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Corrosion Inhibition Studies Of Mild Steel With Carrier Oil Stabilized Of Iron Oxide Nanoparticles Incorporated Into A Paint

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Abstract: Corrosion inhibitors are chemical substances that are added to the corrosive environment to reduce or eliminate corrosion. The good inhibitor has many advantages such as high inhibition efficiency, low price, low toxicity and easy production. Nanomaterials exhibit such advantages with addition of improvement of the environmental impact. The stabilization is the significant factor for these iron oxide nanoparticles to exhibit high corrosion inhibition efficiency. Hence it was decided to have a better corrosion protection for these metals, iron oxide nanoparticles (IONPs) functionalized with carrier oils such as Olive oil and lineed oil as natural stabilizing agents composited with paint after six months of storage at room temperature and coated on mild steels. The morphology of these six months stored IONPs was investigated by scanning electronic microscopy (SEM). The weight loss method was chosen for determining the corrosion inhibition efficiency and corrosion rate.
Key words : Corrosion inhibition, Carrier oils, Iron oxide nanoparticles.

Introduction

Corrosion is an undesirable phenomenon that has to be prevented with the kind of new inventions or technology developed. There are several ways of preventing corrosion and the rates at which it can propagate with a view of improving the lifetime of metallic and alloy materials. The use of inhibitors for the control of corrosion of metals and alloys which are in contact with aggressive environment is one among the acceptable practices used to reduce and/or prevent corrosion. A corrosion inhibitor is a substance which, when added in small concentration to an environment, effectively reduces the corrosion rate of a metal exposed to that environment (1-2).

Removing or separating the corrosion environment from the metal can prevent corrosion. This is the principle of coatings applied for corrosion protection. Paint and galvanizing are examples of coatings that have been used for many years. Nanostructures materials (1–100 nm) are known for their outstanding mechanical and physical properties due to their extremely fine grain size and high grain boundary volume fraction. Significant progress has been made in various aspects of synthesis of nanoscale structures and coatings having greater wear and Corrosion resistance. Steel is widely used as the constructional material in most of the major industries particularly in food, petroleum, power production, chemical and electrochemical industries, especially due to its excellent mechanical properties and low cost.

The good inhibitor has many advantages such as high inhibition efficiency, low price, low toxicity and easy production. Nanomaterials exhibit such advantages with addition of improvement of the environmental impact. In the last two decades, nanotechnology has been playing an increasing important role in supporting innovative technological advances to manage the corrosion of steel. The use of iron oxides as natural pigments has been practiced since earliest times. The iron oxides such as magnetite, hematite, maghemite and goethite are commonly used as pigments for black, red, brown and yellow colours respectively. Predominantly natural red iron oxides are used in primers for steel constructions and cars reducing corrosion problems. These nanoparticles should have good stability at all conditions. Iron oxide Nanoparticles are strong absorbers of ultraviolet radiation and mostly used in automotive paints, wood finishes, construction paints, industrial coatings, plastic, nylon, rubber and print ink. The stabilization is the significant factor for these iron oxide nanoparticles to exhibit high corrosion inhibition efficiency. Hence it was decided to have a better corrosion protection for these metals, iron oxide nanoparticles functionalized with vegetable oils such as Olive oil and lineed oil as natural stabilizing agents composited with paints by having high corrosion inhibition efficiency in eco friendly method (3-9).

Materials and methods

The iron oxide nanoparticles synthesized using co-precipitation method using carrier oils such as olive oil and linseed oil as stabilizing agent and surfactant as we reported in our previous study(10,11). The average particle sizes were 20 nm and exhibited superparamagnetic behaviour. These dried nanoparticles were stored at room temperature for about six months. Scanning Electron Microscope (SEM, Model S3000H, Hitachi, Japan) is used to analyse the morphology of these IONPs after six months. These IONPs were used here by incorporating into a commercial paint for corrosion studies on mild steel. Four mild steel plates, $7.5 \times 3\ cm^2$ in size, were used as the substrates. The surface of the all mild steel plates were ground and polished by using a common metallographic technique. The mild steel panels were then cleaned and dried for 24 hrs. The initial dimensions of all specimens such as length, diameter and weight of the specimen were measured accurately and the weights of the mild steel plates were noted. Then they were coated and labelled as, A) linseed oil stabilized IONPs mixed with paint coated, B) Olive oil stabilized IONPs mixed with paint coated; C) only paint coated and D) bare mild steel. The coated mild steel plates (A, B and C) were dried in the laboratory at room temperature for 24 hours.

Weight loss measurements

The simplest way of measuring the corrosion rate of a metal is to immerse the sample to the test medium (HCl acid) and measure the loss of weight of the material as a function of time (12). Four glass beakers of 250 ml capacity were labeled A to D, each containing 0.5 M HCl solution. After 72 hours of time, the specimens were taken out and they are again cleaned and weighed. From the initial and final Thus the loss in this obtained and corrosion rate (CR) is found from the formula given below.

$$CR = \frac{\text{weight Loss} \times 534}{\text{Density} \times \text{Area} \times \text{Time}}$$

Density of the mild steel = $7.85 g/cm^3$

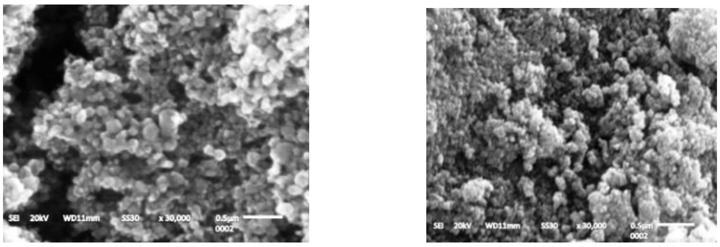
The efficiency of the inhibitor was computed using the following equation:

$$\text{Inhibition Efficiency},\quad \%(IE) = \frac{W_0 - W_1}{W_0} \times 100$$

Where W_0 is the weight loss without inhibitor and W_1 is the weight loss with inhibitor.

Result And Discussion

The SEM photographs of the IONPs stabilized with olive oil (a) and linseed oil (b) were taken and shown in figure 1**.** According to the SEM images, the particle agglomeration due to the Vander Waals force between the particles is seen in olive oil stabilized IONPs less than the linseed oil stabilized IONPs. This may be due to the higher stability of olive oil coated on the surface of the IONPs than the linseed oil coated on the IONPs. Oleic acid, the major constituent of Olive oil, is a fatty acid have higher stability than the α- linoleic acid, the major constituent in linseed oil for a period of six months[11].



(a) **(b)**

The SEM images of IONPs nanoparticles after six months of storage at room temperature
1. Olive oil stabilized IONPs b) Linseed oil stabilized IONPs

Table 1. Corrosion rate and Corrosion Efficiency – Weight Loss Method

Sample	**Initial Weight w_1**	**Final Weight w_2**	**Weight Loss W_1 - W_2**	**Corrosion Rate (CR)** $CR = \frac{weight\ Loss \times 372}{Area \times Time}$	**Inhibition Efficiency (IE %)** $IE = \frac{W_0 - W}{W_0} \times 100$
Linseed oil stabilized IONPs as anti corrosive additive for epoxy paint coated on mild steel	100.12	99.91	0.21	0.00244	69.11
Olive oil stabilized IONPs as anti corrosive additive for epoxy paint coated on mild steel	100.84	100.71	0.13	0.00152	80.88
Paint coated on mild steel	100.48	100.1	0.38	0.00443	44.11
Bare Mild steel	101.02	100.34	0.68	0.0793	--

The corrosion inhibition of the four mild steel samples A, B, C and D in 0.5 M solution of hydrochloric acid was studied at room temperature by weight loss technique. Results obtained from weight loss measurements are as shown in Table 1. The result indicates that the sample B, Olive oil stabilized IONPs Mixed Paint coated mild steel have less reduction in the corrosion. The corrosion inhibition efficiency of other samples A, C and D has decreased than the sample B. This may be due to sufficient adsorption and wider coverage by the inhibitor molecules of olive oil. The corrosion rates (CR) of the various mild steels are also shown in table 1.

Corrosion inhibition in 0.5 M HCl acid before 72 hours

Corrosion inhibition in 0. 5M HCl after 72 hours

A- Linseed Oil Stabilized IONPs Mixed Paint coated Mild steel

B- Olive Oil Stabilized IONPs Mixed Paint coated Mild steel

C- Paint coated Mild steel

D- Bare Mild Steel

Conclusion

A green synthesis procedure was adopted for preparing IONPs using olive oil and linseed oil as stabilizers prepared. These IONPs were stored for six months and formulated with commercially available paint. The samples of two mild steel plates were coated with these paints, the other one was coated with paint only and fourth mild steel plate was used without any coating. The Olive oil stabilized IONPs show higher anti-corrosion behaviour with high inhibition efficiency.

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