Pilot Plant Study of Water-Borne High Molecular Weight Amine Adduct as Corrosion Inhibitor in Emulsion Paints

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ABSTRACT: Ethylamine adduct (30 Kg) was prepared in an industrial field by reaction of ethylamine with epoxydized soybean oil, oxiran content 6.5, and identified by infra-red spectroscopy. The prepared adduct was emulsified using both polyoxyethylene sorbitan monooleate in the continuous medium and sorbitan monooleate in the dispersed medium, using high speed homogenizer, 4000 round per minute. Surface tension measurements were determined by platinum ring technique. The stability of the prepared emulsions was determined thermally. The emulsified adduct was scaled up to ¼ ton using 50 L capacity homogenizer. The emulsified adduct was added to emulsion paint formulations by three different concentrations. Physical, chemical, mechanical, corrosion resistance, water uptake, and weight loss tests had been done in absence and presence of the corrosion inhibitor, to evaluate the corrosion inhibition efficiency of the emulsified adduct. Chosen formulations were scaled up to 5 ton using a 100 L capacity mixer. Carbon steel plates of 15× 15 cm were coated and exposed to natural weather on the roof of National Research Center. The effect of the emulsified ethylamine adduct as corrosion inhibitor was followed up by taking pictures every month for more than 2 years. It was found that the prepared ethylamine adduct was successfully emulsified and could protect steel from corrosion. © 2009 Wiley Periodicals, Inc. J Appl Polym Sci 115: 174–182, 2010

Key words: additives; adhesion; adsorption; coatings; surfactants

INTRODUCTION

A major continuing drive in the coatings field is to reduce the solvents. This alone does not address all of the environmental concerns due to the fact that some paints and coatings contain heavy metals such as lead, chromium, and barium, which are typically in the amount of 25% of the total mass of paint. Since the early part of the 20th century the addition of chromate pigments has been common practice, however, their uses are slowly being phased out in many industrial processes due to their toxicity and environmental hazards.[1]

Amines are effective corrosion inhibitors because of their ability to form protective layers or films on the metallic surfaces.[2,3] The adsorbed inhibitors role is to block the corrosive medium from the metal and/or to alter the electrode reactions that dissolve the metal. Many of them are held to the surface of the metal by electrostatic or Van der Waal's forces. In addition, organic amines are held to the metal by chemisorption. From another point of view, it was suggested that chemisorption takes place by the formation of charge transfer complex.[4] The ground state of the complex is described by a linear combination of the wave functions for a no bond state and a dative state. In the dative state, an electron has been transferred from an orbital of the inhibitor to the metal.

Unfortunately most organic corrosion inhibitors are insoluble in water. Emulsification using suitable surfactants is a way to disperse them in water. Surfactants are added to improve emulsion stability by decreasing interfacial free energy that exists between the two phases. They also provide a mechanical barrier to droplet coalescence.[5] Generally, mixture of emulsifiers is often used rather than a single emulsifier.[6]

This research achieves two goals, replacing toxic anticorrosive pigments containing heavy metals by high molecular weight amine adduct and reducing volatile organic compounds. In this work water is used instead of solvents. This occurs by emulsification of the prepared adduct to be water dispersible and its application and evaluation in water-borne paints to obtain friendly to environment anticorrosive emulsion paint.

MATERIALS AND TECHNIQUES

Materials

Ingredients used are listed in Table I.

Test methods

Infra-red (IR) spectroscopy of epoxydized soybean oil, ethyl amine, and their reaction product were measured using FTIR spectrometer, Nexus 670,

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TABLE I
Materials

Ingredient	Property	Source
Ethylamine	Basicity (pKa) 10.150, Taft constant 0.00, and molecular weight 45.	El-Gomhoreya Company, Egypt
Epoxidized soybean oil	Oxirane content, % 6.5, specific gravity 0.98, and molecular weight 1000.	Hobum Company, Germany
Sorbitan monooleate (Span 80)	Nonionic, HLB 4.3, and molecular weight 428.	Fluka Company, Germany
Polyoxyethylene sorbitan monooleate (Tween 80)	Nonionic, HLB 15, and molecular weight is 1310.	Fluka Company, Germany
Styrene/acrylic Copolymer Stymobil Co 700/50	Solid content is 50%, pH 7.5–9, and specific gravity 1.1.	Mobel Polymers, Egypt
Short Oil Alkyd Uradil AZ601 Z-44	Linolic rich, solid content by weight (%) 43–45, specific gravity 1.003 and oil length (%) 25.	DSM Company, Germany
Talc	60–63% silica, 30–32% magnesium oxide, <1.0% iron oxide, <1.5 % calcium oxide, and <1.5% aluminum oxide.	El- Nasr Phosphate Company, Cairo
Titanium dioxide (Rutile R-902)	91% titanium dioxide, 4.5% aluminum oxide, 2% silicon oxide, and 2% additives.	Du-pont company
Leveling agent (Torysol LAC)	Water dispersible, viscosity (mPa.s) 90.	Troy Chemical Co.
Butyl glycol (Dowanal EB)	Fast-evaporation coalescing agent. evaporation rate (*n*-butyl acetate = 1) is 0.079.	DOW Company
Texanol	Evaporation rate (*n*-butyl acetate = 1) is 0.002.	Eastman Chemical Company
Iso-propanol	Evaporation rate (*n*-butyl acetate = 1) is 2.88.	TCI Company
Dispersing and Wetting agent (EDAPLAN 482)	Solution of acrylic polymer.	Münzing Chemie, Germany
Antifoaming agent (AGITAN 731)	Blend of modified organo polysiloxanes with non-ionic alkoxylated compounds, pH 7.	Münzing Chemie, Germany
Drier (Dapro 7007)	Chelating catalyst designed to replace cobalt driers.	Daniel Products Company
Biocide (MERGAL K6N)	Nonionic.	Troy Chemie GmbH, Germany
Flash rust inhibitor	Ammonium benzoate ($C_7H_9O_2N$).	Fluka Company, Germany
pH stabilizer	Ethanolamine (C_2H_7NO).	Fluka Company, Germany
Thickening agent (TAFIGEL PUR 60)	Nonionic polyurethane in butyltriglycol/water, pH 7.	Münzing Chemie, Germany

Nicolt, Micro Analytical Center, National Research Center, Egypt.

Emulsification of the prepared adduct[7] was carried out using high shear mixer (homogenizer), which manufactured by Greaves Company, England. The high shear action connected with high upward flow rate maintains the immiscible liquids in full circulations while they continue to be passed through the mixer head. The adduct was dissolved in sorbitan monooleate (span 80) and added drop by drop to polyoxyethylene sorbitan monooleate (Tween 80) in distilled water at room temperature. Surface tension of the prepared emulsions was measured by platinum ring technique, Krüss tensiometer at 20°C according to ASTM 1331- 89. Emulsion paint formulations are prepared in two stages.[8,9] The first stage is high speed stirring of filler, pigment, dispersing agent, and water. The second stage is low speed stirring of the emulsion polymer, water, other additives, antifoaming agent and ammonium benzoate as anti flashing rust, with the mixed ingredients from the first stage. The emulsified inhibitor is added before the second stage. The pH of the medium was adjusted to 8–9 using ethanol amine. Solid content of the prepared formulations was measured according to ASTM D 2369-01. Mild steel panels must be treated before use[10] by removing all detrimental foreign matter such as oil, grease, dirt, and other contaminants.

The wet paint formulations were applied on panels using film applicator, 100 μm, according to ASTM D 823-95 (2001). A measurement of paint film hardness was carried out according to ASTM D 3363- 92. Bending test of dry paint film was determined according to ASTM D522-93a (2001). A representative sample of artificial sea water was prepared (Sodium chloride 27.26 g, Magnesium chloride 3.51 g, Magnesium sulphate 1.84 g, Potassium chloride 0.69 g, Sodium bicarbonate 0.11 g, and Calcium sulphate 1.29 g in 1 L of distilled water).[11] Corrosion resistance and scratch tests were done according to ASTM D 1654-92 (2000). Blistering resistance test was done according to ASTM D 714-87 (2000). Alkali and acid resistance tests were done according to DIN 53,168. Water up-take was determined[12]; thin plastic panels were used for paint application and panels were removed from distilled water at intervals of 5, 10, 15, 20,

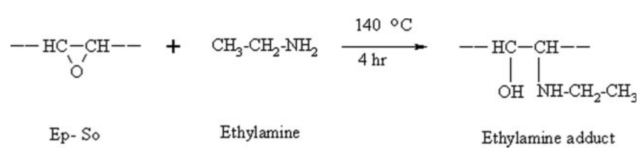

Figure 1 The reaction equation.

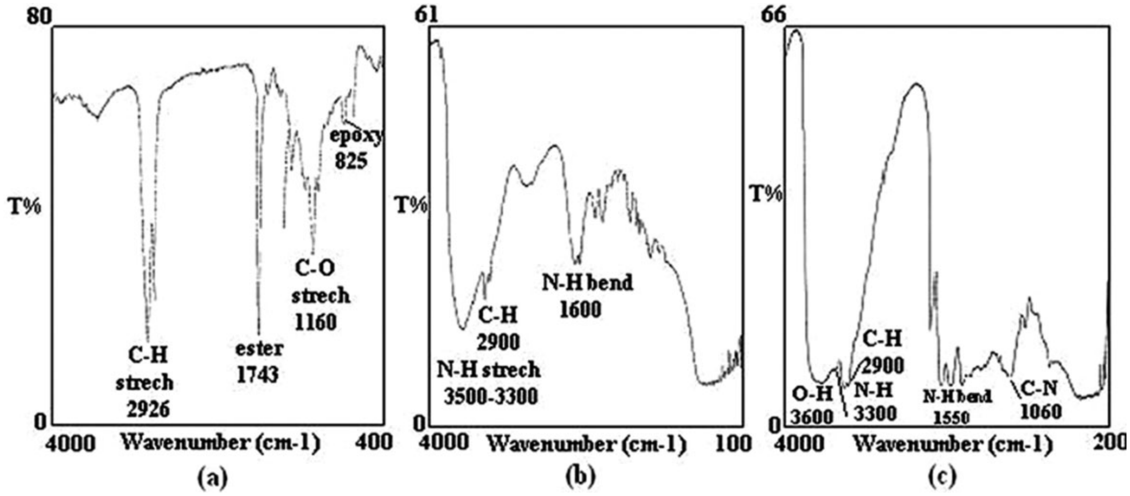

Figure 2 IR chart of: (a) epoxydized soybean oil, (b) ethylamine and (c) ethylamine adduct.

25, and 30 days. Weight loss measurements were done according to ASTM D 2688-94 (1999).

RESULTS AND DISCUSSION

Preparation of ethylamine adduct in an industrial field

The reaction of ethylamine with epoxydized soybean oil was carried out at temperature 130–140°C sealed glass ampoule at for 3–4 hours.30 Kg of Ethylamine adduct was produced in Heliopolis Co. for Chemical Industries, Cairo, Egypt at proceeds according to the reaction equation, Figure 1.

The molecular weight of the prepared adduct is 1180. It is dark yellow in color and freely soluble in benzene, toluene, xylene and acetone, i.e., it is not crosslinked (the reaction stopped at the stage of secondary amine formation).

The above reaction was followed by IR spectra. The spectra of epoxidized soybean oil and ethylamine were compared with spectra of the prepared adduct and were shown in Figure 2.

It can be seen from Figure 2 that, the disappearance of the characteristic band of the starting compound, i.e. the epoxy band at 825 cm^{-1}, and the appearance of a broad band at 3600 cm^{-1} due to free (O—H) group. The band of the secondary amine group at 3300 cm^{-1} (one band), a bending band near 1500 cm^{-1} due to secondary (N—H) and a band at 1060 cm^{-1} due to (C—N) can be seen in Scheme 1 (c). These bands are very characteristic of the formed adduct.

Emulsification of the prepared adduct:

Nonionic surfactants polyoxyethylene sorbitan monooleate (Tween 80) and sorbitan monooleate (Span 80) were selected to emulsify the prepared adduct, because they form relatively stable emulsions of oil-in-water.[13] Figure 3 showed their molecular structure.

The HLB value of a combination of emulsifiers can be calculated as follows[14–16]:

$$\mathrm{HLB} = \frac{(\text{Quantity of surfactant 1})(\text{HLB surfactant 1}) + (\text{Quantity of surfactant 2})\ (\text{HLB surfactant 2})}{\text{Quantity of surfactant 1} + \text{Quantity of surfactant 2}}$$

the critical micelle concentration (CMC) of Tween 80 in distilled water was determined by Pt ring method using Krüss tensiometer and it was 0.0004 mol (0.52 g in 100 mL water).[17]

Many trials have been made in laboratory to obtain stable emulsified ethylamine adduct. The continuous phase is distilled water/Tween 80 and the dispersed phase is the prepared adduct (oil)/Span 80.

The stability of emulsion was determined thermally by transferring constant volume of the prepared emulsion to test tube. The increasing of 10°C in the temperature of the prepared emulsion is considered to double the rate of most reactions. Therefore, 3 months at 45–50°C is equivalent to one year at 20–25°C, (also one week at 45–50°C is equivalent to one month at 20–5°C) for many systems.[18]

Ethylamine adduct (5 g) in absence and presence of 0.5 g Span 80, was added drop by drop to 0.52–1.0% of Tween 80 during stirring using high speed homogenizer with agitation rate 4000 round per

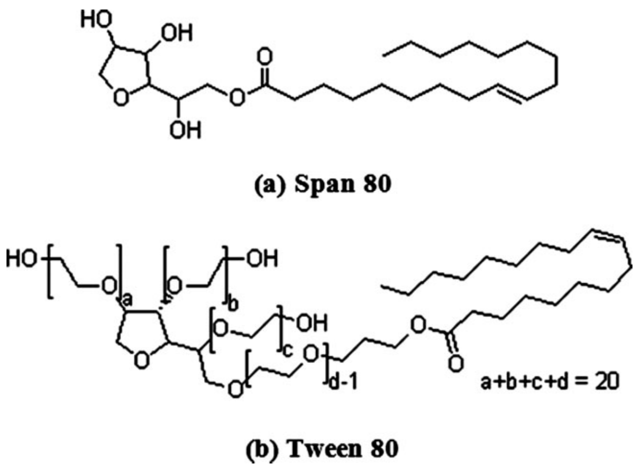

Figure 3 Schematic representation of the molecular structure of (a) Span 80 and (b) Tween 80.

minute (r.p.m,) and for 15 min at room temperature. PH was adjusted to be constant and $\geq$ 8. Stable emulsified adduct for 6 month, 5% concentration, surface tension, 54.1 mN/m was formulated using 1.0 g of Tween 80 in the continuous phase and 0.5 g span 80 in the dispersed phase. Trials of increasing the concentration of adduct was succeeded up to 22% stable emulsified adduct for 4 month, surface tension 55.3 mN/m. Surface tension and stability of each prepared emulsion were summarized Table II.

It is clear from Table II that, the highest stability and the lowest surface tension of the prepared emulsion were obtained using both Tween 80 and Span 80 together in the same emulsion formula. This goes hand in hand with the fact that combinations of emulsifiers can produce more stable emulsions than using a single emulsifier with the same HLB number.[14–16] Moreover high concentration of Tween 80 increased the stability of the prepared emulsion. This goes hand with hand with Ivanov and Dimitrov,[19,20] who suggest that, higher concentrations of surface active agents (emulsifiers) should increase emulsion stability.

The emulsified adduct No. 8 (22% adduct) was chosen to scaled up to 1/4 ton using high speed homogenizer, 50 L capacity in Heliopolis Co. for Chemical Industries, Cairo, Egypt.

Evaluation of emulsified ethylamine adduct as corrosion inhibitor in emulsion paints

Emulsion paint formulations were prepared in two stages.[8,9] The first stage is high speed stirring of filler, pigment, dispersing agent, and water. The second stage is low speed stirring of the emulsion polymer, water, other additives as discussed in the Test Methods section. Many laboratory trials have been made to adjust the blank formulations based on Styrene/Acrylic Copolymer Stymobil Co 700/50 and Short Oil Alkyd Uradil AZ601 Z-44. Finally the chosen formulations of pigment/ binder ratio were 1.55 as shown in Table III.

The emulsified ethylamine adduct was added in three different concentrations 0.1, 0.2, and 0.5% to emulsion paints based on styrene acrylic and short oil alkyd emulsion polymers.

The physical, chemical, and mechanical properties of emulsion paint formulations are represented in Table IV. It is noticed from this Table that all the emulsion paint formulations possess good adhesion, hardness, and ductility. Highest viscosity and hardness were obtained for emulsion paints containing styrene acrylic emulsion copolymer. With respect to chemical (acid/alkali) resistance tests, it was found that all the paint films passed acid and alkali resistance test successfully. Corrosion resistance improved by adding the prepared emulsified adduct specially with 0.5 %.

Water up- take measurements

Relationship between water up-take % of immersed paint films, (based on both Styrene/Acrylic emulsion Copolymer and Short Oil Alkyd emulsion polymer in absence and presence of 0.1–0.5% of

TABLE II
Emulsified Adduct Formulations and their Surface Tension and Stability Measurements

Emulsion No.	Adduct concentration (%)	Emulsifiers concentration T80 : S80 (%)	HLB	Surface tension (mN/m)	Emulsion stability (month)
1	5	0.52 : 0.0	15.0	57.4	3 month
2	5	0.0 : 0.5	4.3	65.2	Unstable
3	5	0.52 : 0.5	9.8	56.2	4 month
4	5	1 : 0.5	11.4	54.1	6 month
5	10	1 : 0.5	11.4	54.3	6 month
6	15	1 : 0.5	11.4	54.8	5 month
7	20	1 : 0.5	11.4	55.1	4 month
8	22	1 : 0.5	11.4	55.3	4 month

TABLE III
Blank Formulation of Water Based Paints

High speed stirring		Low speed stirring	
Composition	Mass (g)	Composition	Mass (g)
Water	10.0	Styrene/acrylic or alkyd (as 100% solid mass)[a]	20
Dispersing and Wetting agent	0.5	Plasticizer or Drier for alkyd	0.5
butyl glycol	2.0	Texanol – isopropanol 1 : 1 blend	1.5
TiO_2	17.0	Leveling agent	0.6
Talc	14.0	Water	31.1
Defoamer	0.2	Thickener	0.3
Biocide	0.3	Defoamer	0.5
Pigment: binder ratio is 1.55		Ethanol amine	1.0
		Flash rust	0.3

[a] The actual added weight of styrene acrylic is 40 g, where its solid content is 50%. Also, the actual added weight of short oil alkyd emulsion is 45.5 g, where its solid content is 44%.

ethylamine adduct) and immersion time up to 30 days was plotted in Figure 4 and summarized in Table V.

Both Table V and Figure 4 showed the change in the weight of the paint films containing styrene/acrylic emulsion copolymer with or without the ethylamine adduct, was negligible and consequently water up-take of them was nil. On the other hand, water up-take of formulations containing alkyd resin emulsion increased with the period of immersion in water. Also it could be seen that the water up-take slightly increased by increasing the concentration of the emulsified methylamine adduct added.

Weight loss measurements

The weight loss measurements of steel panels under the paint films based on styrene/acrylic emulsion copolymer and short oil urethane alkyd emulsion polymer after immersion in artificial sea water for 60 days of the present group are given in Table VI and represented graphically in Figure 5.

As shown from both Table VI and Figure 5, the addition of emulsified ethylamine adduct protected mild steel from corrosion and decreased weight loss of metal compared with corresponding blank formulations (free from emulsified ethylamine adduct). It was clear that concentration 0.5% of the adduct, showed the lowest weight loss in metal and the highest corrosion inhibition performance of the adduct and consequently it could be considered as the optimum concentration. The emulsified adduct at this concentration may form an adsorbed monolayer film on the metal surface, and the adduct molecules may direct themselves to be adsorbed on the metal surface via the lone pairs of electrons on the sulfur atom and oxygen atom of the prepared adduct; so, the adhesion of the paint films may be improved. Also 0.5% adduct formulated with short oil alkyd resin in showed the lowest weight loss under the paint film compared with those formulated with styrene/acrylic resin. This may be attributed to the crosslinked film, which was formed by short oil alkyd as convertible resin, and this gave

TABLE IV
Physical, Chemical, Mechanical, and Corrosion Tests of the Prepared Emulsion Paint Formulations

	Styrene/acrylic based emulsion paint with different adduct concentration				Short oil alkyd based emulsion paint with different adduct concentration			
Formula Test	0.0%	0.1	0.3%	0.5%	0.0%	0.1	0.3%	0.5%
Viscosity (cP)	825	823	820	815	803	800	797	790
Adhesion[1]	Gt0	Gt0	Gt0	Gt0	Gt0	Gt0	Gt0	Gt0
Hardness[2]	4H	4H	3H	3H	2H	2H	H	H
Ductility	6.7	6.8	6.9	6.9	6.9	7.0	7.0	7.1
Bending (0.9 mm)	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Acid/Alkali resistance	v.g.	v.g.	v.g.	v.g.	v.g.	v.g.	v.g.	v.g.
Corrosion resistance[3]	h.t.	m.t.	b	b	m.t.	v.s.t.	b	b
Degree of blistering[4]	4D	8F	10	10	2D	8F	10	10
Corrosion scratch[5]	C	B	A	A	C	B	A	A

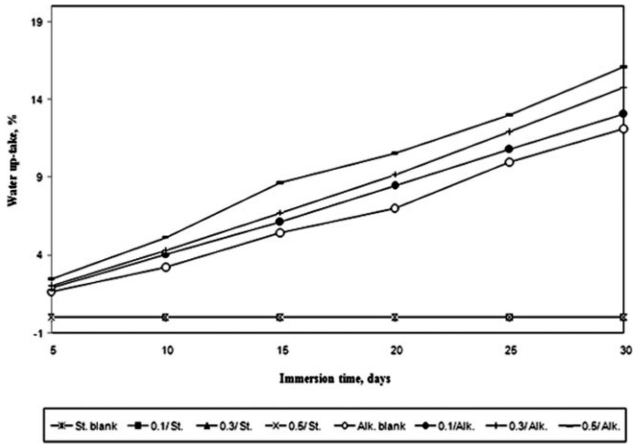

Figure 4 Waterup take measurements of emulsion paint formulations.

extra protection to the metal surface and enhance the corrosion inhibition of the prepared adduct.

Field study

In Heliopolis Co. for Chemical Industries, Cairo, Egypt, 30 Kg of Ethylamine adduct was produced as mentioned above. The produced adduct was emulsified by Tween 80 and Span 80 using high speed homogenizer, 50 L capacity and scaled up to 1/4 ton. Four paint formulations had been chosen for the field test. Two of them were blanks (free from anticorrosion inhibitor) based on styrene acrylic copolymer and alkyd. The optimum amount of ethylamine adduct added to both formulations was 0.5% as concluded from corrosion resistance and weight loss test. Formulations of 5 ton were produced in using 100 L capacity mixer.

Carbon steel test panels of dimensions 15 cm $\times$ 15 cm are cleaned mechanically to St 3 (ASTM D 1653), and then coated by blanks and paint formulations containing 0.5% ethylamine adduct. The average dry paint film thickness was 100 μ. The edges of the coated steel panels were coated by epoxy binder/hardener. Two test panels of each formulation had been coated in addition to two for blanks. The coated panels were mounted to a fixed frame on the roof of National Research Center and exposed to natural weather, facing the sun most of the day. The effect of emulsified ethylamine adduct as corrosion inhibitor was followed up by taking pictures every month for more than 2 years. The following are some photos for the test panels, Figures 6–11.

It was clear from the above photos that, the chosen formulations were good enough to resist corrosion. After 12 months exposure, corrosion started only at one of the blank of formulation based on styrene/acrylic copolymer, as seen from Figure 9. Also Figure 11 showed slight corrosion on alkyd blank only after exposure 24 months.

TABLE V
Water Up-Take Measurements (%) of Emulsion Paint Formulations in Absence and Presence of Adduct

Time (days) Formula No.	5	10	15	20	25	30
St. Blank	0.000	0.000	0.000	0.001	0.005	0.008
0.1/St.	0.002	0.006	0.008	0.011	0.015	0.018
0.3/St	0.002	0.007	0.01	0.012	0.016	0.021
0.5/St	0.003	0.009	0.013	0.015	0.019	0.023
Alk. Blank	1.63	3.25	5.46	7.01	9.96	12.132
0.1/Alk.	1.908	4.071	6.116	8.446	10.807	13.053
0.3/Alk.	2.014	4.323	6.715	9.183	11.944	14.755
0.5/Alk.	2.451	5.153	8.634	10.527	12.996	16.101

TABLE VI
Weight Loss Measurements (g/cm^2) of Emulsion Paint Formulations in Absence and Presence of Adduct

Time (days) Formula	10	20	30	40	50	60
St. blank	0.025	0.097	0.186	0.268	0.387	0.438
0.1/St.	0.023	0.091	0.144	0.216	0.327	0.401
0.3/St	0.02	0.073	0.105	0.184	0.278	0.351
0.5/St	0.018	0.041	0.066	0.142	0.213	0.246
Alk. blank	0.02	0.078	0.109	0.189	0.284	0.363
0.1/Alk.	0.021	0.058	0.091	0.173	0.246	0.312
0.3/Alk.	0.019	0.038	0.061	0.089	0.153	0.189
0.5/Alk.	0.013	0.028	0.046	0.078	0.122	0.165

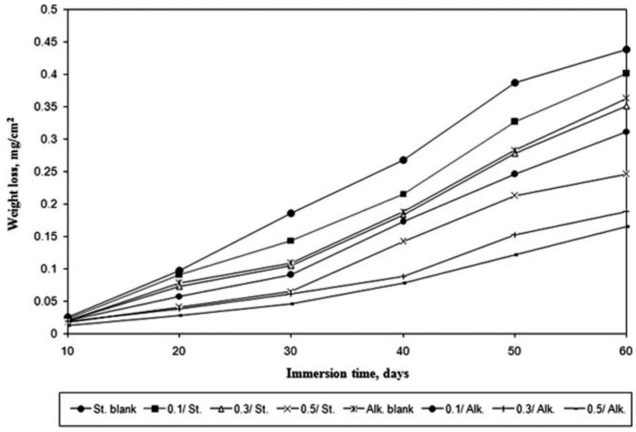

Figure 5 Weight loss measurements of emulsion paint formulations.

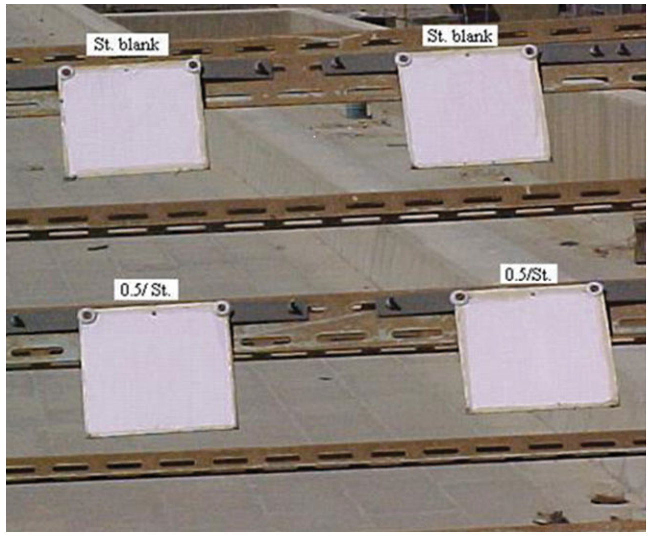

Figure 7 Styrene acrylic coated test panels after 6 months exposure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

CONCLUSIONS

1. The reaction between epoxidized soybean oil and ethylamine had taken place successfully, and in an industrial field.
2. Tween 80 in the continuous phase, concentration $\geq$ critical micelle concentration and span 80 in the dispersed phase, 5% concentration could disperse the prepared high molecular weight adduct in water.
3. Combinations of Tween 80 and span 80 with total HLB 11.4 could produce more stable emulsions than using a single emulsifier.
4. Oil-in-water (adduct/water) (22%) was obtained by using 1% of Tween 80 and 5% of Span 80 at pH $\geq$ 8, and it was stable for 4 months.
5. The chosen emulsion formula containing 22% adduct and stable for 4 months was to scaled up to 1/4 ton successfully, using high speed homogenizer (4000 round per minute), 50 L capacity.
6. The emulsified ethylamine adduct with different concentrations, 0.1–0.5% has confirmed a good compatibility in water-borne paints based on Short Oil Alkyd Uradil AZ601 Z-44 and Styrene/Acrylic Copolymer Stymobil Co 700/50.
7. The optimum concentration of emulsified ethylamine adduct, which showed high performance of the adduct as corrosion inhibitor in emulsion paint formulations based on both on Short Oil Alkyd Uradil AZ601 Z-44 and Styrene/Acrylic Copolymer Stymobil Co 700/50, was 0.5%.
8. The emulsified ethylamine adduct can protect mild steel from corrosion in both laboratory and field tests.

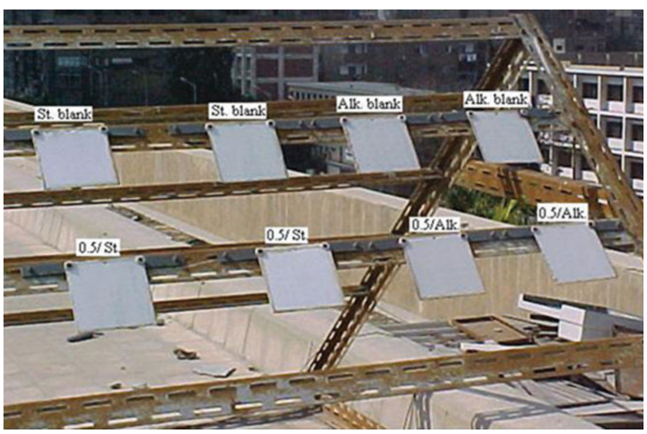

Figure 6 Coated test panels at zero time exposure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

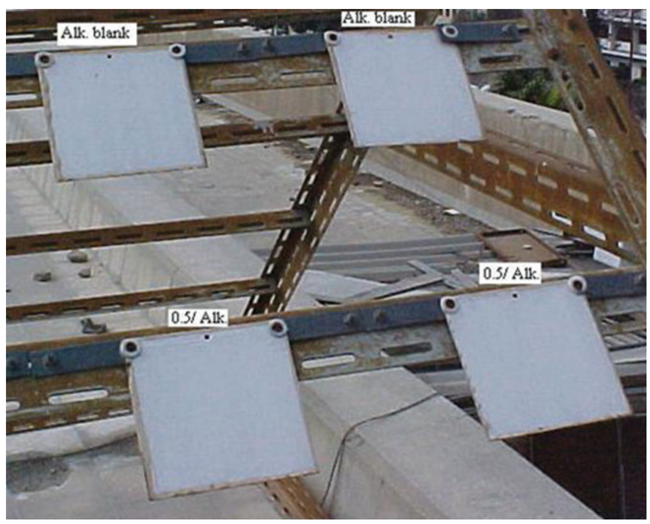

Figure 8 Alkyd coated test panels after 6 month exposure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

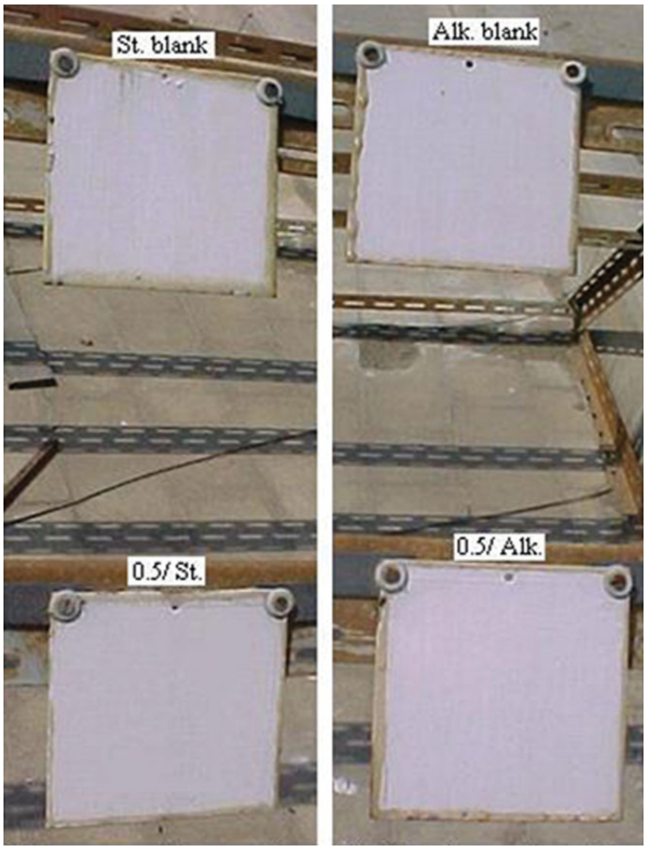

Figure 9 Coated panels after 12 months exposure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

9. The protective properties of paints containing Short Oil Alkyd Uradil AZ601 Z-44 emulsion polymer as binder are better than those containing Styrene/Acrylic Copolymer Stymobil Co 700/50.
10. The pilot plant study was done successfully in Heliopolis Co. for Chemical Industries, Cairo, Egypt, and followed by picking pictures for coated steel panels, which were hanged on the roof of National Research Center.

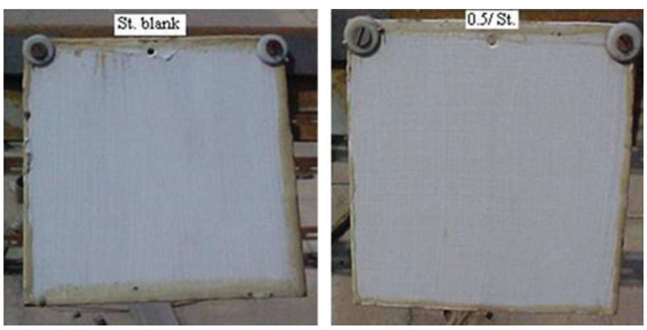

Figure 10 Styrene/acrylic coated panels after 24 months exposure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

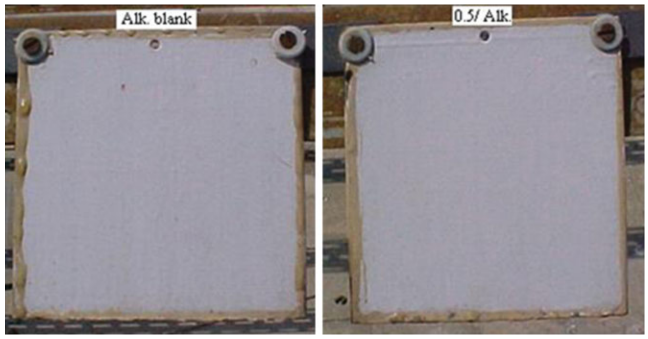

Figure 11 Alkyd coated panels after 24 months exposure. [Color figure can be viewed in the online issue, which is available at www.interscience.wiley.com.]

NOMENCLATURE

St. Blank — Emulsion paint formulation based on, Styrene/ Acrylic Stymobil Co 700/ 50 emulsion copolymer and free from ethylamine adduct.

0.1/ St. — Emulsion paint formulation based on, Styrene/ Acrylic Stymobil Co 700/50 emulsion copolymer and contains 0.1% of ethylamine adduct.

0.3/ St. — Emulsion paint formulation based on, Styrene/ Acrylic Stymobil Co 700/50 emulsion copolymer and contains 0.3% of ethylamine adduct.

0.5/ St. — Emulsion paint formulation based on, Styrene/ Acrylic Stymobil Co 700/50 emulsion copolymer and contains 0.5% of ethylamine adduct.

Alk. Blank — Emulsion paint formulations based on, Short Oil Alkyd Uradil AZ601 Z-44 emulsion polymer and free from ethylamine adduct.

0.1/ Alk. — Emulsion paint formulation based on, Short Oil Alkyd Uradil AZ601 Z-44 emulsion polymer and contains 0.1% of ethylamine adduct.

0.3/ Alk. — Emulsion paint formulation based on, Short Oil Alkyd Uradil AZ601 Z-44 emulsion polymer and contains 0.3% of ethylamine adduct.

0.5/ Alk. — Emulsion paint formulation based on, Short Oil Alkyd Uradil AZ601 Z-44 emulsion polymer and contains 0.5% of ethylamine adduct.

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