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MORPHOLINE AND ITS DERIVATIVES AS VAPOUR PHASE CORROSION INHIBITORS FOR MILD STEEL

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Morpholine and its derivatives such as carbonate, borate and phosphate were synthesized and evaluated as vapour-phase corrosion inhibitors (VPIs) for mild steel using weight loss and visual observation methods under continuous condensation test (CCT). From the results the performance of morpholine and its derivatives as VPI for mild steel is comparatively assessed.

Keywords: Vapour-phase inhibitors (VPIs) and morpholine.

INTRODUCTION

Many methods to minimize or prevent atmospheric corrosion attack on metals have been reported. Among them, use of vapour phase inhibitors to protect metallic articles and equipments during storage and transportation, is an effective and convenient means. The inhibition mechanism of many vapour phase inhibitors is that they vapourise and diffuse to the surface of metals, then hydrolyse or ionize in the thin film electrolyte and produce the protective ions, which are the same as in the bulk solution [1]. Several chemicals qualify as vapour phase corrosion inhibitors, for example dicyclohexylaminenitrite [2] and cyclohexylamine carbonate for ferrous metals [3] and benzotriazole for copper [4] and silver. The effectiveness and the length of life of the inhibitors depend on the vapour pressures. Vapour pressure must be high enough to render sufficient concentrations of inhibitors in the vapour phase for effective inhibition and low enough for an acceptable service life. Some work has been done with morpholine and its derivatives by E.Vuorinen et al [5] for mild steel. The derivatives studied include morpholine borate, sorbate, laurate, succinate, azelate, sebarate and thiophenolate. Also, some of the morpholine mannich base derivatives have also been reported. In the present study three new derivatives of morpholine i.e. morpholine carbonate, morpholine borate and morpholine phosphate have been synthesised and studied for the inhibition of atmospheric corrosion of mild steel, besides morpholine and its borate which have been taken for comparison.

EXPERIMENTAL

Synthesis of vapour phase corrosion inhibitors

Morpholine and its derivatives such as carbonate, borate and phosphate have been synthesised as detailed below.

Morpholine (M)

Two moles of diethanolamine undergo condensation reaction with 70 percent sulphuric acid to form morpholine.

Morpholine carbonate (MCO_3)

Dry carbondioxide was passed through a cold 30 percent solution of morpholine in dry ether to form morpholine carbonate.

Morpholine borate (MBO_3)

Three moles of morpholine undergo neutralization with one mole of boric acid which is dissolved in hot water to form morpholine borate.

Morpholine phosphate (MPO_4)

Three moles of morpholine undergo neutralisation with one mole of phosphoric acid at ice cold condition to form morpholine phosphate.

The above synthesised compounds have been identified by thin layer chromatography (TLC) and laboratory tests.

Visual observation and weight loss measurements by continuous condensation test (CCT).

This test was carried out to study the effect of inhibition under conditions of continuous condensation of water vapour on metal specimens. The experiments were carried out in presence and in the absence of inhibitors at various concentrations. In this experiment one litre bottle

TABLE I: Visual observation and weight loss measurements by CCT for Morpholine and its derivatives in 100% relative humidity at 313 K

Name of the VPI	Cono. of VPI (mg)	Visual Observation	Weight loss (g)	Corrosion rate (mmpy) x 10^{-14}	I.E (%)
Blank	Dis.water	Severely rusted all over the surface	0.020	1.47	-----
	200	one or two rust spots here and there on the surface	0.006	0.44	70.0
M	400	-do-	0.006	0.44	70.0
	600	no rusting visibly	0.002	0.15	90.0
	800	no rusting visibly	0.002	0.15	90.0
	1000	one or two rust spots here and there on the surface	0.006	0.44	70.0
MCO_3	200	one or two rust spots here and there on the surface	0.007	0.52	65.0
	400	-do-	0.007	0.52	65.0
	600	no rusting visibly	0.003	0.22	85.0
	800	no rusting visibly	0.003	0.22	85.0
	1000	one or two rust spots here and there on the surface	0.008	0.55	62.5
MBO_3	200	more rusted spots all over the surface	0.015	1.10	25.0
	400	-do-	0.014	1.03	30.0
	600	-do-	0.016	1.17	20.0
	800	-do-	0.014	1.03	30.0
	1000	-do-	0.013	0.96	35.0
MPO_4	200	more rusted spots all over the surface	0.015	1.07	27.5
	400	-do-	0.018	1.32	10.0
	600	-do-	0.019	1.39	5.0
	800	-do-	0.016	1.17	20.0
	1000	-do-	0.013	0.96	35.0

(10" long x 4" wide) with tight fitting rubber cork was taken. The bottom of the cork carried glass rods with hooks to suspend mild steel specimens. Just below the specimens, cup with lid provision to place vapour phase inhibitor samples were made. It had an inclined cap to prevent condensation of moisture, into it and at the same time there was enough space for the vapour to escape from the cup and to fill the space in the jar. The jars were kept at 313 K in a thermostatic bath for 14 days to allow for copious and continuous condensation of moisture on the metal specimen. The experimental results are given in Table I.

RESULTS AND DISCUSSION

From Table I, it is clearly revealed that in morpholine, no rusting is observed and the maximum efficiency of 90% is reached for 600 mg/l of vapour space. There are one or two rust spots here and there, on the surface and the efficiency falls to 70% at 1000 mg/lit of vapour space. A similar trend is observed for MCO_3. In the case of MBO_3, without exception all the specimens were corroded in all the concentrations. However the corrosion is minimum at the maximum concentration and the efficiency does not cross 35% even at the highest concentration of 1000 mg/l of vapour space.

For MPO_4, a similar trend is observed and its performance is still worse. Also there is no consistent performance.

CONCLUSION

The vapour phase corrosion inhibition of mild steel carried out by the above methods brings out the following main conclusions.

1. Under vapour phase conditions, MCO_3 equals the performance of morpholine.
2. MBO_3 and MPO_4 gave poor performance and the grading of the compounds are $M \approx MCO_3 > MBO_3 \approx MPO_4$
3. MCO_3, being a solid and having equal performance to morpholine can increase the areas of applications.

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