Fundamental Journals
IJFPS
International Journal of Fundamental Physical Sciences
ISSN : 2231-8186
Full Length Research Paper
http://fundamentaljournals.org/ijfpss

Study on the properties of the hybrid organic coatings for corrosion protection

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(*Received Feb 2011; Published June 2011*)

ABSTRACT

Organic coatings play an important role in preventing the metal substrate from adverse effect of corrosion. Coatings are developed by single polymeric resins and or combination of resins with or without pigments Silicone resin (S2) and polyester resin (P2) were used to develop binders with different weight ratios. Polyisocyante was used as the curing agent. Physical, mechanical, thermal and electrical properties were studied. The maximum value 5B has been attained by the S240P260 and S250P250 coatings. The binders containing 40% S2 and 70% P2 and 50% S2 and 50% P2 showed high performance compared to the samples containing 20, 30, 70 and 80% of S2 40% P2 resin with S2 resins withstood temperatures up to 448 K for 24 hours and from the potential time measurement it has been found that S240P260 could withstand without any formation of corrosion for longer time.

Key words: Corrosion, coatings, impact resistance, adhesion, heat resistant coatings

DOI: 10.14331/ijfps.2011.330008

INTRODUCTION

Organic coatings play an important role in preventing the metal substrate from adverse effect of corrosion. Coatings are developed by single polymeric resins and or combination of resins with or without pigments (Ramesh et al. 2007), (Naderi et al. 2009), (Anand Kumar et al. 2010). The resins are used since they are cheap and easy to make different hybrid combinations with other resins. The application of the coatings on the metal substrate is also very simple. Prevention is better than cure. So that the metal substrates have to be coated before any exposure to corrosive environment especially the structures used in sea and marine applications. Various resins are used for the development of coatings (Nikravesh et al. 2011). Silicone resin has good mechanical and thermal stability. While considering polyester resins, they have good physical strength and can be easily crosslinked with silicone resin (Ramesh et al. 2007), (Anand Kumar et al. 2010). In this work, silicone (S2) and polyester resin (P2) were selected to formulate the coating system. The important parameters have been extensively studied.

MATERIALS AND METHODS

The substrate samples used in this study are surface treated cold rolled mild steel panels. The surface preparation is very important to prevent any unwanted reactions in the metal coating interface. The grease and dust will be cleaned and dried. Sand blasting and cleaning are carried out to obtain the surface to reach SP2 standard. Silicone resin (S2) and polyester resin (P2) were obtained and used as such. Polyisocyante was used as the curing agent. Various weight ratios of these two resins were blended as given in the Table 1.

Table 1 Composition of S2 : P2 resins

Composition	Designation
20 : 80	S220P280
30 : 70	S230P270
40 : 60	S240P260
50 : 50	S250P250
60 : 40	S260P240
70 : 30	S2270P230
80 : 20	S280P220

The blended resins were applied on the steel substrate and allowed to cure for one week. The important characteristics of the coatings (Scrinzi et al. 2009) (Liu et al. 2009), (Diaz et al. 2010) such as dry film thickness, adhesion, impact resistance, thermal resistance and electrical resistance were evaluated by Elcometer, cross hatch test, impact resistance tester, ASTM 2485 standard and potential time measurement respectively. Sheen cross-hatch cutter was used in this study. The test method specifies suitable cutting tools with either single or multiple cutting edges. All the tests were carried out following ASTM D3359 standards. Falling weight method was employed to study the impact resistance. The damage observed when the weight intended on the coating. The samples were heated for 24 hours in furnace. The surface of the coating was analysed for the damage in terms of colour change and crack. Potential time measurement was used to analyse the corrosion protection ability of the coatings. The coated samples were immersed in 3% NaCl solution. Using standard calomel electrode and substrate as working electrode, the potential change was noted for a period of time (Jafarzadeh, et al. 2011).

RESULTS AND DISCUSSION

The coated samples were tested for the complete curing by touching the surface. If there was no finger prints appeared showing the curing of the coatings. The average dry film thickness was maintained less than 100 µ. Pure S2 and P2 resins have not formed a cured film in this work. The other combinations have dried properly. The curing may be attributed to the evaporation of solvents and crosslinking between the resins and hardener. The important phenomenon for the coating is adhesion. It can be clarified that the resistance offered to separate the coating from the substrate. The coating system must flow well over the substrate to have a good intermolecular contact between the surfaces of the substrate. Cross hatch method was used to evaluate the adhesion properties. The comparative results are given in Table 2. The adhesion results show that binders with low concentration of silicone and polyester resins have low adhesion power. S280P220 with low polyester content has 2B characteristics S220P280 and S220P380 with low silicone content have 3B characteristics. This may be due more crosslink formation in both resins compared to crosslinks between resins and substrate. The maximum value 5B has been attained by the S240P260 and S250P250 coatings.

Table 2 Adhesion Power of S2P2 Binder System

Composition	S2P2
20 : 80	3B
30 : 70	4B
40 : 60	5B
50 : 50	5B
60 : 40	4B
70 : 30	3B
80 : 20	2B

Fig.1 shows the impact resistance of the binder systems developed by S2P2 systems. The binders containing 40% S2 and 70% P2 and 50% S2 and 50% P2 showed high performance compared to the samples containing 20, 30, 70 and 80% of S2. These coatings have good adhesion power according to cross-hatch test. The functional group interaction will create a higher network density than interactions between the functional groups in S2P2. Hence binders formed from the combination of S2 and P2 are more flexural and then can absorb more shock. From a practical point of view the binder systems with high impact resistance could withstand external attack (Aretxabaleta *et al.* 2005).

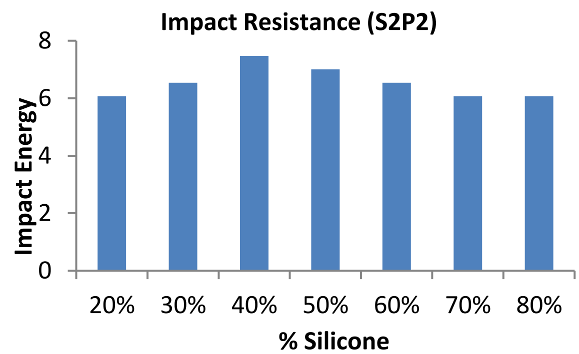

Fig.1. Variation of Impact Resistance

In the heat resistance test, the samples were heated in a furnace at different temperatures. The maximum temperature that the coating could withstand was found by identifying cracks, chalking and colour changes. 40% P2 resin with S2 resins withstood temperatures up to 448 K for 24 hours. The other compositions had showed lower thermal stability. The effect of silicone composition on the ability to withstand for higher temperature is shown in Fig. 2.

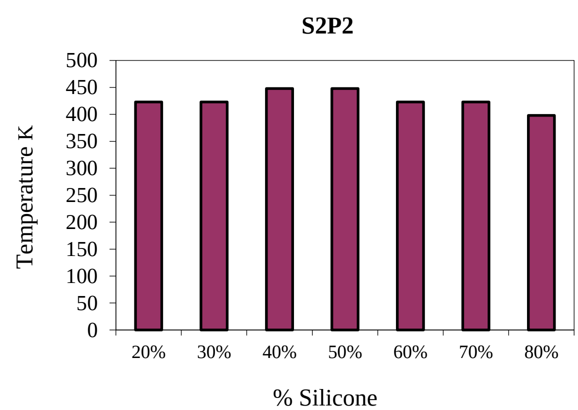

Fig.2. Thermal Stability of the Coating

Fig.3 shows the change in potential values with respect to time for different silicone concentrations in the S2P2 system. On the first day of immersion, all coatings had higher potential values over the corrosion potential. Upon further immersion, the potential values decreased with time, which must be caused by the permeation of electrolyte molecules through the coating until it reaches the interface (Liu et al., 2009, Jafarzadeh et al., 2011, Nikravesh, et al., 2011).

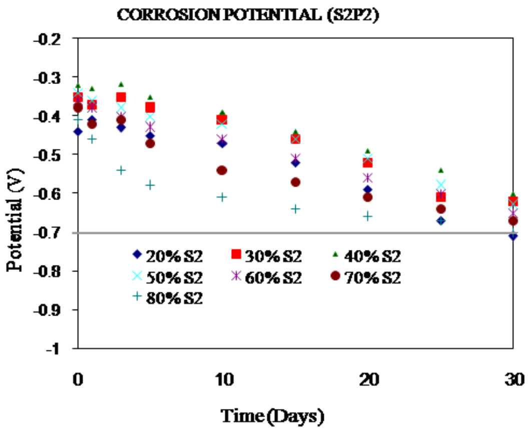

Fig.3. PTM Results for S2P2 Binder System

The driving force that enabled the diffusion of electrolyte solution through the coating may be the concentration difference through the pores in the coating. The samples coated by the organic coatings consisting of 70%, 60% and 50% P2 resin had not reached the corrosion potential. In other words, these coatings had protected the substrate for a longer time. The 20% P2 concentration binder systems failed on the 20th day of immersion. On the 25th day 80% P2 system reached the corrosion potential even on the 30th day of immersion (Ramesh, 2007).

CONCLUSION

Protective coatings were developed by silicone resin (S2) and polyester resin (P2) with different weight ratios. Polyisocyante was used as the curing agent. Physical, mechanical, thermal and electrical properties were studied. The maximum value 5B has been attained by the S240P260 and S250P250 coatings. The binders containing 40% S2 and 70% P2 and 50% S2 and 50% P2 showed high performance compared to the samples containing 20, 30, 70 and 80% of S2 40% P2 resin with S2 resins withstood temperatures up to 448 K for 24 hours and from the potential time measurement it has been found that S240P260 could withstand without any formation of corrosion for longer time.

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