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STUDY OF SYNERGISTIC INHIBITIVE PROPERTIES OF ETHANOLIC EXTRACTS OF *CALATROPIS PROCERA* ON THE CORROSION OF MILD STEEL IN HCl SOLUTION

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ABSTRACT

The of *Calotropis procera* leaves extract (CPLE) as corrosion inhibitor for mild steel in HCl solution was studied using the thermometric technique. The percentage inhibition efficiency (%I) of the plant extract was found to increase with the increase in doses of the extract. Acid concentration was found to linearly affect the rate of corrosion in the mild steel sample used. *Calotropis procera* leaves extract showed maximum inhibition efficiency of 60.01% in 0.4M HCl. The effect of halide ions (I^-) was also studied. The synergistic influence of iodide ions on the mild steel corrosion inhibition performance of *Calotropis procera* leaves extract in 0.4M HCl led to an increased performance of the extracts to 96.92 %. *

Keywords: *Synergy, corrosion inhibition, mild steel, Calotropis procera, HCl*

INTRODUCTION

Corrosion is a general term applied to the process in which uncombined metals change to compounds. It may be considered as the destruction of materials under the action of the environment [1]. This natural process originates from the chemical and/or electrochemical interaction of metals with the corrosive environment. Sulfides, oxides, and others are generated through reactions between the metal surface and the corrosive medium [2]. Mild steel is the most widely used in the oil, food, energy, chemical, and construction industries due to its different applications, most of which are based on its excellent mechanical properties. This metal shows high mechanical resistance, durability, and toughness. Consequently, solutions to problems related to degradation caused by corrosion of steel, mostly mild steel is a high priority topic. To a lesser extent, copper and aluminum alloys are as well studied. The high cost associated with corrosion, due to the replacement of rusted metals, can be reduced by using corrosion inhibitors [3].

The use of corrosion inhibitors has become a solution to corrosion attack on mild steel which has led to damages and in some cases total replacement of these mild steels. Many plant extracts have been used as corrosion inhibitors including Calotropis procera extracts [4-6]. The phytochemical screening of the Calotropis procera leaves showed the presence of tannins, flavonoids, Volatile Oils, Saponins, Glycosides, alkaloids, Cardiac glycoside [7], but very little has been reported on the synergistic effect of inhibitors in acidic medium. Recently, researchers have been paying more attention to mixed inhibitors, especially due to their synergistic effects. It has been proven that the effect of inhibitor mixture is better than the single inhibitor effect; halide ions such (such as I^-) are known to stimulate and inhibit corrosion in acid solutions [4, 5, 8].

EXPERIMENTAL

Sample Preparations

The mild steel used for this research was obtained from the auto-mechanical workshop of Hassan Usman Katsina Polytechnic, Katsina. The steel had a chemical composition (in wt. %) of 0.09 % P; 0.38 % Si; 0.01 % Al; 0.05 % Mn; 0.21 % C; 0.05 % S and 99.21% Fe). The mild steel of 6 cm by 2.5cm size was cut into a rectangular shape and degreased with ethanol washed with distilled water and dried. The mild steel sample was pre-treated by grinding with emery paper SiC (grades 400, 600, and 1200), then washed thoroughly with double-distilled water, degreased with ethanol and finally dried at room temperature before use.

Samples of *Calotropis procera* leaves were obtained from Umaru Musa Yar'adua University, Katsina, Nigeria. The leaves were washed and dried using a vacuum oven and then ground, sieved at120um mesh size and soaked in a solution of ethanol for 48 hours to percolate and were filtered using filter paper. The filtrates were heated in a rotary evaporator to obtain thick syrup which was allowed to air dry. The dry extract so obtained was used in preparing different concentrations of the plant extract by dissolving 0.1 g, 0.2 g, 0.3

g 0.4g, 0.6g, and 0.8g of the extract each differently in HCl solution at varying concentrations [4].

Preparation Corrodent (HCl) Solution

The stock HCl solution with a density of 1.18, percentage purity of 37 % and molecular weight of 36.46 g/mol was used to prepare 0.2M, 0.4M, 0.6M, and 0.8M of HCl through serial dilutions.

The Thermometric Studies

Three round bottom flasks were used as reaction vessel and the method described by Ebenso (1998) and Umoren et al, (2008) was used to study the corrosion behavior [9,10]. In this method, flasks were well-lagged to prevent heat losses. The corrodent (HCl) concentration was varied at 0.2, 0.4, 0.6 and0.8 M, while the concentration of the inhibitor was varied at 0.1 g, 0.2 g, 0.3 g 0.4g 0.6g, and 0.8g. The volume of the test solution used was 50 cm^3. The initial temperature (Ti) in all the experiments was kept at room temperature. Progress of the corrosion reaction was monitored by determining the changes in temperature with time using a calibrated thermometer. The temperature of the system was found to increase until it reaches maximum temperature (Tm) and then decreased. The initial and the maximum (final) temperatures of all the systems were recorded. The data were generated for one hour.

Synergistic studies were carried out on the combination of Calotropis procera leaves extract CPLE with KI, KBr, or KCl solutions to measure the effects of their presence on the corrosion of mild steel in HCl solution. The reaction number (RN) was calculated from the rise in temperature of the system per minute using equation (1):

$$RN(°C min^{-1}) = \frac{T_m - T_i}{t} \quad (1)$$

Where T_m is the maximum temperature attained by the system, T_i is the initial temperature and t is the time required to reach the maximum temperature.

The inhibition efficiency (%I) of the used inhibitor was determined using equation (2)

$$(\%I) = \frac{RN_f - RN_i}{RN_f} \quad (2)$$

Where RN_f is the reaction number of the aqueous acid in the absence of CPLE, and RN_i is the reaction number of aqueous acid in the presence of CPLE [9].

RESULTS AND DISCUSSION

Results of the inhibitive and synergistic properties of the Calotropis procera leaves extract and halides on mild steel in HCl solution are presented in figures I and II.

Effect of Inhibitor Concentration

The effect of CPLE concentration on the mild steel corrosion inhibition efficiency in HCl solution of different concentrations was studied using varying amount of the leaf extract as shown in figure 1. Results of these findings showed that concentrations of both corrodent and inhibitor affected the corrosion process of mild steel in HCl solution. It was observed that the presence of CPLE reduced the reaction temperatures and also slowed down the corrosion of mild steel. It was observed that increase in concentration of the inhibitor reduced the reaction number which resulted in the increase of % I in any of the three different HCl concentrations used. The results also indicate a maximum inhibition efficiency of about 82.99 % was achieved with 0.1M HCl solution whereas only 60.01 % was achieved with 0.6M HCl using the same amount of CPLE. This indicates that the higher the corrodent concentration the higher will be the amount of CPLE extract required for the prevention of mild steel from corrosion [5, 8, 11].

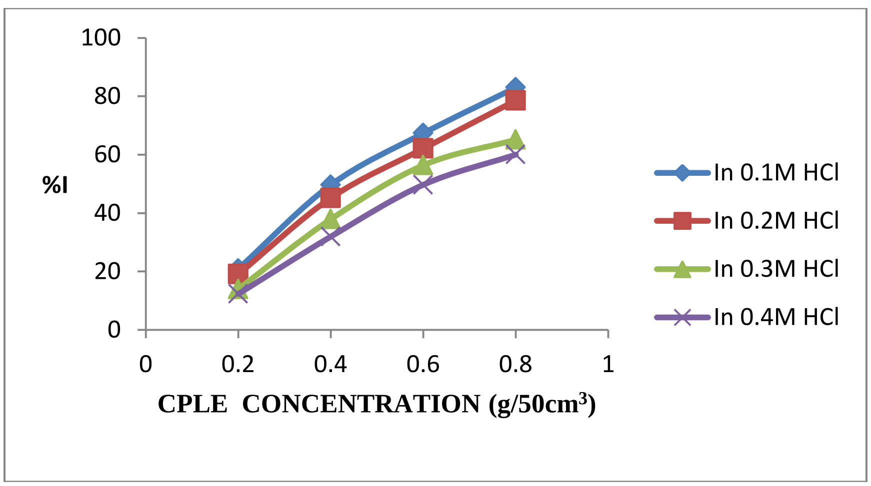

Figure 1: Effect of CPLE concentration on mild steel corrosion HCl solution of in varying concentrations

Effect of Iodide Ions

The results of the synergetic effect of iodide ions on the inhibitive performance of CPLE on mild steel corrosion in aqueous 0.4M HCl using 0.8 g of the leaf extracts are presented in figure 2.

Halide ions usually boost the corrosion inhibitive ability of plant extracts [5]. They are believed to exert synergistic influence due to their ionic radii which play an important role in the synergistic influence. For this reason, the order of reactivity of halide ions is KI > KBr > KCl. Having the largest ionic radius, iodide ion (I^-) has a large hydrophobicity and less electronegativity related to other halide ions, and therefore offering the most effect [12].

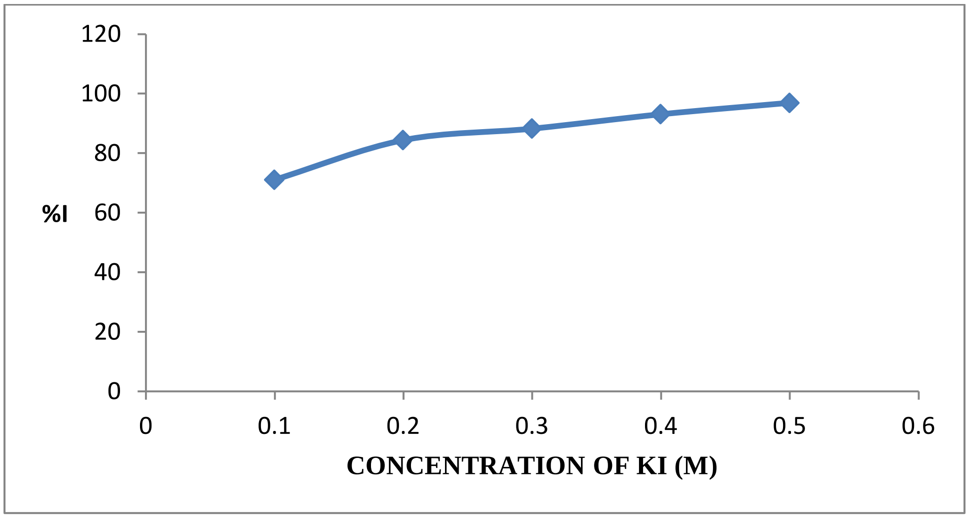

Figure 2: Synergistic effect of iodide ions on the inhibitive efficiency of CPLE on mild steel corrosion in 0.4M HCl

From figure 2, a significant increase in the inhibitive ability of CPLE was observed as the concentration of iodide ions increases. The maximum inhibition efficiency of 96.92 % was recorded upon the addition 0.5 M KI. This indicate that *Calotropis procera* leaves extract in combination with iodide ions retard the dissolution rate of mild steel in HCl medium when compared to leaves extract alone [5, 8, 12].

CONCLUSION

From the results and findings of this study, ethanol extract of Calotropis procera leaves has proven to be an excellent inhibitor to the corrosion of mild steel in HCl solution; the synergistic effect of iodide ions was found to increase the inhibition efficiency of the plant extracts [5, 11].

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