion inhibitor was thoroughly mixed in a ratio of 50:50 (orange peel and leave of chrysophyllum albidum extract) and agitated for about 5 minutes to achieve a good blend. To prevent and avoid contamination, the beakers containing the produced water and the coupons with different concentration ranging from 200ppm,400pm,500ppm and 700ppm was properly covered with foil and kept at a temperature 40^{O}C for 7days(168hours). Corrosion rate was calculated using the formula:

$$R = \frac{W \times k}{\rho A T} \quad (3)$$

Where, T= Operational time(days), W= Weight loss (g),ρ = density of steel (g/cm^2) A= exposed area of the coupon (cm^2), K = Constant (22,300)
The efficiency of an inhibitor is expressed by:

$$E\ (\%) = \frac{W_0 - W_1}{W_0} X100 \quad (4)$$

Where W_0 = weight loss in inhibited medium (blank)(g), W_1 = weight loss in inhibited medium (g)

3.0 RESULTS AND DISCUSSION

3.1 Plant Extract Saturation

The yield percentage (saturation) of 9.65% and 16.87% values were obtained for orange peels

(OP) and Chrysophyllum Albidum (CA) leaves as shown in table 1. this gave a high saturation of the extracted products. The difference in saturation is as a result of the grade of solubility in the polar solvent used during extraction.

Table 1: percentage yield of the plant extracts.

Sample	Weight Of Empty Flask (g)	Weight of sample (g)	Weight of empty flask and weight of extract (g)	Weight of extracts (g)	Saturation (%)
OP	288.38	1100	361.39	106.20	9.65
CA	255.19	660	366.56	111.37	16.87

3.2 Phytochemical Screening

The results of the phytochemical screening of OP and CA plants extracts are presented using Table 2. From the results obtained, the evaluations into the qualitative phytochemical of the orange peels extract and Chrysophyllum albidium showed the presence of active phytochemicals constituents which contributes to the inhibition of corrosion. Although, the presence of these secondary metabolites is the basic of physiological activity and all tested extracts exhibited physiological bioactive properties (Amitha & Basu 2012). Physitochemical properties were further investigated and summarized using Table 3.

The density of the extract was determine using pycnometer. Orange Peels has higher average density value of 0.875 compared to 0.849 recorded for Chrysophyllum Albidum. Determining the average pH value of orange peels and Chrysophyllum albidium (CA) gave 6.34 and 7.78 respectively. The pH value of the extract when combined gave 6.73. Orange peels has a pale-yellow colour with orange fresh juicy sweet odor and Liquid appearance while Chrysophyllum Albidum showed Dark-green colour with a pleasant odor and semi-solid in appearance. Although, when mixed together gave an orange fragrance. It is cleared that chrysophyllum Albidum is more viscose than orange peels extract.

Table 2: Phytochemical screening results for extract

Phytochemicals	
Alkaloid	+
Flavonoid	+
Saponin	+
Terpenoids	+
Tannin	+

+:Trace

Table 3: Phytochemical properties of the plant

Parameters	Orange peels	Chrysophyllum Albidum
Colour	Pale-yellow	Dark-green
Odour	Sweet Orange juicy	Pleasant
Appearance	Liquid	Semi-solid
Density (g/ml)	0.875	0.849
Viscosity (Cp@29^{0}C)	1.359	12.3
pH	6.34	6.78
pH for cocktail 6.73		

3.3 Physical Properties and Chemical Composition of Produced Oilfield Water

The produced water sample used as a corrosive media was analyzed to know their chemical and physical properties using a clean square sample cell of a spectrophotometer, DR2800 (HACH, Texas). Table 3 summarized the chemical and the physical properties found in the produced water.

Table 4: chemical and physical properties of produced oilfield water

Parameters	Result
Ph	7.19
Temperature ^{o}C	23.2
Total Dissolved Solid mg/l	4992
Conductivity μS/cm	7625
Resistivity	0.131
Salinity as Chloride mg/l	4.5
RFA mg/l	2.7
Sulphate mg/l	4
Carbonate, mg$CaCO_3$/l	0.00
Bicarbonate, mg$CaCO_3$/l	0.2
Hydroxyl, mg$CaCO_3$/l	0.00
Hydrogen Sulphide mg/l	0.20
Specific gravity	1.09
Manganese mg/l	3.6
Barium mg/l	14
Calcium mg/l	2.8

Magnesium mg/l	3.64
Sodium mg/l	1038
Soluble Iron mg/l	0.45
Total Iron mg/l	4.83
SRB, cell/mil	1700

3.4 Trend of Corrosion Rate in Oilfield Produced Water

Fig.1 shows the effect of immersion time on the corrosion rate of carbon steel in produced oilfield water in the absence and presence of 400 ppm the Cocktail extract, as studied by weight loss method over a period of twenty-eight (28) days. Produced oilfield water containing the blank coupon revealed a fast rise in the corrosion rate during the first seven days of immersion down to twenty-eight (28) days. Afterwards, a stabilized value was attained. It was observed that the corrosion rate decreased continuously with time in the inhibited produced water. It can be seen from all indication that corrosive components in the blank water attacked the carbon steel aggressively, whereas, the corrosion product gathered on the surface of the steel sample acted as a barrier to reduce the corrosion rate. Table 5 shows the results gotten from effect of immersion time on corrosion rate for produced water in the presence and absent of the inhibitor.

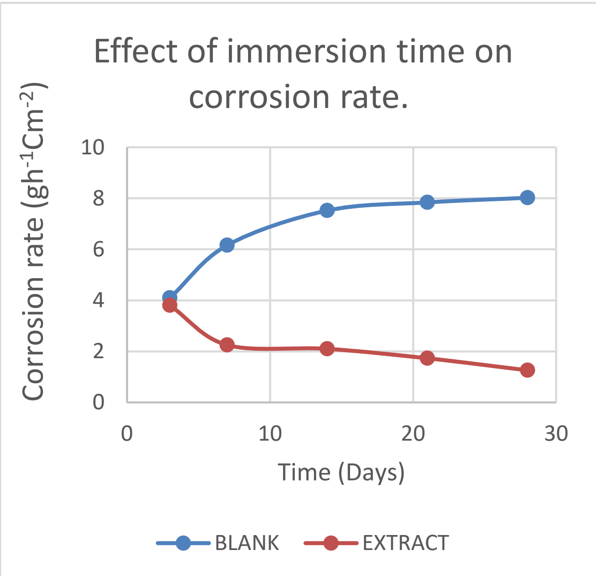

Figure 1: Effect of immersion time on corrosion rate

Table 5: Effect of immersion time on corrosion rate for produced water

Time (days)	Blank ($gcm^{-2}h^{-1}$)	Extract ($gcm^{-2}h^{-1}$)
3	4.1	3.8
7	6.16	2.25
14	7.52	2.1
21	7.89	1.73
28	8.02	1.26

3.3 Inhibition Efficiency for Produced Oilfield Water

The maximum percentage efficiency value obtained from weight loss method was 70.18% at 400 ppm after a period of 7 days at 40 ^{0}C. Increasing the extract concentration above this value resulted in a small decrease in the corrosion protection. This can be as a result the possible changes happening on the metal surface during evolution of some adsorbed extract molecules from the planar form to the vertical arrangement at higher inhibitor addition less than 400 ppm (Mousa et al, 1975). Table 6 shows the inhibition efficiency at different concentration in produced water for 7 days. This was done to know the concentration at which the inhibitor will have the highest inhibitive effect.

Table 6: Inhibition Efficiency at different PPM for produced water

PPM	Corrosion Rate ($gcm^{-2}h^{-1}$)	Efficiency (%)
Blank	6.16	-
100	3.21	43.12
200	2.92	52.63
400	1.84	70.18
500	2.05	66.67
700	2.27	63.16

4 Conclusions

The combining effect of Orange peels and Chrysophyllum albidum leaf extracts act as reliable inhibitors for carbon steel corrosion in produced oilfield water. It was observed that in the produced oilfield water, the inhibition activity increases as a function of concentration up to four hundred (400 ppm) and decreases slightly above this limit. The essential phytochemical constituents such as saponins and tanins which could be frequently adsorbed to the surface of metals played a major role in the inhibiting effect of the extract.

Weight loss method also showed that the combined extract has an anti-corrosion effect for carbon steel in produced oilfield water. The decrease in corrosion rate with both extract concentration and immersion time in the study suggests that the extract molecules can adsorb on carbon steel surface.
Proper storage and preservation of plant extract should be taken into consideration as they are easily contaminated when not properly preserved.

The use of plant extracts should be encouraged in large scale corrosion control activities because it has the tendency of reducing corrosion rate in produced oilfield water and any aggressive environment.

REFERENCES

[1] M. A. Deyab (2016), Inhibition activity of Seaweed extract for mild carbon steel corrosion in saline produced oilfield water, Desalination, 2016, 384, 60–67.

[2] M. A. Deyab and S. S. A. El-Rehim (2014), Effect of succinic acid on carbon steel corrosion in produced water of crude oil, J.Taiwan Inst. Chem. Eng., 45, 1065–1072.

[3] Al-amiery,A.A., Kaadhum,A.H., A., Mohamad,A., Hon, C. K and Junaedi,S.(2014). Inhibition of mild steel corrosion in sulfuric Acid Solution by New Schiff Base materials, 7(2), 787-804.

[4] Akalezi C.O, Enenebaku C .K and Oguzie E. E (2012).Application of aqueous extracts of coffee senna for control of mild steel corrosion in acidic environments.international journal of industrial chemistry, 3(13). engineering and applied sciences,4(1);138-143.

[5] Offurum, F.C and Offurum, J.C (2017). Evaluation of the corrosion inhibition effects of chrysophyllum albidum extracts on mild steel, CARD international of science and advanced innovative research(l) SAIR) 2(2), 18-27

[6] Janaina Cardozo da Rocha, José Antônio da Cunha Ponciano Gomes and Eliane D'Elia (2014). Aqueous Extracts of Mango and Orange Peel as Green Inhibitors for carbon steel in Hydrochloric Acid Solution. Material Research 17(6): 1581-1587

[7] Ribeiro SMR, Barbosa LCA, Queiroz JH, Knodler M and Schieber A. Phenolic compounds and antioxidant capacity of Brazilian mango (Mangifera indica L.) varieties. Food Chemistry. 2008; 110(3):620-626. http://dx.doi.org/10.1016/j.foodchem.2008.02.067.

[8] Ajila CM, Naidu KA, Bhat SG and Prasada Rao UJS.Bioactive compounds and antioxidant potential of mango peel extract. Food Chemistry. 2007; 105(3):982-988. http://dx.doi.org/10.1016/j.foodchem.2007.04.052.

[9] Okwu, D. E. (2001). Evaluation of the Chemical Composition of indigenous species and flavouring agents, Global Journal of Pure and Applied Science, 7(3), 455 – 459.

[10] Rahilla, T. N., Rukh, S., and Ziaidi, A. A. (1994). Phytochemical Screening of Medicinal Plants belonging to Euphoribiaceae Pak, Veterinary Journal, 14: 160 – 2.

[11] Sofowara, A. (1993). Medicinal Plants and Traditional Medicine in Africa, Ibadan, Nigeria, Spectrum Book Ltd., 289.

[12] Amitha, B.E and Basu, JB (2012) Green inhibitors for corrosion protection of metals and alloys: an overview. International Journal of Corrosion, 1–15.

[13] Moussa A, H. Ghaly, M. Abou-Romia and F. El-Taib Heakal (1975), Adsorption and orientation of coumarin molecules on mercury—II: Differential capacitance of mercury in pure and coumarinated aqueous electrolytes: characterization of the adsorption isotherms, Electrochim. Acta, 20, 489–497.