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IMPEDANCE STUDIES OF EPOXY-POLYAMIDE VARNISH COATED MILD STEEL IN SODIUM CHLORIDE SOLUTION

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ABSTRACT

The protective performance of varnish coated mild steel in 3% sodium chloride solution has been examined by the impedance technique. It has been found that the coatings formed by lower epoxide equivalent epoxies (450 - 525 and 880 - 1050) have more corrosion resistance.

Key Words:Impedance measurement, epoxy-polyamide varnish coating

INTRODUCTION

Various electrical and electrochemical methods have been used for studying the protective property of organic coatings [1-3]. Most of the measurements have been made under direct current. In recent years impedance method has been widely used since this method provides an analytical examination of the various processes involved in the protective action of organic coatings [3-9]. Besides the coating performance, the mechanism of protection of paint coatings such as chlorinated rubber [6], coaltar epoxy [7], polyurethene varnish [8] and metal pigmented paints [9] has also been elucidated by the impedance method.

In this paper, the behaviour of polyamide cured epoxy coated mild steel in sodium chloride solution is reported.

EXPERIMENTAL

a) Impedance measurements Mild steel specimens of size 2.5 cm x 2.5 cm were sand blasted and coated with epoxy-polyamide varnish. Studies were carried out with araldite A of epoxide equivalent 450-525, araldite B of epoxide equivalent 880-1050 and araldite C of epoxide equivalent 1650-2100 epoxy resins for different ratios of polyamide viz. 60:40, 70:30 and 80:20 ratios. The thickness of the coating was 40-50 μ.

Impedance measurements were carried out at corrosion potential using Frequency Response Analyser (1174, Solartron, UK) and the Electrochemical Interface (1120, Solartron, UK) for a frequency range of 1 mHZ to 10 KHZ. The coated panels were immersed in 3% sodium chloride solution and impedance measurements for different periods of immersion were made. From the plots of Z' (real part) vs. Z'' (imaginary part), the resistance values R were calculated from the difference in values of Z' at high and low frequency. The capacitance C was calculated from the relationship - $f_{(max)} = 1/2\pi C R$ where $f_{(max)}$ - the frequency at which the imaginary part is maximum.

b) Water uptake measurements

Glass plates of size 7.5 cms x 5.0 cms were coated with epoxy-polyamide varnish on one side, weighed and immersed in distilled water. Periodically their weights were determined after removing the water with filter paper and from this the percentage of water uptake of the coated resin was calculated.

RESULTS AND DISCUSSION

Fig. 1 gives the typical plot of epoxy-polyamide 'A' (60:40) varnish coated mild steel in 3% NaCl. Initially the behaviour is of Warburg impedance type since the varnish film behaves similar to the dielectric of parallel capacitor. With increased periods of immersion, the coatings depart from purely capacitive behaviour and the impedance response becomes approximately semi-circular. Such a behaviour has been reported by previous authors [6-9] and a model of the metal-varnish couple can be given as:

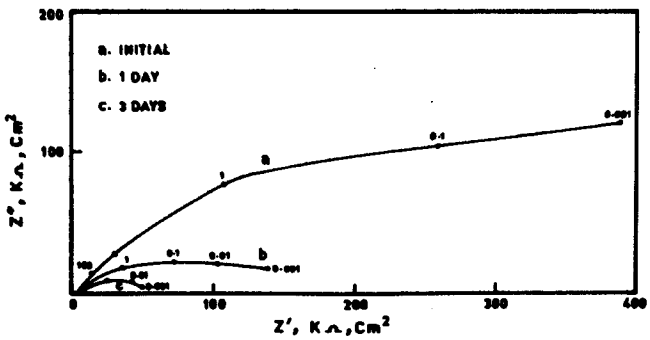
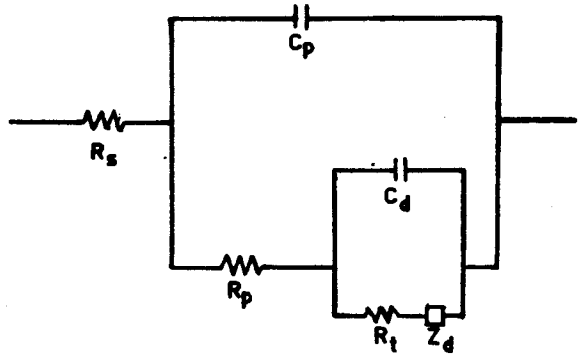


Fig.1



C_p- capacitance characterizing the continuous part of the coating, R_p - the resistance of varnish coating, C_d - double layer capacitance of the metal electrolyte interface, R_t - change transfer resistance and Z_d - diffusion impedance, R_s - solution resistance.

Table I : Impedance values of epoxy-polyamide varnish coated mild steel in 3% sodium chloride solution

Epoxy Type Equivalent	Period of immersion (days)	60:40*			70:30*			80:20 *		
		E_{corr}	R	C	E_{corr}	R	C	E_{corr}	R	C
A	0	−0.600	383.1	2.0	−0.550	185.0	2.1	−0.570	106.8	3.7
	1	−0.631	133.7	2.9	−0.642	43.1	4.6	−0.600	43.8	45.4
	2	−0.633	90.6	1.8	−0.646	33.1	5.4	−0.610	28.1	56.4
	3	−0.614	60.6	2.6	−0.644	37.5	7.1	−0.626	26.9	59.2
	5	−0.680	53.7	2.9	−0.630	28.1	14.2	−0.620	33.8	58.8
B	0	−0.620	1155.0	1.8	−0.570	259.4	61.4	−0.560	26.2	69.1
	1	−0.614	280.0	0.7	−0.610	116.2	136.9	−0.625	55.6	286.0
	2	−0.607	160.6	0.1	−0.580	83.1	47.9	−0.625	28.1	5658.0
	3	−0.574	109.4	0.18	−0.585	46.6	17.2	−0.620	36.9	4316.0
	5	−0.580	157.5	25.2	−0.603	40.0	66.3	−0.627	19.4	8214.4
C	0	−0.614	2289.1	0.18	−0.636	310.0	12.8	−0.616	154.4	10.9
	1	−0.585	165.6	9.6	−0.660	136.2	19.4	−0.644	136.9	29.5
	2	−0.593	117.5	22.6	−0.661	60.6	26.3	−0.620	60.0	26.5
	3	−0.585	83.1	23.9	−0.650	39.4	44.2	−0.605	96.2	19.8
	5	−0.586	46.2	57.3	−0.641	24.4	56.5	−0.648	86.2	92.3

Note: E_{corr} - Corrosion potential vs SCE
C - Capacitance F/cm²
R - Resistance K ohms/cm²
* Ratio of epoxy to polyamide

The protective performance of the coating can be easily assessed from the resistance and capacitance values. Table I gives the impedance values of the various systems. An overall picture is that the resistance values of the coating decrease with time while the capacitance values increase with time. This is due to the absorption of water which leads to an increase in the dielectric constant [10,11]. Table II gives the percentage of water uptake values.

Table II: Water absorption (%) values of epoxy polyamide varnish coatings

Epoxy type (Equivalent)	Period (days)	60:40	70:30	80:20
A	1	1.99	5.3	4.8
	2	3.6	3.1	2.2
	3	3.0	2.9	3.2
	5	1.8	1.7	1.8
B	1	1.63	1.34	1.3
	2	2.6	2.3	1.6
	3	—	—	—
	5	3.2	3.03	3.29
C	1	8.7	4.3	7.5
	2	6.03	5.1	6.8
	3	4.6	6.4	9.4
	5	4.9	3.6	11.3

A comparison of resistance and capacitiance values of the coating of 60:40, 70:30 and 80:20 ratios of a given epoxy type shows that the coating of 60:40 ratio has got higher resistance, lower capacitance and smaller amount of water absorption. Hence it can be concluded that the coating of 60:40 has got good protective property. Further it is observed that the high resistance values of coating of epoxy resin (C) decrease markedly with time indicating that the coatings formed by this resin allows more water to penetrate through the film. This has also been confirmed by the higher water uptake values of epoxy resin (C) coating (Table II).

CONCLUSION

Impedance studies have shown that the coating formed by A or B epoxy resin in 60:40 ratio with polyamide has got good protective property for mild steel.

REFERENCES

1. J Wolstenholme, *Corrosion Science,* **13,** (1973) 521

2. H Jullien, *Prog Org Coatings,* **2** (1973) 99

3. H Leidheiser, *Prog Org Coatings,* **7** (1979) 79

4. H W Kendig and H Leidheiser, *J Electrochem Soc* **123** (1978) 982

5. L Beaunier, J Epelboin, J C Lestrade and H Takenouti, *Surface Tech* **4** (1976) 237

6. J D Scantelbury and K N Ho, *J Oil Col Chem Ass* **62** (1979) 89

7. J D Scantelbury and G A Sussex, *Corrosion control by organic coating,* Ed. H Leidheiser, NACE (1981) p.51

8. M Piens and R Verbist, *ibid,* **32**

9. T Szaner and A Brandt, *J Oil Col Chem Ass* **67** (1984) **13**

10. H Leidheiser Jr and M W Kendig, *Corrosion,* **32** (1976) **69**

11. D M Brasher and A H Kingsbury, *J Appl Chem* **4** (1954) **62**