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Corrosion Protection Of Mild Steel In Sea Water Using Chemical Inhibitor

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Abstract. The effect of sodium nitrite as a corrosion inhibitor of mild steel in sea water (i.e ASTM standard prepared sea water and sea water obtained from a local river) was investigated, using the weight loss technique. Different amount of sodium nitrite were prepared (i.e 2 % to 10 %) in the inhibition of the mild steel corrosion in sea water exposed to irradiation condition from sunlight exposure. The cut samples of mild steel were exposed to these corrosive media and the corresponding weight loss subsequently obtained was recorded at intervals of 1 to 4 weeks. It was observed that corrosion rate increases with the time of exposure to the corrosive medium exposed to sunlight and that sodium nitrite that was used at the chemical inhibitor was able to retard the corrosion rate of mild steel if the appropriate concentration is applied. The results obtained from the weight loss analysis shows that the optimum percentage of sodium nitrate in sea water that gives the optimum corrosion inhibition of mild steel is 4 %.

1. Introduction

Corrosion is known to be a problem normally associated with material deterioration in the field of oil and gas, construction, and other engineering fields. Mild steel find used in most structural shapes such as beams, bars and pipes [1]. Due to the level of the damage caused by corrosion in various engineering field, there is the need to retard the corrosion rate, if not to prevent it completely [2]. The different methods that have been reported for the prevention control of corrosive activity comprise the separation of the metal interphase from corrosive media or by altering the environment. This method of corrosion prevention includes but not limited to anodic protection, cathodic protection, coating and inhibitors [3]. Inhibitors generally are substances when added in the right concentrations to the environment decrease the corrosion rate considerably. To be fully effective the inhibitors required should be present above a certain minimum concentration.

Corrosion inhibitors can be classified as anodic, cathodic or mixed according to their influence on the electrochemical reaction involving the metals, and their interaction with the environment. Corrosion inhibitors have been in use for several years and the most familiar examples of their applications are in paints and coatings on metals where nitrate, chromate, phosphate, benzoates, borates and oxides are incorporated [4].

It is known that inhibitors could function in several ways to control corrosion activity by adsorption of the film onto the surface of a corroding material, thereby inducing the formation of a thick corrosion product, or by changing the characteristics of the environment resulting in reduced aggressiveness. This work is to study the potency of different concentrations of sodium nitrite in corrosion inhibition of mild steel in sea water obtained from the local river exposed to sunlight [5].

2. Materials and methods

The main material used for this research work is mild steel (i.e. AISI/SAE 1020). The mild steel was purchased locally from a metal fabrication workshop at padang besar , uniciti alam. The XRF analysis of the purchased mild steel used is shown in Table 1:

Table 1. X-ray fluorescence spectrometer of as-received mild steel

Element	C	Si	Mn	Cu	Fe
Weight percent (%)	0.203	0.152	0.627	0.204	Balance

2.1 Sample preparation

Sea water

1. The sea water was prepared according to the ASTM G1 standard 35g/ 1 liter.
2. An original sea water was also obtained from a local river in Pantai Irama, Bachok, Kelantan, Malaysia.

Mild steel

The test specimens of each mild steel to be tested, were measured to obtain fixed and regular dimensions, and cleaned to remove grease and oxidation films that could be present on its surface. The mild steel was cut to a sample dimension of 3.5 cm diameter and 7.5 cm length. The sample was weighed before and after the experiment. Each of the test samples is marked and its initial weight is recorded.

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2.2 Solution Preparation

Five different solutions were prepared, each having different concentrations of sodium nitrite to be used as the inhibitor in both sea water. The percentages of the sodium nitrite in the prepared corrosive media are as follows; 2 %, 4 %, 6 %, 8 %, and 10 % respectively.

Eighteen test samples were carefully arranged into each of the corrosive media prepared and left for 4 weeks shown in Figure 1 before being transferred and exposed to sunlight. For every week the corrosion behaviour was observed. After the corrosion testing each sample was removed from the corrosive media, dried and weighed to determine the weight loss.

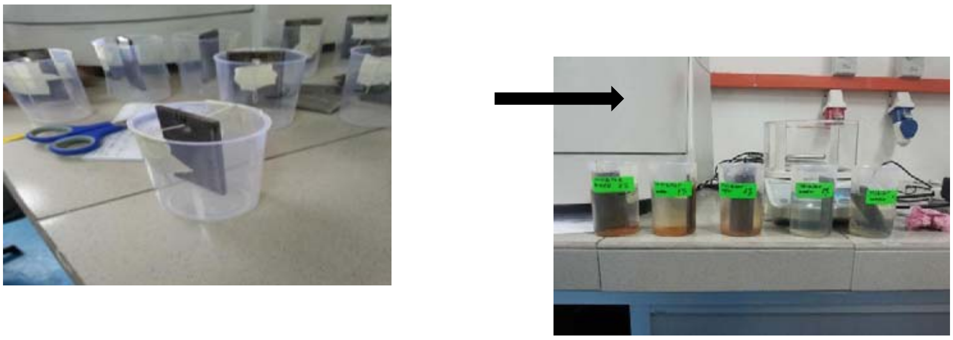

Figure 1: The immersion of mild steel in sea water for 4 weeks before field exposure

3. Results and Discussion

The weight loss for the mild steel without sodium nitrite inhibitor is shown in Table 2 and Figure 2. It was observed that the rate of corrosion activity increases with time as the weight loss increases which can lead to serious material failure when in use in the engineering field.
The data from one week immersion test shows that the increase in the weight loss started at 0.78 for the original seawater (sea water from the local river) and 1.04 for ASTM prepared sea water and it continued for the subsequent weeks. The data observed for week four analyses for the immersion test shows the weight loss of mild steel in original sea water is higher than the ASTM prepared standard. This is probably due to the presence of other contaminants that could speed up the corrosion activity in the local river. For week four the weight loss in original sea water is 3.35 g while the weight loss in ASTM prepared standard is 2.64 g.

Table 2: The results for comparison without inhibitor

Time (weeks)	Weight loss	
	Sea water (original)	Sea water (based on ASTM)
1	0.78	1.04
2	1.82	1.80
3	2.54	2.32
4	3.35	2.64

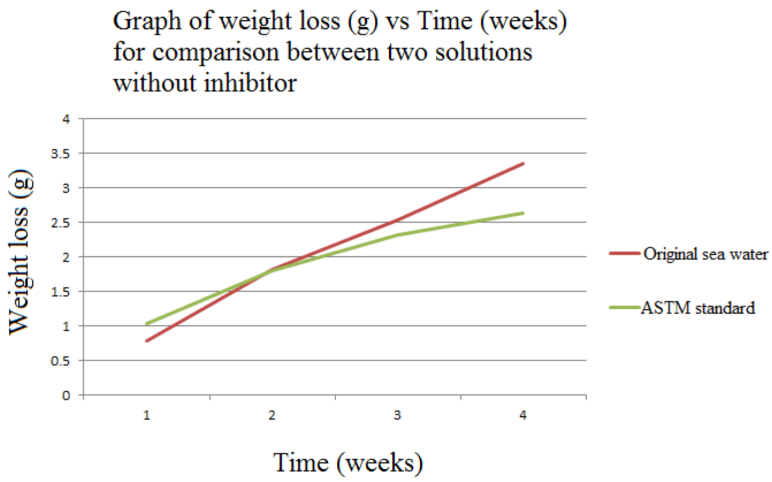

Figure 2: Mild steel weight loss without inhibitor

Figure 3 shows the weight loss that was recorded against the percentage of sodium nitrite in the corrosive media for two different solutions exposed to sunlight.
Based on the graph, for comparison between both sample solutions it was observed that the original sea water sourced from a local river with 2 % sodium nitrite concentration has the highest weight loss and for the ASTM Standard 10 % concentration of inhibitor has the highest weight loss from the immersion test. This can be summarized that the 2 % concentration of inhibitor cannot support and protect the mild steel from rust. Then, the 8 % and 10 % concentration of inhibitor for both samples also could not protect the mild steel from corroding and the best result of decreasing weight loss was 4 % and 6 % concentration of the sodium nitrite inhibitor. The percentage was enough to protect and slow the rate of weight loss in the mild steel.

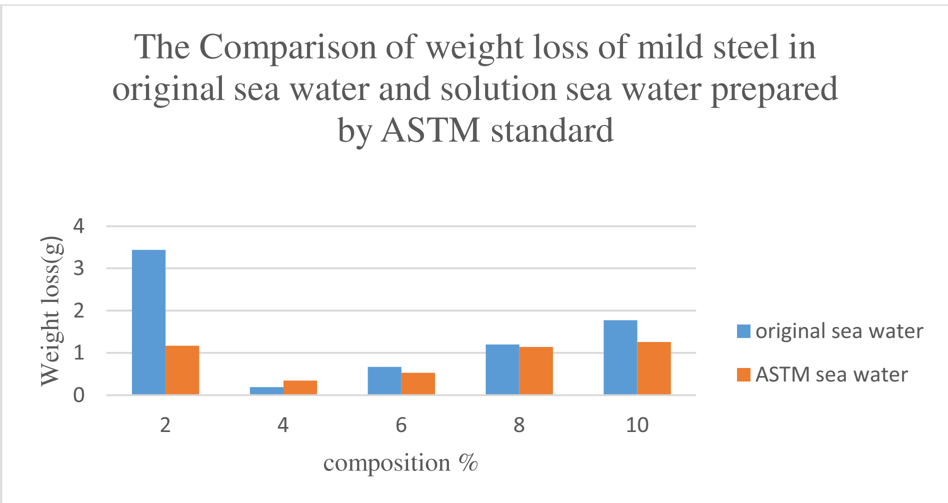

Figure 3: The graph show the comparison weight loss between two sea water conditions

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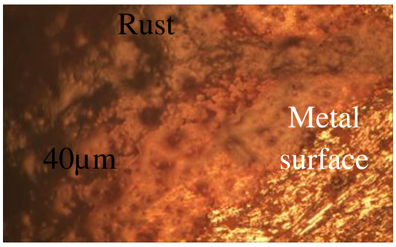
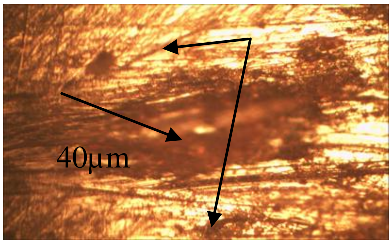
The surface morphology as observed by optical microscope in Figures 4 (a), (b), (c), (d) and (e) for 2 %, 4 %, 6 %, 8 % and 10 % concentration of sodium nitrite inhibitor in sea water. Rust was observed from the morphology to indicate corrosion activity while the concentration with the most effective inhibitor shows minimal presence of rust on the surface.

(a) 2 % concentration **(b) 4 % concentration**

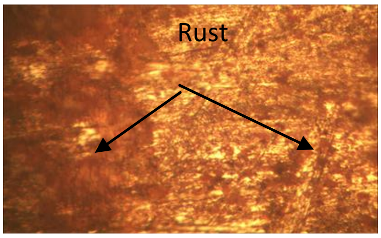
Rust



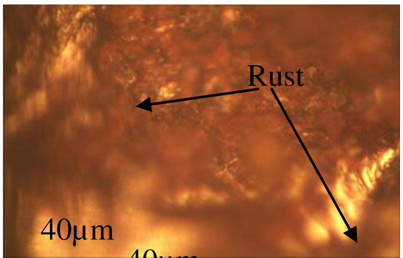


Metal surface

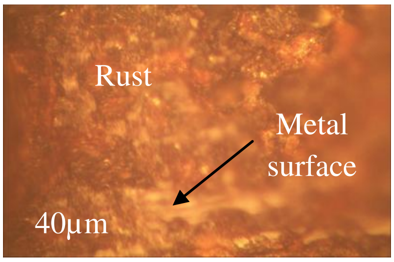
(c) 6 % concentration



(d) 8 % concentration **(e) 10 % concentration**



40µm



40µm

4. Conclusions

Mild steel corrodes when exposed to any aggressive or marine environment which can lead to material failure and shortened life span of engineering materials in service. Sodium nitrite inhibitor provides an alternative method of inhibiting the corrosion behavior when the right dosage or concentration is applied. The corrosion rate was observed to increase with the time of exposure to the corrosive medium being inhibited or not inhibited. Sodium nitrite is shown in this experiment as a suitable inhibitor which can retard the corrosion rate of mild steel if the appropriate concentration is used in sea water. The optimum percentage composition of sodium nitrite required in sea water for optimum corrosion inhibiting performance of mild steel is 4 %.

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