UNIVERSITI TEKNOLOGI MARA

# SURFACE MODIFICATION FOR ENHANCEMENT OF BARRIER AND ADHESION PROPERTIES OF RUBBER/MILD STEEL BONDING SYSTEM IN SALT ENVIRONMENT

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# AUTHOR'S DECLARATION

I declare that the work in this thesis 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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# ABSTRACT

The bond durability of rubber/mild steel components exposed to aggressive environments depends on the types of environments and duration to which the components are exposed to. Corrosion reactions on mild steel substrate have induced premature adhesion failures of rubber/mild steel components after exposure to marine conditions. An alkaline media generated by the cathodic reduction reaction in a corrosion process, was found to have degraded the commercial phenolic modified chlorinated rubber primer coating used in the bonding system leading to premature adhesion failure of the components. Thus, the strategic goal of this research is to reduce corrosion and minimize the effects of its processes on adhesion loss of primer coating through surface modification of the mild steel substrate. This research emphasizes on developing a multifunctional mild steel surface modification system using silane-based compound with the intention of improving the surface energy for adhesion while simultaneously inhibiting corrosion through the use of inhibitors. In this work, a synergistic effect of silane coupling agent, 3-glycidoxypropyltrimethoxysilane (3-GPS), surfactant inhibitor, sodium dodecylbenzene sulfonates (SDBS) and $ZnSO_4$ pretreatment on mild steel has been investigated. The surface characterizations were done using FTIR, SEM, EDX, XPS and contact angle analysis. The effects of surface modification on the electrochemical reactions were examined through potentiodynamic measurement combined with the electrochemical impedance spectroscopy (EIS), while, its effect on the surface energy was evaluated through adhesion analysis. A two-pack polyamide cured epoxy, and a commercial phenolic modified chlorinated rubber coatings were used to measure the effectiveness of the surface modification of mild steel. The overall performance of the coated mild steel against corrosion was further evaluated through EIS, cathodic, and anodic delamination tests. The result found that SDBS:$ZnSO_4$ mixtures resist the mild steel corrosion in 0.05 M NaCl solution with inhibition efficiency of 96 % obtained at a 200:200 ppm ratio. This phenomenon was due to the formation of a compact insoluble layer of zinc hydroxide/oxide together with SDBS complex on the metal surface, which then impedes both the oxygen reduction and oxidation reactions on mild steel. The dense hydrophobic tail of SDBS compound that deposited on the metal surface further hinders the electrolyte diffusion towards the mild steel surface. This formation of the protective layer was confirmed through surface characterizations. A neat 3-GPS silane was not able to provide an effective corrosion-resistant film on mild steel although it did significantly improves the adhesion of epoxy coating. On the other hand, 3-GPS silane used in combination with SDBS:$ZnSO_4$ inhibitors was found to have improved both the corrosion resistance of mild steel substrates as well as adhesion of the epoxy coating. However, the result shows that the adhesion strength is lower if compared to the neat silane indicating that SDBS:$ZnSO_4$ inhibitors has distrupted the bond formation between epoxy and mild steel substrate. However, this sample has higher resistance towards cathodic and anodic delamination. These combined results show that there is no correlation between adhesion and corrosion resistance. It shows that excellent adhesion is not always necessary to prevent corrosion in which underfilm corrosion depends on inhibition rather than adhesion. Phenolic modified chlorinated rubber coating applied on 3-GPS/SDBS:$ZnSO_4$ treated mild steel was found to be more resistant towards cathodic and anodic delamination despite having a lower adhesion compared to the untreated mild steel.

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