UNIVERSITI TEKNOLOGI MARA

UNSATURATED POLYESTER-GRAPHENE COATINGS TREATED SILANE COUPLING AGENT FOR METAL CORROSION PROTECTION

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MSc

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AUTHOR'S DECLARATION

I declare that the work in this dissertation was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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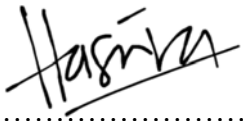
Signature of Student	:	 ……..
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ABSTRACT

This study has been develop to reduce the corrosion and improved the protection of the offshore platform by using unsaturated polyester (UPE) resin reinforced graphene (GR) primer coatings. The study was done by firstly; modifying GR loadings from 0-8% to determine the optimum loading, secondly; the optimization studies were undergone by using different mixing techniques (ultrasonication and mechanical stirring) and different mixing times at 30, 60, and 90 minutes to determine the optimum condition and lastly; the effect of silanization of GR with different loading of silane coupling agent, 3-aminopropyltriethoxysilane (3-APTES) from 1-7% to improve the dispersion of GR into the UPE resin. The primer coatings have been coated onto the carbon steel plate by using hand brush. Fourier Transform Infrared Spectroscopy (FT-IR) characterization technique is successfully done to analyze the functional group present and evaluate the UPE-GR and treated GR interaction. The Field Emission Scanning Electron Microscope (FE-SEM) analysis also has been done to study the surface morphology of the coatings. Corrosion rate for the preliminary studies shows the optimum results at 2% of GR loadings at 0.586 millimetre per year (mmpy) and no corrosion was found on the coating for immersion test in seawater and salt solution for 9 days. Whilst, mechanical properties which are pencil hardness, cross-cut adhesion strength and pull-off adhesion strength also shows the optimum properties at 2% of GR loading with 5H of pencil hardness, 0% of area has been removed from cross-cut adhesion test, and 3.35MPa of adhesion for pull-off adhesion strength test. The incorporation of 2% of GR loadings in UPE primer system successfully improved the mechanical properties and inhibits the corrosion of metal substrate due to well dispersion of GR into the UPE resin. The ultrasonication and mechanical stirring method in optimization studies shows the optimum anti-corrosive and mechanical properties at 60 minutes mixing times. The optimum corrosion rate for ultrasonication method is 0.375 mmpy whilst for mechanical stirring method is 0.536 mmpy. Both methods shows the optimum pencil hardness at 5H and 0% of coating being detached from the substrate for cross-cut adhesion strength. The optimum pull-off adhesion strength has been observed for ultrasonication method and mechanical stirring method at 3.78MPa and 3.58MPa, respectively. The optimum condition was found at 60 minutes mixing time by using ultrasonication method. This is due to the ultrasonication method produced more uniform dispersion of GR compared to the mechanical stirring method as the ultrasonication possessed a good vibration energy dissipation to enable a better disentanglement of GR. The enhancement of UPE-GR 2% using 3-APTES with different loading (1, 3, 5 and 7%) by using ultrasonication method at 60 minutes mixing time was also successfully conducted. The results showed the optimum properties with improved mechanical and anti-corrosive behaviour at 3% of APTES. The corrosion rate is found at 0.073 mmpy and the corrosion has not been formed on the substrate after immersion test. The conductivity also was found at 1.289×10^{-8} $\Omega.cm^2$. The mechanical properties also showed the optimum condition at 3% of treated GR with 5H of the pencil hardness, 0% of area being detached from the substrate, pull-off adhesion strength at 4.19MPa and 160.23°of contact angle. This is attributed to the 3-APTES that acted as a dispersion agent and enhanced the interaction of GR with UPE resin as well as improved the mechanical and anti-corrosive properties of the coatings.

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