Silicone-Polyester Blended Coatings for Corrosion Protection

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ABSTRACT

Corrosion can be protected by the application of protective coatings developed by organic resins. Metal lose due to corrosion affects a country economic to a higher extent. Organic coating is the cheapest method to prevent corrosion. Silicone and polyester resins have good physical, mechanical and anticorrosive properties. They can be blended and made hybrid networks. Various concentrations of the two resins were mixed. The curing agent used in the study was polyisocyanate. The network of different functional groups between silicone and polyester resins was examined by FTIR spectroscopy. The crosslink formation between the resins was observed by the identification and analysis of NH bond, Si-O-Si, Si-O-C functional groups. The developed coating systems have got adhesion property which was evaluated by cross hatch test. Electrochemical Impedance Spectroscopy (EIS) was used to study the anticorrosion property of the systems by exposing the samples to 3% NaCl solution. EIS experimental results show that the coatings could protect the metal surface for the exposure to corrosive medium for more than 30 days.

Key words: Coating, corrosion, FTIR, EIS

INTRODUCTION

Corrosion is the destruction and deterioration of metals. The metals are damaged by the formation of unusable metal oxides by corrosion. The increase in the material cost gives an alarmic awareness to protect the existing metals used in industries, bridges, buildings and other places from the adverse effect of corrosion. Cathodic protection, alloying, metal coatings and organic coatings have been used in the past to protect the metal surface. There is a lot of improvement in the materials and methods to achieve perfect anticorrosive system. Organic coatings are the cheapest and easiest method for this purpose. Various types of organic resins (Erich, Laven, Pel, Huinink, & Kopinga, 2005; Gite, Mahulikar, & Hundiwale, 2010; Rossi, Deflorian, & Risatti, 2006) resins have been used for coating purposes in the past few decades. Among these, silicone resins have good resistance for corrosion in all kinds of environments and better thermal stability owing to their exclusive organic – inorganic hybrid molecular formation (Erich et al., 2005; Ramesh, Osman, & Arof, 2007; Rossi et al., 2006). Epoxy resin has good toughness, adhesion and chemical resistance, but, thermal and mechanical properties are not adequate for the applications in structural products (Rossi et al., 2006). Silicone resins have good compatibility with organic resins for modification. They have superior thermal properties such as higher thermo-oxidative stability. The important properties are good moisture resistance, partially ionic in nature, free rotation about bonds and good compressivity. Polyester resins have higher tensile and flexural strengths and can be cross-linked using different cross-linking agents, become quite resistant to softening and deformation at high temperatures. Once cross-linked, polyester resins become quite resistant to softening and deformation at high temperatures (Anand Prabu & Alagar, 2004; Perruchot, Watts, Lowe, & Beamson, 2003). The corrosion protection ability can be enhanced by blending more than one organic resin. The hybrid coating system can protect the surface more efficiently (Ramesh et al., 2007). In this work silicone (S2) and polyester (P1) resins were used for the coating formulations.

EXPERIMENTAL METHODS AND MATERIALS

Coating consists of binder, pigment, extenders and additives. In this study, the properties of binder system and the interaction of different resins used have been analyzed. S2 and P2 were taken in different compositions to prepare various binders. Polyisocyanate was used as a hardener. The resins and
The isocyanate hardener and the organic resins. It is supported by the disappearance of NCO peak (Anand Prabu & Alagar, 2004). The peak values assigned for C=O and C=C are 1725 cm$^{-1}$ and 1590 to 1640 cm$^{-1}$ respectively. For the pure S2 resin these peaks are available at 1714 cm$^{-1}$ and 1594 cm$^{-1}$. For P2 system, they appear at 1724 and 1608 cm$^{-1}$. For the S2P2 binder systems, the peaks have been changed 1726 and 1638 cm$^{-1}$ respectively. Hence the shift in these bands and the difference in the shape of the spectrum of the blends indicate the formation of Si – O – C bands.

Cross hatch test results show that the S2 concentrations between 30-60% are classified in 4B categories. Binders developed by 50% and 40% S2have 5B characteristics. From the results as shown in Table 2, it is observed that most of the coating systems have good adhesion power. Addition of silicone to the polyester resin has increased the network density, which helped to increase the adhesion power. The carboxylic and hydroxyl functional groups in silicone and polyester interacted with the hydroxides on the substrate surface to ensure adhesion of the resins to the substrate [8]. However, according to (Packham, 1996), crosslinkings not only occur between the resin molecules and the hydroxides of the substrate surface but also between themselves. When S2 and P2 resins react/crosslink, Si-O-C bonds will form, which provides good strength for the coatings. The coatings having 20% polyester resin possibly may have lesser Si-O-C bonds and hence have lower adhesion power.

Table 2 Cross Hatch Cutter Equivalent Results

<table>
<thead>
<tr>
<th>Composition</th>
<th>S2P2</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 : 80</td>
<td>3B</td>
</tr>
<tr>
<td>30 : 70</td>
<td>4B</td>
</tr>
<tr>
<td>40 : 60</td>
<td>5B</td>
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<tr>
<td>50 : 50</td>
<td>5B</td>
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<tr>
<td>60 : 40</td>
<td>4B</td>
</tr>
<tr>
<td>70 : 30</td>
<td>3B</td>
</tr>
<tr>
<td>80 : 20</td>
<td>2B</td>
</tr>
</tbody>
</table>
EIS studies were carried out by exposing the samples to 3% NaCl solution. Initially the resistance values of the binder systems did not reduce significantly. This is because initially the coating film was still strong and did not allow water molecules to enter or penetrate to the substrate. Once the ions begin to enter the coating, resistance decreased (Lazarevic, Mijovic-Stankovic, Kacarevic-Popovic, & Drazic, 2005). During the course of exposure, the values of coating resistance was in the range of $10^0 - 10^7$ Ω for a high performing coating system (Mills & Schaefer, 2010). The binder systems consisting of 40% P2 with S2 resin showed higher resistance for the 30 days of immersion. 20% and 80% of all the three systems concentrations have lower values. Figure 2 shows the corrosion resistance values for S2P2 system.

![Figure 2](image_url)

**Figure 2** Corrosion Resistance Values of S2P2 system for 30 days.

The initial penetration of electrolyte into the interface of the coating and substrate would have caused the formation of corrosion product and this would have extended to other areas and reduce the adhesion of the coating with the substrate and hence the resistance values decreased further (Doherty & Sykes, 2004; Hinderliter, Croll, Tallman, Su, & Bierwagen, 2006). The transport mechanism of electrolyte solution to the interface of the coating and the substrate may have occurred by means of Fick’s diffusion. The driving force was the concentration difference at the interface. The diffusion of electrolyte to the interface enabled the molecules to disrupt the polar interaction between the coating and the metal substrate which had resulted in good adhesion (Kolek, 1997).

**CONCLUSION**

A study was conducted to analyse the corrosion protection ability of the organic resin blends. Silicone and polyester resins were used to develop the binder systems. The coatings with 40 to 60% polyester resins showed good adhesion power. Various concentrations of the two resins were mixed. The curing agent used in the study was polyisocyanate. The network of different functional groups between silicone and polyester resins was examined by FTIR spectroscopy. The crosslink formation between the resins was observed by the identification and analysis of NH bond, Si-O-Si, Si-O-C functional groups. The developed coating systems have got adhesion property which was evaluated by cross hatch test. Electrochemical Impedance Spectroscopy (EIS) was used to study the anticorrosion property of the systems by exposing the samples to 3% NaCl solution. EIS experimental results show that the coatings could protect the metal surface for the exposure to corrosive medium for more than 30 days.

**REFERENCES**


