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EVALUATION OF PROTECTIVE SCHEMES BY CAPACITANCE AND RESISTANCE MEASUREMENTS

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ABSTRACT

Capacitance measurements as a function of time can give specific information on the uptake of water by paint films. More recently it has been shown that information on dielectric behaviour of paint before and after immersion in corrosive medium can be obtained by the measurement of capacitance as a function of frequency. The resistance and capacitance values of different indigenously prepared paint schemes were compared with imported schemes. The results are discussed in relation to the water uptake of the paint films.

Key Words: capacitance/resistanca measurement, paint scheme, protective coating

INTRODUCTION

It has already been established that changes in electrical resistance of a paint film in a medium can be related to its corrosion protection behaviour [1]. Both DC and AC methods are used for measuring electrical resistance [2,3]. The pores in the paint film give access to the corrosive medium to attack the basis metal and hence the comparative protective property can be assessed from the change in in the resistance. Capacitance of the paint film can provide some information on the absorption of water by the film. It has further been reported that measurement of these dielectric properties at different frequencies can give more information on the behaviour of the paint films.

In an earlier communication [4], the authors had reported the studies they have made with a few varnishes based on epoxy-polyamide resin formulations in different media like sodium chloride, sodium hydroxide, feelpol, etc. In the studies, they have measured the variation of capacitance and resistance of the films in these media at different frequencies. In the present paper they have compared the resistance and capacitance for different paint schemes based on epoxy-polyamide paint, both single coat and multicoat with primers and undercoat. The water uptake of these paint films coated over glass plates was also found out for a definite period of time and this property compared with the dielectric property.

EXPERIMENTAL

Preparation of samples

10 cms x 10 cms mild steel panels were sand blasted, degreased and were used as the substrate material. The following paint schemes, prepared indigenously were applied:

1. Epoxy polyamide undercoat .. 50 μ
2. Zinc rich primer + undercoat .. 88 μ
3. Zinc rich primer + undercoat .. 125 μ
4. Undercoat + finish coat .. 125 μ
5. Zinc rich primer + undercoat + finish coat .. 225 μ

For comparison purposes, the same paint schemes with imported formulations were also coated (Schemes numbered 1a, 2a, 3a, 4a, and 5a). Resistance and capacitance measurements were carried out in two media, 3% sodium chloride and 5% sodium hydroxide, using the universal bridge B 224 (Wayne Kerr, UK). Two frequencies of 1 KHz and 10 KHz were chosen for which an external source was used. Glass tubes of 1 cm dia and 4 cm length were fixed over the coating surface to facilitate holding of the solution and platinum was used as the lead. The studies were carried out over a period of 30 days.

Determination of water uptake of the films

Glass plates of size 5.0 cms x 7.5 cms were cleaned well, weighed and each of the paint schemes mentioned above was applied over the same and cured and weighed again. The difference gives the weight of the paint coated on glass. The coated plates were immersed separately in distilled water. The panels were removed periodically and the surface water was cleared with the help of filter paper and weighed again. The difference gives the amount of water absorbed. From this the percentage of water uptake is calculated.

RESULTS AND DISCUSSIONS

Tables I to IV give the variation of resistance and capacitance of different paint schemes, in sodium chloride and sodium hydroxide solutions, at different frequencies in a period of 30 days.

Table I: The change in resistance/capacitance of the painted panels with time in 3% NaCl at 1 KHz

Paint Scheme No.	Resistance (Megaohms)		Capacitance (PF)	
	Initial	Final	Initial	Final
1	41.0	4.0	44.0	81.0
2	3.6	0.6	110.0	220.0
3	59.0	6.1	38.0	61.0
4	200.0	8.5	28.0	49.0
5	300.0	52.0	12.2	15.2
1a	45.0	3.1	48.0	82.0
2a	3.2	0.3	121.0	233.0
3a	60.0	5.9	138.0	60.0
4a	215.0	10.6	27.0	52.0
5a	300.0	53.0	11.6	18.5

Table II: The change in resistance/capacitance of the painted panels in 3% NaCl at 10 KHz

Scheme No.	Resistance (Megaohms) Initial	Resistance (Megaohms) Final	Capacitance (PF) Initial	Capacitance (PF) Final
1	45.0	3.8	42.0	78.0
2	3.9	0.5	110.0	330.0
3	60.0	5.8	39.0	59.0
4	220.0	8.0	26.0	50.0
5	300.0	50.0	12.2	15.3
1a	45.0	3.3	50.0	80.0
2a	3.5	0.2	120.0	340.0
3a	70.0	6.8	40.0	62.0
4a	320.0	10.0	25.0	45.0
5a	310.0	55.0	11.6	18.9

Table III: The change in resistance/capacitance of the painted panels in 5% NaOH at 1 KHz

Scheme No.	Resistance (Megaohms) Initial	Resistance (Megaohms) Final	Capacitance (PF) Initial	Capacitance (PF) Final
1	62.0	1.1	62.0	200.0
2	5.0	0.5	150.0	430.0
3	80.0	5.8	48.0	250.0
4	380.0	5.0	38.0	220.0
5	2000.0	80.0	13.4	27.4
1a	63.0	1.5	62.0	270.0
2a	5.2	0.4	152.0	450.0
3a	75.0	6.1	46.0	267.0
4a	580.0	4.5	40.0	220.0
5a	2200.0	60.0	13.3	26.2

Table IV: The change in resistance/capacitance of the painted panels in 5% NaOH at 10 KHz

Scheme No.	Resistance (Megaohms) Initial	Resistance (Megaohms) Final	Capacitance (PF) Initial	Capacitance (PF) Final
1	63.0	1.2	62.0	250.0
2	5.0	0.4	150.0	450.0
3	72.0	6.3	50.0	190.0
4	600.0	4.8	40.0	232.0
5	2100.0	50.0	14.1	31.3
1a	63.0	1.1	62.0	281.0
2a	5.3	0.3	155.0	462.0
3a	70.0	6.1	55.0	210.0
4a	530.0	3.2	45.0	247.0
5a	2050.0	44.0	13.8	31.5

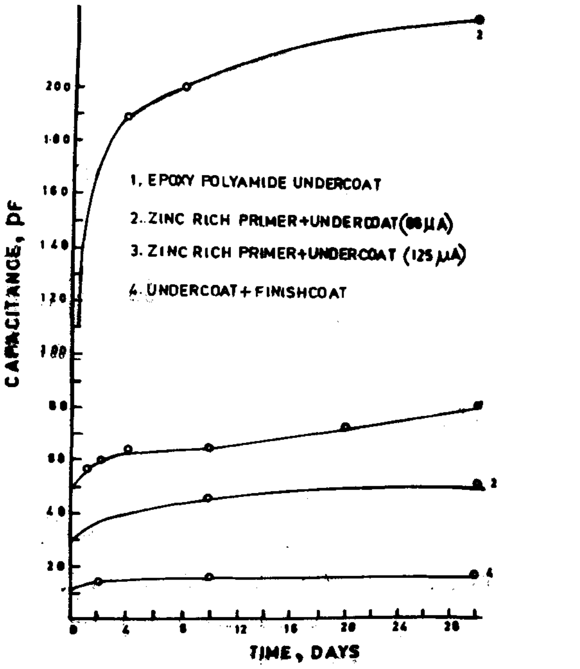

Fig.1 : Change in capacitance of the painted panels with time in 3% NaCl at 1 KHz

It can be seen that the best performance is obtained with paint scheme No. 5 on the expected lines because of the multicoats given and also of the higher thickness of the multicoat. But in the case of the coating with zinc rich primer and undercoat, the initial capacitance value itself is high and accordingly the resistance has shown a downward trend. This is well complimented by the results obtained by the water uptake experiments which is shown in Fig. 2.

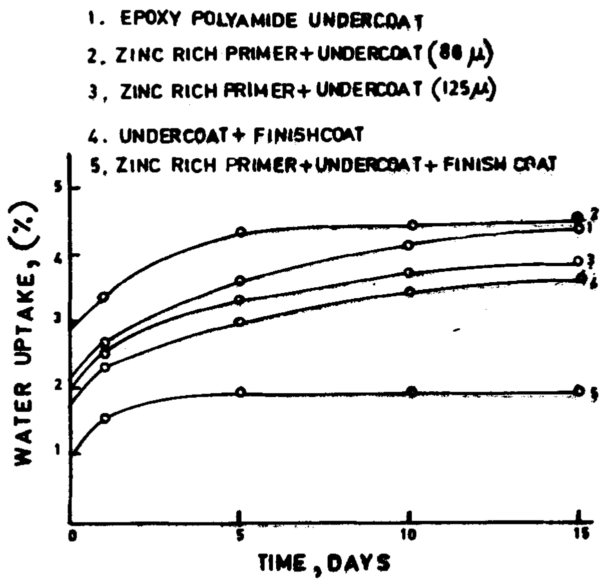

Fig 2: Percentage water uptake of the painted panels with time

In systems 2 and 2a, the trend is that there is maximum uptake of water during the initial stage and afterwards the saturation point is reached. However, when the thickness of the undercoat is increased, this trend is reversed, so it could be that the undercoat should be highly non-porous for getting best results. This behaviour may be due to the high zinc content of the coating. However, the low resistance cannot be attributed to the low corrosion resistance of the film as the mechanism of action of zinc rich primer is entirely different.

The multicoat with zinc rich primer, undercoat and finish coat is extremely corrosion resistant and practically there is not much change in the capacitance or resistance values, when they are put under test for 30 days. From the water uptake also it is clear that there is not much change in the water absorption values even during the initial stages. Water uptake after five days is practically negligible, which can be very well seen from the variation of capacitance with time (Figs. 1 and 2). In almost all systems, the capacitance value increases in the first few days and shows a steady trend indicating a saturation in the water uptake of the films.

CONCLUSION

By comparing the coatings that have been formulated with those of the imported samples, it is quite clear that the indigenous samples possess almost identical properties to imported ones, as far as the behaviour in the media studied are concerned. The behaviour is almost identical at different frequencies also.

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