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Role of Steel Surface Finish on the Performance of Sodium Nitrite Inhibitor

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دور نعومة عينات من الفولاذ عن أداء المثبط نيترات الصوديوم

تالة أبوحلقومة وفوزي الشاوش ونعيمة الأحرش ووليد بن زقلام

لقد تم دراسة دور نعومة أسطح عيّنات من الفولاذ تعرضت لدرجات مختلفة من النعومة في أداء تراكيز مختلفة (100,400 and 800 ppm) لمثبط التآكل نيترايت الصوديوم عند درجتي الحرارة 2±70 °م، 2±22 وذلك باستخدام طرق كهروكيميائية (طريقة مقاومة الاستقطاب الخطي).

بيّنت النتائج المعملية أن العيّنات الفولاذية ذات السطح الخشن (100grit) لها مقاومة استقطاب (Rp) منخفضة أي معدل تآكل عالي ويزداد هذا المعدل بانخفاض تركيز المثبط . أما بالنسبة لعينات الفولاذ ذات الأسطح الملساء (100grit) فان النتائج أظهرت معدلات تآكل منخفضة (مقاومة استقطاب مرتفعة) حتى عند استخدام التركيز المنخفض 100grit من المثبط . كما لوحظ بوجه عام انخفاض مقاومة الاستقطاب أي ارتفاع معدلات التآكل لجميع العينات المدروسة عند درجة الحرارة المرتفعة (2± 70°).

ABSTRACT : *The role of surface finish of carbon steel samples subjected to different degrees of surface finish (as received, ground and ground and corroded), on the performance of sodium nitrite inhibitor (100, 400 and 800 ppm), at temperatures (22± 2° C) and (70 ± 2° C) was assessed using different electrochemical test techniques.*

Rough ground samples (100 grit paper), showed pronounced corrosion attack (low Rp). The severity of corrosion attack was more pronounced when tests were conducted in aqueous solution containing low concentration of inhibitor (100 ppm). In contrast, low to/or no corrosion attack (high Rp/ inhibitor efficiency) was observed when carbon steel samples were subjected to soft grinding using 1000 grit paper. This was observed even when tests were conducted at inhibitor concentrations as low as (100 ppm).

Marked decrease in the inhibitor efficiency was recorded for ground and corroded carbon steel samples even when samples were ground at 1000 grit paper.

Generally, tests at high temperature of (70 ± 2° C) observed to reduce the inhibitor efficiency.

INTRODUTION

Many types of aqueous corrosion inhibitors are being used to combat the corrosion of steel in water and oil mediums such as cooling water system and oil / gas production facilities respectively.

The interaction of corrosion inhibitor with clean steel surface seems to be well known. However, it is difficult to get a clean surface of steel in cooling water system which is in contact with neutral aqueous solution. There are many types of corrosion attack encountered in the cooling system. One type of corrosion attack is known as under deposit corrosion attack.[1-3] This was historically the source of many equipment failures as a result of pitting corrosion that

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can lead to perforation thus requiring a premature replacement of the failed equipment.[4] Smooth surface finish samples require low inhibitor concentration and the build-up of a passive film is expected to be adherent, coherent and homogenous.[5,6] In addition to that the presence of oxide film mix of hydrated FeO and Fe_2O_3 is expected to reduce the rate of nitrite adsorption on the sample surface and the formation of continuous, adherent and regular passive film.[6,7] Iron has a tendency to precipitate with an ions within the environment on the metal surface. The impact of iron oxide deposits on the over all corrosion control process is two fold. First the deposit of iron oxide creates a self-perpetuating corrosion reaction, where by a differential result in under the deposit corrosion. Localized corrosion attack (pitting) which in turn reduces the effectiveness of corrosion inhibitors by preventing them from reaching the metal surface. The second possibility is the incorporation of non protective iron oxides into the corrosion inhibitor film.

At high temperature a reduction in physicochemical properties of the inhibitor as well as the diffusion of oxygen to the metal surface are expected to be markedly affected. The oxygen carried molecules of sodium nitrite is expected to vanish with the increase of temperature and less quantity of inhibitor is expected to adsorb at metal surface.[8]

The objective of this paper is to assess the role of metal surface finish on the efficiency and/or performance of sodium nitrite as a passive film corrosion inhibitor at room temperature (22± 2° C) and (70 ±2° C) using electrochemical technique.

EXPERIMENTAL METHOD

The effect of surface finish on the performance of sodium nitrite inhibitor ($NaNO_2$) was assessed using electrochemical technique. Linear polarization resistance (LPR) was measured at each test condition and from that a corrosion rate was calculated. Mild steel samples having a chemical composition as shown in Table 1 were subjected to the following surface treatment:

1-Samples ground on two grades of emery papers (100 and 1000 grit paper).

Table 1 . Chemical composition of used mild steel samples (wt. %).

UNC	AISI	C	Mn	Pmax	S_{max}
G10180	1018	0.14 -0.20	0.60 - 0.90	0.040	0.050

2-Samples ground at 100 and 1000 grit paper and afterward corroded by inserting them in tap water for 72 hours. The corroded samples were then removed and dried before being tested.

All corrosion tests were conducted using distilled water with various concentrations of sodium nitrite inhibitor (blank, 100, 400, and 800 ppm) and temperatures of (22±2° C & 70 ±2° C) using potentio-dynamic test technique.

RESULTS AND DISCUSSION

The test results of the effect of surface finish on the performance of sodium nitrite inhibitor at 22±2° C and 70 ±2° C are shown in Figures 1-8. Figures 1 and 2, exhibit the effect of grinding of test samples, at different paper grades (100 and 1000 grit paper), on the performance of sodium nitrite inhibitor at room temperature. When tests were carried out, at highest concentrations of corrosion inhibitor, it was observed that samples with very smooth surface finish (1000 grit paper) showed a very high polarization resistance (Rp) value ($\approx$ 550,000 ohm.cm^2) compared with (Rp $\approx$ 70,000 ohm.cm^2) for sample ground at (100 grit paper). In addition to that samples with smooth surface finish showed higher values of Rp (120,000 ohm.cm^2) at low inhibitor concentration of 100ppm compared with (42,000 ohm.cm^2) obtained for samples ground at (100 grit paper). This can be contributed to the fact that smooth surface finish samples require low inhibitor concentration as well as the built-up passive film is expected to be adherent, coherent and homogenous.[5,6] In contrast, the surface finish for samples ground at 100 grit paper is expected to be rough and irregular as result of confined plastic deformation. Therefore, high inhibitor concentration is required to cover the non uniform steel surface. [5,6]

Marked reduction of Rp was reported when samples were ground (100 and 1000 grit papers) and corroded then tested in the same above condition, as shown in Figures 3 and 4. This was pronounced for grind (1000 grit) and corroded samples, where ten fold reduction in Rp was reported at corrosion inhibitors concentration of 800 ppm , as shown in Figure 4. This can be attributed to the presence of corroded sites over the test samples, where high quantity of inhibitor is required. In addition to that the presence of oxide film mix of hydrated FeO and Fe_2O_3 is expected to reduce the rate of nitrite adsorption on the sample surface and formation of continuous, adherent and regular passive film.[6,7]

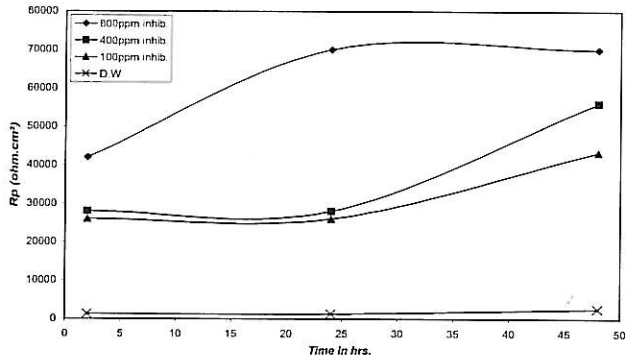


Fig. 1. Relationship between Rpxs values and duration time for samples ground (100 grit paper) and tested at room temperature (22±2° C) over various inhibitor concentrations.

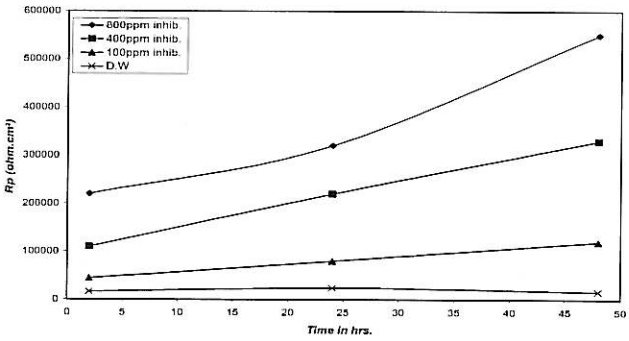


Fig. 2. Relationship between Rpxs values and duration time for samples ground (1000 grit paper) and tested at room temperature over various inhibitor concentrations.

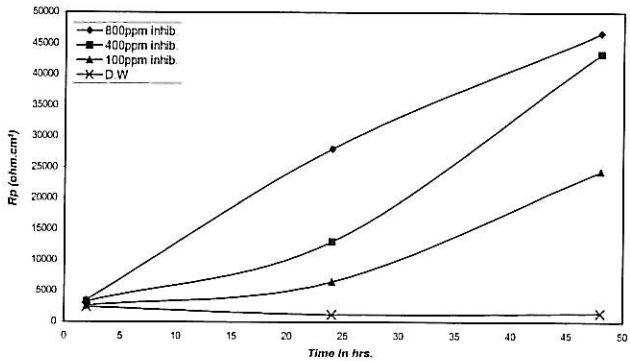


Fig. 3. Relationship between Rpxs values and duration time for samples ground (100 grit paper) and rusted then tested at room temperature over various inhibitor concentrations.

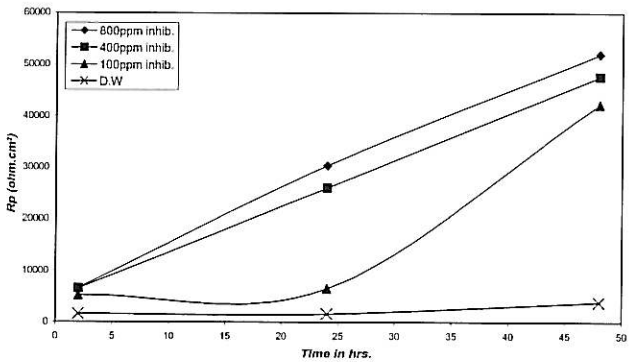


Fig. 4. Relationship between Rpxs values and duration time for samples ground (1000 grit paper) and rusted then tested at room temperature over various inhibitor concentrations.

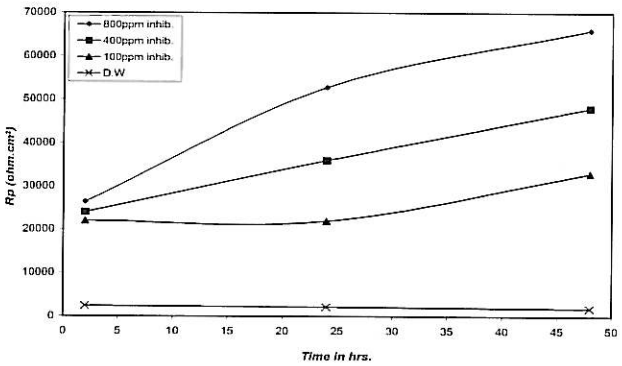


Fig. 5. Relationship between Rpxs values and duration time for samples ground (100 grit paper) and tested at (70± 2° C) over various inhibitor concentrations.

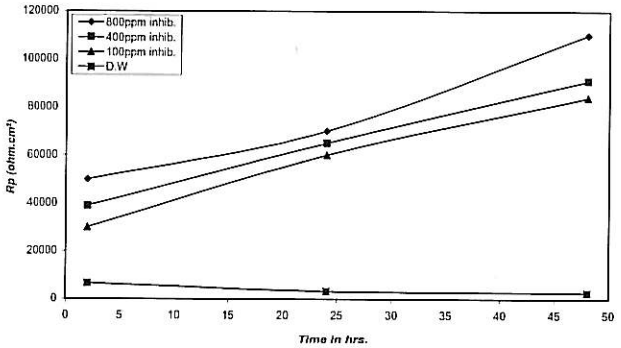


Fig. 6. Relationship between Rpxs values and duration time for samples ground (1000 grit paper) and tested at (70 ±2° C) over various inhibitor concentrations.

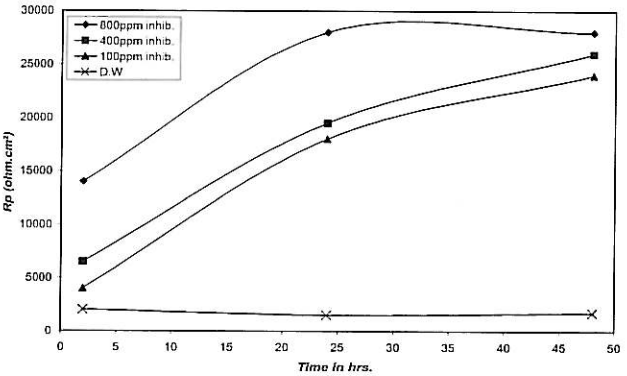


Fig. 7. Relationship between Rpxs values and duration time for samples ground (100 grit paper) and rusted then tested at (70 ±2° C) over various inhibitor concentrations.

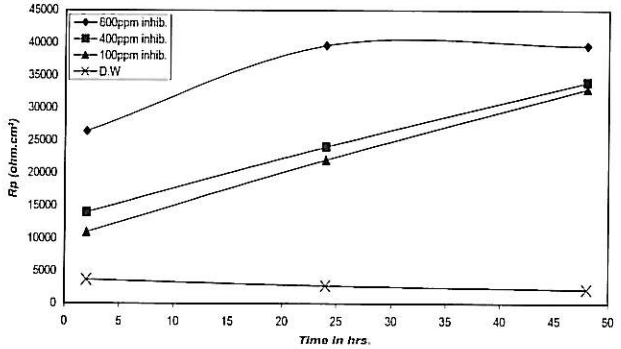


Fig. 8. Relationship between Rpxs values and duration time for samples ground (1000 grit paper) and rusted then tested at (70 ±2° C) over various inhibitor concentrations.

In contrast less marked reduction of Rp was reported for ground (100 g) and corroded samples, where two fold reduction of Rp was reported at 800 ppm inhibitor concentration (Fig. 3) compared with ground samples only, (Fig. 1). This can be attributed to the low Rp values for samples ground at 100 grit paper.

Tests at high temperature of (70 ± 2° C) caused marked reduction of Rp or inhibitor efficiency as shown in Figures 5 to 8.Tests at this temperature with an inhibitor concentration of 800ppm result in low Rp value (110,000 ohm.cm^2) for samples ground at 1000 emery paper compare with tests conducted at 22±2° C where high Rp value (550,000 ohm.cm^2) was observed. In contrast, ground and corroded samples (100 and 1000 grit papers) showed much less Rp values (low inhibitor performance) when tested at various inhibitor concentration, as shown in Figures 7, 8. This can be attributed to the fact that the tests at high temperature caused a reduction in physicochemical properties of the inhibitor as well as the diffusion of oxygen to the metal surface is expected to be markedly affected. The oxygen carried molecules of sodium nitrite is expected to vanish with the increase of temperature and less quantity of inhibitor compare with tests at room temperature is expected to be adsorbed at metal surface.[8]

CONCLUSIONS

1- The inhibitor efficiency found to be markedly dependence on the degree of metal surface finish. Samples ground using smooth grinding paper (1000 grit paper) showed highest Rp value and the inhibitor performance was found to be highest.

2- Ground and corroded samples markedly reduced the performance of sodium nitrite inhibitor. This was found to depend on the degree of metal surface finish.

3- Tests at (70 ± 2° C) markedly reduced the performance of sodium nitrite inhibitor even when tests were conducted on smooth surface finish samples (ground at 1000 grit paper) and highest inhibitor concentration (800 ppm).

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