The effect of mango bark and leaf extract solution additives on the corrosion inhibition of mild steel in dilute sulphuric acid - Part I

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THE PERFORMANCE of bark and leaf solution extracts of mango (Mangifera Indica) on the corrosion inhibition of mild steel test specimen immersed in 0.2M dilute sulphuric acid at ambient temperature was investigated.

The experimental work was performed by using the weight-loss method and potential measurement technique. Solution extracts were made from the bark and leaves of the tree. The results obtained showed that the bark and the leaves, separately used, will provide very little inhibition. The combination of the two, however, at a concentration of 1.0ml/100ml of 0.2M dilute sulphuric acid, gave very good results that could make it a very useful inhibitor at the ambient temperature.

Introduction

There has been considerable recent interest in investigating the corrosive and/or corrosion inhibiting properties of plant extracts, such as tannin, cassava juice, etc. [1-8]. In most cases, the results obtained have been satisfactory. The presence of tannin in the solution extracts has been associated with the corrosion inhibitive effect of the different plants extracts investigated [1].

The leaves and bark of mango were used in this work. Mango is a member of the cashew family (*Anacardiaceae*) that originated in the Indo-Burma region, and is now grown throughout the tropical and subtropical areas of the world [9]. The tree is evergreen, often reaching 15-18m (50-60ft) in height, and attaining great age. The leaves are lanceolate, and up to 30cm long; the flowers are small, pinkish, and fragrant, and are borne in large terminal panicles (loose clusters). They are polygamous, i.e. some have stamens and pistils, others stamens only [9].

Mangoes are a rich source of vitamins A, C, and D. The ripe fruit is eaten raw as a dessert, or used in the manufacture of juice, jams, jellies, and preserves. Unripe fruits can be made into pickles or chutneys. In Nigeria, the bark and leaves of mango trees are used to treat malarial fever.

Though one of the most important and widely-used cultivated fruits of the tropical world, the chemical constituents of the bark and leaves of the mango are yet to be well determined and/or documented. The very bitter taste of the juices extracted from the barks and leaves has, however, been attributed to the presence of tannins [10]. Tannins, particularly, the condensed types, occur normally in the roots, woods, barks, leaves, and fruit of many plants, and could be obtained by water extraction from a variety of these sources. In addition

Juice extract	Concentration in mils/100ml of 0.2M H_2SO_4	Corrosion rate (mm/year)	Inhibitor efficiency (%)
Bark	0.2	3.508	-19.40
	0.5	2.911	0.919
	1.0	1.620	39.07
Leaf	0.2	3.916	-33.29
	0.5	2.089	28.90
	1.0	2.297	21.82
Bark and leaf	0.2	2.222	24.37
	0.5	2.080	29.20
	1.0	0.877	70.15

Table 1. Inhibitor efficiency.
Note: The corrosion rate for the mild steel immersed in 0.2M H_2SO_4 without any juice extract addition at 21st day of the experiment is 2.938mm/yr.

to their principal applications in leather manufacture and dyeing, tannins are used in the classification of wine and beer, as a constituent to reduce viscosity of drilling mud for oil wells, and in boiler water to prevent scale formation. There are also many other medicinal uses, such as in the treatment of intestinal bleeding, tonsillitis, haemorrhoids, pharygitis, and skin eruptions. Tannin has also been used as an antidote for metallic, alkaloidal, and glycosidic poisons [11]. The corrosion inhibitive property associated with tannin has been reported [1,8].

In this work, the corrosion inhibitive effectiveness of the extracts from the bark and leaves of mango on the corrosion of a mild steel specimen immersed in 0.2M sulphuric acid (H_2SO_4) has been studied. The study will help in making a contribution to the present interest in elucidating the corrosion inhibitive properties of plants such as the one that has now been investigated. Furthermore, the study aims at looking into the use of the plant's barks and leaves as a natural source of inhibitor against the corrosion of mild steel in strong inorganic acids that have very wide industrial applications.

This work is part of the series of investigation in this research area. It is anticipated that a positive result will undoubtedly be of technological and economic benefit in the control of metallic corrosion.

Experimental procedure

Preparation of specimens

The mild steel specimen was locally obtained from a rolling mill in Nigeria. The nominal percentage composition of the steel was 0.15C, 0.20Si, 0.04S, 0.85Mn, 0.10Ni, 0.20Cr, 0.02Mo, 0.001V, 0.25Cu, and the rest Fe. The steel bar was cut into various cylindrical pieces of different measured dimensions. A wire brush was used to descale the test specimens. They were then ground with silicon carbide abrasive paper of 240, 320, 400, and 600 grits, polished to 1μm, cleaned thoroughly, rinsed in ultrasonic cleaner, dried, and kept in a desiccator for further weight-loss tests. Some selected specimens were, in turn, mounted in araldite resin after spot welding to the connecting insulated flexible

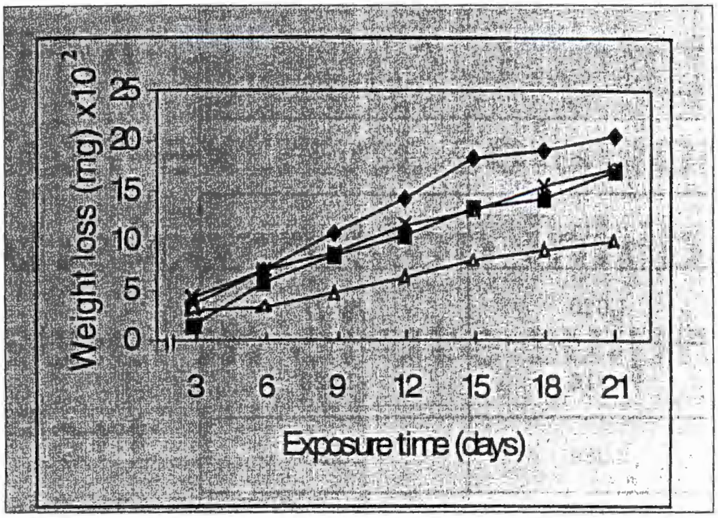

Fig.1. Variation of weight loss with exposure time for the steel specimen immersed in 0.2M H_2SO_4 with varied concentrations of mango bark juice extract.

Key: ▲ = *0.2ml juice extract/100ml H_2SO_4*
■ = *0.5ml juice extract/100ml H_2SO_4*
Δ = *1.0ml juice extract/100ml H_2SO_4*
x = *without addition of juice extract*

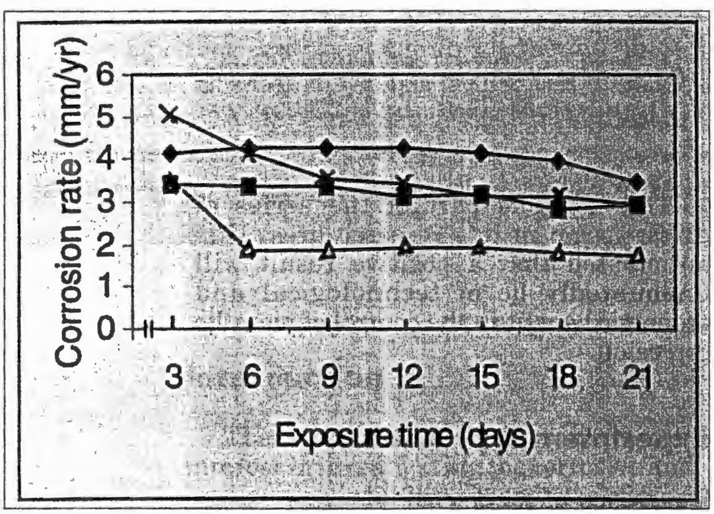

Fig.2. Variation of corrosion rate with exposure time for the steel specimen immersed in 0.2M H_2SO_4 with varied concentrations of mango bark juice extract. Key as in Fig.1.

wire. These specimens were prepared for potential measurements of the steel/test environment interfacial reactions.

Test media

The experiment was performed in 0.2M H_2SO_4, of Analar grade. The solution extracts, separately extracted from the bark and leaves of a mango tree, were used as the corrosion inhibitor in different concentrations as explained below.

Extraction of mango solution extracts

The bark of a tree was removed and cut into small pieces. Similarly, the leaves were cut and blended. These were separately dried at 110°C for two hours. After cooling, they were weighed: the bark weighed 0.25kg, and the leaves 0.1kg. These were ground into powder in turn, and then soaked in two different containers containing ethanol for five days, to extract the juice by leaching. Each of the different solution extracts was filtered at the end of the soaking period to remove any impurity. The ethanol solution was then distilled at 79°C to remove the ethanol from the extract and concentrate the inhibiting chemical(s). Each solution extract was stored in a clean covered bottle.

Preparation of test media and the solution extracts

100ml of 0.2M H_2SO_4 was measured into four different 250-ml beakers. The solution extract from the tree's bark in different concentrations of 0.20, 0.50, and 1.0ml, was separately put in the first three beakers. No extract was added to the fourth beaker. This same process was repeated for the same concentrations and quantities of the solution extract from the mango tree's leaves. This formed the second set of experiments.

The extracts from the bark and leaves were added together and thoroughly mixed. Following the same procedure as above, the mixture of the leaves and bark juices were used in the same quantities and concentrations to form the third set of experiments. The corrosive media contained the added juice solution extracts in the first three beakers. The fourth beaker has no extract addition.

Weight-loss experiment

Weighed test pieces were separately and fully immersed for 21 days in each of the beakers containing the 0.2M sulphuric acid and the solution extracts for the three sets of the experiment described above, and the solution without the extract addition. Each of the test specimens was taken out every three days, washed with distilled water, rinsed with methanol, dried, and re-weighed. Plots of weight loss vs exposure time and corrosion rate vs exposure time were made (Figs 1-12).

The percentage inhibitor efficiency, P, for each of the results obtained at the end of the experiment was calculated from the relationship:

$$P = 100 [1 - (W_2/W_1)]$$

where W_1 and W_2 are, respectively, the corrosion rates in the absence and presence of the predetermined concentration of inhibitor.

The results obtained are presented in Table 1. All the experiments were performed at the ambient temperature. The poor qualities of the photomicrographs rendered them unsuitable for use.

Potential measurements

The mounted and polished specimens were tested for potential measurements. They were immersed in turns in each of the different test media containing different concentrations of the inhibitor (extracted mango juice). The potential measurement tests were also performed in the acid test medium without the solution extract (inhibitor) addition. The potential was recorded at three-day intervals using a digital voltmeter and saturated calomel electrode as the reference electrode. Plots of variation of potential (vs SCE) with the exposure time were made, and these are presented in Figs 13-15.

Results and discussion

Mango bark solution extract

The results obtained for the variation of weight loss with exposure time for the mild steel test specimen immersed in 0.2M H_2SO_4 with varied concentration of added mango bark juice extract (0.20, 0.50, and 1.0ml solution extract per 100ml of H_2SO_4) are presented in Fig.1. The corresponding corrosion rate vs the exposure time curves is presented in Fig.2. The corrosion rates were obtained by calculation of weight-loss data used in Fig.1. In Fig.1, the four different experiments presented results in which the weight loss (an indication of magnitude of corrosion) increased with experimental time.

The acid test medium with 0.2ml juice extract addition had the least corrosion inhibition effect for the immersed specimen. The weight loss achieved a weight value of 2.058g at the 21st day of the experiment.

The weight loss recorded throughout the experimental period for the corrosive acid medium with added 0.50ml of solution extracts, and for the test medium without extract addition, are almost the same, on average. At the end of the experiment on the 21st day, the weight loss value for the former was 1.704g, and for the latter (the plain acid medium), was 1.72g.

The acid test medium with 1.0ml of solution extract addition recorded the lowest weight loss value right from the sixth (6th) day to the 21st day (end) of the experiment, with a weight loss value of 1.007g.

It is clear from these results that the test medium with 0.2ml solution extract addition increased the corrosion, as shown in the curve. The medium with 0.50ml solution extract addition had no apparent effect: no corrosion inhibition nor increase of corrosion. The test with 1.0ml solution extract addition, however, presented the positive result of inhibiting corrosion throughout the experimental period at ambient temperature. It thus means that 0.2ml of bark solution extract provided insufficient concentration of the reacting inhibitive species (assumed to be tannin) in the test medium. It is in most cases characteristic of inhibitors to accelerate corrosion instead of inhibiting it if the right concentration is used.

The 1.0ml solution extract addition provided a concentration of the inhibitor that was effective for corrosion inhibition. However, more work needs to be done to determine and/or achieve the optimum concentration of the solution extract (from the bark) for this type of acid test medium.

The corresponding corrosion rate vs the exposure time results in Fig.2 gave a good correlation with the results in Fig.1. The corrosion rate did not increase with experimental time. This indicates some stifling of corrosion reactions due to the corrosion product contamination of the acid medium. The test medium with added 1.0ml solution extract gave the least corrosion rate, which ranged between 1.883mm/yr on the 6th day, and 1.720mm/yr on the 21st day (the end) of the experiment. The test medium with 0.2ml of bark solution extract addition gave the highest overall corrosion rate.

In Part 2 of the paper, to be published in the next issue, the author discusses the effects of the leaf solution, and the bark and leaf solution, and reaches his conclusions, that the best inhibition performance was obtained with the use of the combined solution.