Anticorrosive Coatings from Different Marine Natural Resources

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Abstract: The main objective of this study is to create some promising marine protective coatings for anticorrosive purposes in case of different containers, offshore constructions, wind turbines, storage tanks, bridges, ballast tanks, cargo holds, cargo tanks and decks in addition to engine rooms on ships. In this study different marine natural resources (Corallina mediterranea, Grateloupia filicina, Mangrove leaves, Ulva lactuca) were collected, cleaned and extracted using methanol in 1:1 (wt/vol). The extracted products were dried and added in a certain ratio using an oil binder material, iron oxide, zinc oxide and xylene. This anticorrosive formulation was prepared through mixing each extraction solely with the paint ingredients using a ball mill. The tested anticorrosive coatings was through immersing the four coated steel panels each in 2L natural seawater sample collected from the Eastern Harbor of Alexandria for a month. A coated steel panel containing the formulation without any active product as anticorrosive agent, two panels containing the two commercial anticorrosive paints and a blank (steel panel without any paint) were also immersed each in 2L natural seawater sample in the same time with the four previous coated panels. The detection of the anticorrosive activity was carried out using the weight loss and it was found that the most promising and effective anticorrosion resource was the extractable materials of the mangrove leaves followed by that of the Corallina mediterranea in comparison with the other tested resources and the two commercial anticorrosive paints.

Key words: Anti Corrosive · Natural · Marine Resources · Algae · Mangrove Plant

INTRODUCTION

In the past decades, several marine paint formulations containing organic solvent-born coatings have reached the commercial market. The formation of iron oxides (rust) is a well-known consequence of the corrosion process when iron and steel corrode. It results from the interaction between the used metal and the physicochemical parameters in its environment.

Green algae were tested as a natural additive for a paint formulation based on vinyl chloride copolymer (VYHH) to evaluate its efficiency for protection of steel against corrosion in seawater using spectrophotometry, alternating current (AC) and direct current (DC) electrochemical measurements, visual inspection and surface analysis [1].

Moreover, it was found mangrove plant (Rhizophora mucronata) tannin (RMT) able to act as corrosion inhibitor for carbon steel and copper it was cost effective and environmentally friendly corrosion inhibiting agent [2].

However, if algae and specifically diatoms can be used to increase the efficiency of environmentally friendly anti-corrosion coatings, all kinds of structures – aircraft, trains and military tanks could be protected without using toxic and expensive materials [3].

So, this study aims to create some promising marine protective coatings for anticorrosive purposes in case of different containers, offshore constructions, wind turbines, storage tanks, bridges, ballast tanks, cargo holds, cargo tanks and decks in addition to engine rooms on ships.
MATERIALS AND METHODS

Collection of Marine Algae and Marine Plant: Three algal samples were collected by hand from Abu Qir Bay. While the mangrove leaves plant was collected from Hurghada. The collection was carried out through spring - 2016. Each sample was kept in two different plastic bags labeled with a certain code. One was kept fresh in a little amount of clean sea water for preliminary identification and the second sample from the same species was kept without adding water. These samples were thoroughly washed using fresh clean sea water in the laboratory, distilled water and then spread on clean tissue papers and let for drying. Each sample was packed in an aluminum foil with certain code and weighed giving the fresh weight of the algal sample.

Identification of Algal Species: The identification and the taxonomic classification of these algal species were carried out according to Chapman and Chapman [4] and Trainor [5].

Preparation of Steel Panels: Steel panels with dimensions 7cm×3cm×0.5cm were used. Their surfaces were polished using different grades of emery papers till finesse grade and cleaned using xylene.

Steel Panels’ Composition: The element analysis of the steel panels’ composition was carried out at the Faculty of Engineering –Alexandria University, Egypt. It was found that the composition was as follows: 97.815 % Fe, 0.073% Ni, 0.006% Mo, 0.056% Cr, 0.001% S, 0.001% P, 1.03% Mn, 0.146% Si and 0.53% C.

Preparation of Anti-Corrosive Coatings: The different marine natural resources were dried in air followed by an ordinary oven adjusted at 40°C till a constant weight was obtained. These dried samples were grinded to powder till mesh size 50 micron in a porcelain mortar (16.0 cm), then preserved in well-sealed, labeled small plastic bags and kept in a deep freezer at -20°C (not more than one week). Then they undergo extraction process using methanol in 1:1 (wt/vol). The extracted products were dried and added in a certain ratio to a paint formulation containing; oil binder material, iron oxide, zinc oxide and xylene. This anticorrosive formulation was prepared through mixing each extraction solely with the paint ingredients using a ball mill for two hours.

Application on Steel Panels: Each steel panel was coated twice allowing an interval time between them for each paint formulation. The four tested coated steel panels with anticorrosive coatings were immersed each in 2L natural seawater sample collected from the Eastern Harbor-Alexandria for a month. A coated steel panel containing the formulation without any active product as anticorrosive agent, two panels containing the two commercial anticorrosive paints and a blank (steel panel without any paint) were also immersed each in 2L natural seawater sample in the same time with the four previous coated panels.

Detection of Some Physicochemical Parameters of Seawater Samples

Temperature: The water temperature was measured using an inductive portable thermometer.

Salinity: The salinity % was measured using Salinometer model Beckman RS-10-X3 range to about 0.1 units.

pH- Value: pH- values of water samples were measured to about 0.1 unit in situ by using a portable pH- meter (Orion Research model 210 digital pH- meters) after necessary precautions in sampling and standardization processes.

Dissolved Oxygen (DO): The dissolved O, determination of water samples were collected in 125 ml glass bottles and fixed with 1 ml manganous sulphate followed by 1ml iodide solution until the analysis in the laboratory. DO was determined according to the classical Winkler's method modified by Grasshoff [6]. The amount of dissolved oxygen in each sample was calculated by applying the following equation:

\[ \text{O mL/L} = \frac{(N \times V \times 32000/4)}{4(B)} \times 1.43 \]

N = Normality of sodium thiosulphate,
V = Volume of sodium thiosulphate
B = Volume of oxygen bottle

Weight Loss Measurements of the Steel Panels: Each steel sample was weighed before immersion. At the end of the experiment after a month each sample was weighed again after washing well with distilled water and drying well.
From the difference in weight, the weight loss is calculated according to Standard Practice [7] and Robert [8].

The corrosion rate of steel in seawater samples was measured by using the weight loss technique and it was calculated according to the equation [9, 10].

\[
\text{Corrosion rate} = \left( \frac{K \times W}{A \times T \times D} \right) \text{ month of immersion in seawater medium containing all algal species beside the two commercial paints (R1, R2).}
\]

\[K: \text{Is a constant, } W: \text{is the weight loss (g), } A: \text{is the area of steel (cm}^2\text{),} \]
\[T: \text{Is the time of exposure (h), } D: \text{is the density of steel (g/cm}^2\text{) .} \]

**RESULTS AND DISCUSSION**

**The Natural Marine Resources:** The algal species used in this study were identified under two classes, Chlorophyceae and Corallinaceae on the basis of morphological and anatomical characteristics Fig. 1. They were Grateloupia filicina (A), Corallina mediterranea (B), Ulva lactuca (C) and Mangrove leaves (D).

**The Impacts on Some Physicochemical Parameters of the Used Seawater Samples:** The data presented in Table (1) showed that the temperature was slightly higher after one month of immersion in seawater medium containing all algal species beside the two commercial paints (R1, R2). Slightly increase in salinity and pH was noticed, also the detected dissolved oxygen decreased indicating the ability of these algae and commercial paints to resist corrosion by different grades as shown from the variations in the formed rust along a month of seawater immersion Fig. 2.

**Weight Loss of Steel Panels:** Generally, results obtained from all coated steel panels with paint formulations containing algae were better or nearly in the same level of the commercial paints. From Table (2) it was noticed that after a month of immersion from the different coated

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**Table 1:** The impacts of the tested anticorrosive coatings on some physicochemical parameters of the examined seawater samples before and after the application process of the used steel panels

<table>
<thead>
<tr>
<th>Source of anticorrosive paint</th>
<th>Temp °C Before</th>
<th>Temp °C After</th>
<th>Salinity % Before</th>
<th>Salinity % After</th>
<th>pH Before</th>
<th>pH After</th>
<th>DO ml/l Before</th>
<th>DO ml/l After</th>
</tr>
</thead>
<tbody>
<tr>
<td>*C Blank</td>
<td>20.5</td>
<td>20.5</td>
<td>37.35</td>
<td>37.36</td>
<td>8.16</td>
<td>8.16</td>
<td>6.95</td>
<td>6.97</td>
</tr>
<tr>
<td><strong>Blank</strong></td>
<td>20.4</td>
<td>20.4</td>
<td>37.41</td>
<td>37.43</td>
<td>8.15</td>
<td>8.16</td>
<td>5.69</td>
<td>2.48</td>
</tr>
<tr>
<td>Grateloupia filicina</td>
<td>20.5</td>
<td>20.7</td>
<td>37.42</td>
<td>37.51</td>
<td>8.16</td>
<td>8.17</td>
<td>5.69</td>
<td>5.42</td>
</tr>
<tr>
<td>Corallina mediterranea</td>
<td>20.4</td>
<td>20.6</td>
<td>37.26</td>
<td>37.34</td>
<td>8.15</td>
<td>8.15</td>
<td>4.55</td>
<td>4.22</td>
</tr>
<tr>
<td>Ulva lactuca</td>
<td>20.3</td>
<td>20.5</td>
<td>37.3</td>
<td>37.35</td>
<td>8.13</td>
<td>8.14</td>
<td>4.78</td>
<td>4.49</td>
</tr>
<tr>
<td>mangrove leaves</td>
<td>20.4</td>
<td>20.4</td>
<td>37.22</td>
<td>37.28</td>
<td>8.17</td>
<td>8.18</td>
<td>6.83</td>
<td>4.18</td>
</tr>
<tr>
<td>R1</td>
<td>20.5</td>
<td>20.6</td>
<td>37.55</td>
<td>37.57</td>
<td>8.14</td>
<td>8.14</td>
<td>5.92</td>
<td>5.10</td>
</tr>
<tr>
<td>R2</td>
<td>20.4</td>
<td>20.5</td>
<td>37.46</td>
<td>37.49</td>
<td>8.12</td>
<td>8.13</td>
<td>4.78</td>
<td>3.75</td>
</tr>
</tbody>
</table>

*C (control seawater sample) ** Blank (Paint without anticorrosive agent)*
panels with different algal paints and comparing the results with the control (Paint without anticorrosive agent) and the two commercial paints it was found that best results was for the steel coated panel with the paint formulation containing the Mangrove leaf extract followed by Corallina mediterranea. Similarly, the anticorrosion ability of a synthesized coumarin, namely 2-(coumarin-4-yloxy) acetohydrazide (EFCI), for mild steel (MS) in 1 M hydrochloric acid solution has been studied using a weight loss method. They also studied the effect of temperature on the corrosion rate was investigated; the results indicated that inhibition efficiencies were enhanced with an increase in concentration of inhibitor and decreased with a rise in temperature [9, 10, 11].

**CONCLUSION**

From the results observed in this study it was found that the most promising and effective anticorrosion resource was the extractable materials of the mangrove leaves followed by that of the Corallina mediterranea in comparison with the other tested recourses and the two commercial anticorrosive paints. Also, it is a must to use such friendly environment resources to improve and protect our marine environment from the toxic chemical hazards commonly used in the anticorrosive products especially to protect the aquatic organisms and even the human health.

**REFERENCES**