

### SUPERVISOR'S DECLARATION

We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Science.



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## STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ENHANCE FORMULATION OF ORGANIC COATING FOR BARRIER  
PROTECTION OF MILD STEEL UPON CORROSIVE ENVIRONMENT

ENGKU NORFATIMA BINTI ENGKU DAHALAN

Thesis submitted in fulfilment of the requirements  
for the award of the degree of  
Master of Science

Faculty of Chemical and Natural Resources Engineering  
UNIVERSITI MALAYSIA PAHANG

FEBRUARY 2019

PERPUSTAKAAN  UNIVERSITI MALAYSIA PAHANG	
No. Perolehan <b>127327</b>	No. Panggilan EKKR4
Tarikh <b>17 APR 2019</b>	- NG7 2019 Thesis

**This page is entirely dedicated to...**

*... my lovely mother and father (Endon Binti Muda and Engku Dahalan Bin Engku Itam), family and friends who have always been at my side and given me the encouragement and support that carries me through my study. Thanks for their never-ending love, support and care to me...*

*(May ALLAH S.W.T. always be with all of you)*

## **ACKNOWLEDGEMENTS**

**In the Name of Allah, the Most Merciful, the Most Compassionate, Peace and Blessings be upon His Beloved Prophet.**

I am making uncounted praises to my Allah the Almighty who has guided me to remember Him at this time. I praised Him, for it is Him who made this master study possible. Nothing is possible unless He made it possible.

I would like to express my special appreciation and thanks to my supervisor, Dr Azizul Helmi Bin Sofian. You have been a brilliant mentor for me. I would like to thank you for your never-ending support during my tenure as a research student under your guidance, for giving insightful comments and suggestions of which without it, my research path would be a difficult one. Your advice on my research has been valuable. My fullest appreciation goes as well to my co-supervisor, Ir. Dr Arman Bin Abdullah for his idea and support from the beginning till the end of my research.

My sincere thanks also go to Chemical Engineering's Lab, Faculty of Chemical and Natural Resources Engineering, Universiti Malaysia Pahang because give me the opportunity for access and using the laboratory and research facilities. Without the facilities support, it would not be possible to conduct this research. I would also like to express my gratitude to Universiti Malaysia Pahang, which granted me the financial assistance under the RACE grant RDU 14 03141, RDU 151308, RDU 150386 and UMP Postgraduate Research Grant Scheme PGRS160375.

I would also like to thank all of my friends who supported me during experimental work and writing and motivate me to strive towards my goal. I am sincerely grateful to the staffs of Chemical Engineering and Natural Resources Faculty who helped me in many ways and made my stay in UMP pleasant and unforgettable.

Special thanks to my family. Words cannot express how grateful I am to my mother, father and siblings for the love and support throughout these years. Your prayer for me was what sustained me thus far. I would like express appreciation to my beloved friends who always be my support in the moments when there was no one to answer my queries and for all the sacrifices you have made on my behalf.

## ABSTRAK

Isu kakisan telah ditandai dengan jelas dalam sains moden sebagai salah satu faktor yang boleh menyebabkan peningkatan kos ekonomi, ketinggalan teknologi dan kelemahan dalam struktur bangunan. Kandungan pigmen (PVC) yang tinggi dalam penyalut organik menawarkan perlindungan katodik yang lebih baik dengan mengorbankan pigmen aktifnya untuk membentuk “perlindungan secara halangan” untuk melindungi keluli daripada berkarat. Walau bagaimanapun, teknik ini didatangi dengan beberapa masalah seperti masalah lekatan kerana kandungan pengikat yang rendah, sifat mekanikal yang lemah dan lapisan penyalut yang berliang yang membolehkan unsur menghakis berlaku dengan cara menembusi lapisan penyalut, seterusnya menghakis keluli. Abu cerobong diperkenalkan sebagai pengisi baru dalam kajian ini untuk menggantikan kaolin dalam penyalut kerana kandungan alumina dan silika yang tinggi berbanding dengan kaolin. Objektif kajian ini adalah untuk membandingkan penyalut organik yang diolah (kaolin sebagai pengisi) dengan semburan komersial (faktor kakisan 60) dan untuk mengkaji keberkesanan parameter yang mempengaruhi kelakuan kakisan dengan menggunakan kaedah “One Factor at Time” (OFAT). Perlindungan yang ditawarkan dibandingkan dengan penyalut organik (kaolin) dan penyembur komersial. Parameter yang digunakan dalam kaedah OFAT adalah PVC, kepekatan abu cerobong dan lapisan penyalut. Pemerhatian lekatan digunakan untuk menguji kejayaan dan keberkesanan perumusan penyalut. Tingkah laku kakisan penyalut dikaji dengan menggunakan pengukuran elektrokimia dan ujian rendaman. Manakala, “Pengimbasan Mikroskop Elektron” (SEM) dan “Analisis Gravimetrik Termal” (TGA) telah digunakan dalam kajian morfologi permukaan dan kelakuan haba penyalut. Respon dari pemeriksaan menunjukkan persamaan regresi berganda linear dan memperoleh korelasi ( $R^2 = 0.93$ ) antara data percubaan dan data model. Analisis varians (ANOVA) menunjukkan bahawa model itu penting (P-nilai 0.0026) bagi jumlah rintangan kakisan. Dari penyiasatan OFAT ke atas penyalut organik dengan abu cerobong sebagai pengisi, PVC rendah mempunyai perlindungan halangan yang baik berbanding dengan perlindungan galvanik dari PVC tinggi. Penambahan abu cerobong dalam penyalut mengubah sifat penyalut dari perlindungan halangan ke sifat perlindungan katodik pada PVC rendah. Oleh itu, PVC rendah dengan kandungan abu cerobong yang tinggi (sampel FA40) menunjukkan rumusan terbaik penyalut zink epoksi dengan ketahanan polarisasi  $7.43E+09 \Omega$  dan kadar kakisan  $2.17E-03 \mu\text{m}/\text{tahun}$ . Keseluruhannya, kajian ini menunjukkan bahawa penyalut organik (kaolin) yang dirumus mempunyai perlindungan halangan, manakala penyembur komersial mempunyai perlindungan galvanik yang baik. Berdasarkan hasil yang diperoleh daripada analisis OFAT, PVC didapati memainkan peranan penting dalam perilaku kakisan berbanding parameter lain. Manakala, hasil daripada pengukuran TGA memberikan keterangan bahawa ketahanan unggul boleh ditawarkan oleh abu cerobong.

## ABSTRACT

Corrosion issues have been clearly marked in modern sciences as one of the factors that can trigger economic costs, technological delays as well as structural failures. The high content of pigment volume concentration (PVC) in organic coating offered better cathodic protection by sacrificed its active pigment to form a barrier protection to protect the steel from corroded. However, this technique came with several problems such as adhesion problem due to the low content of the binder, poor mechanical properties and a porous film which allowed the corrosive element to penetrate the coating layer thus, corroding the steel. Fly ash was introduced as new filler in this research to replaced kaolin in the coating due to the high content of alumina and silica compared to kaolin. The objectives of this research include comparing the formulated organic coating (kaolin as filler) with the commercial spray (corrosion factor 60) and to study the effectiveness of the parameters that influence the corrosion behaviour by using One Factor at Time (OFAT) method. The protection offered was compared among the formulated organic coatings (kaolin) and commercial spray. The parameters used in the OFAT method are PVC, the concentration of fly ash and the layers of the coatings. The adhesion observation was used to test the success and effectiveness of the coating formulation. The corrosion behaviour of the coating was studied by using electrochemical measurements and immersion test. Likewise, Scanning Electron Microscopy (SEM) and Thermal Gravimetric Analysis (TGA) were used in the study of the surface morphology and thermal behaviour of the coating. The responses from screening were fitted with a multiple linear regression equation and obtained a correlation ( $R^2 = 0.93$ ) between the experimental data and model data. Analysis of variance (ANOVA) showed that the model is significant (P-value of 0.0026) for the total corrosion resistance. From the OFAT investigation on the organic coating with fly ash as filler, the low PVC had a good barrier protection compared to galvanic protection from high PVC. The addition of fly ash in the coating changed the properties of the coating from barrier to cathodic properties at low PVC. Therefore, the low PVC with a high content of fly ash (sample FA40) showed the best formulation of epoxy zinc coating with polarization resistance of  $7.43E+9 \Omega$  and corrosion rates of  $2.17E-03 \mu\text{m}/\text{yr}$ . Overall, this study showed that the formulated organic coating (kaolin) possesses a barrier protection, whereas the commercial spray has good galvanic protection. Based on the result obtained from the OFAT analysis, it was found that the PVC plays an important role in corrosion behaviour compared to other parameters. On the other hand, the results from TGA measurement provided evidence that superior endurance can be offered by the fly ash.

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