

POTENTIAL AND PERFORMANCE OF
Rhizophora apiculata (MANGROVE
TANNIN) AS ENVIRONMENTAL
FRIENDLY ANTICORROSIVE AND
ANTI FOULING PIGMENT FOR EPOXY
PAINT IN TROPICAL SEAWATER

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MASTER OF SCIENCE
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**Thesis Submitted in Fulfillment of the Requirement for the
Degree of Master of Science in Maritime Technology**

**SCHOOL OF OCEAN ENGINEERING
UNIVERSITI MALAYSIA TERENGGANU**

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DEDICATION

This thesis is proudly dedicated to....

To my parents Mr. Mohd Sukarnoor Sulong and Mrs. Gayah Mohamad

and

To my love Mr. Muhammad Aizat Mohd Khalid

Thank for your endless love, sacrifices, prayers, supports and advices.

ABSTRACT

Abstract of thesis presented to the Senate of Universiti Malaysia Terengganu in fulfillment of the requirement for the degree of Master of Science

POTENTIAL AND PERFORMANCE OF *Rhizophora apiculata* (MANGROVE TANNIN) AS ENVIRONMENTAL FRIENDLY ANTICORROSIVE AND ANTIFOULING PIGMENT FOR EPOXY PAINT IN TROPICAL SEAWATER

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School : School of Ocean Engineering

Nowadays, the prevention of corrosion and fouling of steel surfaces at seawater-based environments issue become an important issue in marine industry. There were several proposals on the implementation of new compounds, for example the eco-friendly paints which help reduce environmental damage. In this approach, mangrove tannins, extracted from the bark of *Rhizophora apiculata* was used. Together with the incorporation of zinc nitrate, a less soluble formulation called zinc-tannate was produced. In fact, this derived compound enhances the protection offered by epoxy paints and meets the main purpose of this study. Zinc-tannate was used to test the capabilities as an anticorrosive and antifouling agent and ascertain suitable compositions in epoxy paint. Along with this, several tests were also carried out *i.e.* inhibitive properties through the use of Fourier Transform Infrared spectroscopy, Electrochemical Impedance Spectroscopy, Potentiodynamic Polarisation, weight loss measurements, the evaluation of zinc-tannate antifouling performance

through *in vitro* anti-biofilm assessments and, surface conditioning through Scanning Electron Microscopy observations. With this, zinc-tannate successfully prevented steel corrosion by providing a protective coat. Interestingly, the antioxidant properties of tannin offers resistance to corrosion and this reduced the overall steel weight loss. Such was evident after corrosion test by weight loss measurement (Inhibition efficiency: 83.86% at 6 g of zinc-tannate), Electrochemical Impedance Spectroscopy analysis (Inhibition efficiency: 93.91% at 6 g of zinc-tannate), Potentiodynamic Polarization measurement (Inhibition efficiency: 95.08% at 6 g of zinc-tannate), as well as fouling test by *in vitro* anti-biofilm assessments (Biofilm inhibition: 97.26% at 35 mg/ml of zinc-tannate) Besides, the addition of zinc nitrate into mangrove tannin was found to decrease the solubility of the tannin in seawater. The total amount of polyphenol (tannin) leached from the paint formulated with zinc-tannate into the seawater was 0.012 mg compared to the paint formulated with pure tannin, 0.030 mg at 25 days in immersion test. In short, the combination of mangrove tannin and zinc nitrate (zinc-tannate) increased the anticorrosive properties of epoxy paint and produced valuable environmentally friendly antifouling potential. Mild steel coated with 6 g of zinc-tannate offers more corrosion inhibition and antifouling effect in seawater compared to other mild steel. Therefore, the addition of zinc-tannate into conventional epoxy paints was proven effective as an inhibitor but it highly depends on the formulation prepared.

ABSTRAK

Abstrak tesis yang dikemukakan kepada Senat Universiti Malaysia Terengganu sebagai memenuhi keperluan untuk ijazah Master Sains

POTENSI DAN PRESTASI *Rhizophora apiculata* (TANIN BAKAU) SEBAGAI PIGMEN ANTI KAKISAN DAN TUMBUHAN MESRA ALAM UNTUK CAT EPOKSI DALAM PERSEKITARAN AIR LAUT TROPIKA

NOOR IDORA BINTI MOHD SUKARNOOR

OGOS 2015

Penyelia Utama : Prof. Dr. Wan Mohd Norsani Wan Nik, Ph.D.
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Pusat Pengajian : Pusat Pengajian Kejuruteraan Kelautan

Pada masa kini, pencegahan kakisan dan kelekatan tumbuhan pada permukaan keluli di persekitaran berasaskan air laut menjadi isu penting dalam industry marin. Terdapat beberapa cadangan mengenai pelaksanaan kompaun baru contohnya cat mesra alam yang membantu mengurangkan kerosakan alam sekitar. Dalam pendekatan ini, tanin bakau, diekstrak daripada kulit *Rhizophora apiculata* digunakan. Bersama-sama dengan gabungan zink nitrat, formulasi bahan yang kurang larut telah dihasilkan, dipanggil sebagai zink-tannate. Malah, sebatian yang diperolehi ini meningkatkan perlindungan yang dibawa oleh cat epoksi dan memenuhi tujuan utama kajian ini. Zink-tannate telah digunakan untuk menguji keupayaan sebagai ejen anti karat dan tumbuhan dan menentukan komposisi yang sesuai di dalam cat epoksi. Bersama-sama dengan ini, beberapa ujian juga telah dijalankan seperti ciri-ciri perencatan melalui penggunaan *Fourier Transform Infrared spectroscopy*, *Electrochemical Impedance Spectroscopy*, *Potentiodynamic Polarisation*, pengurangan berat, penilaian prestasi zink-tannate sebagai anti tumbuhan melalui ujian *in vitro* anti-biofilm dan, keadaan permukaan melalui pemerhatian Imbasan Elektron Mikroskop. Dengan ini, zink-tannate berjaya menghalang

kakisan keluli dengan menyediakan lapisan pelindung. Menariknya, sifat-sifat antioksidan tanin menghalang kakisan dan ini mengurangkan kehilangan keseluruhan berat keluli. Itu terbukti selepas ujian kakisan melalui pengukuran pengurangan berat keluli (kecekapan perencatan: 83.86% pada 6 g zink-tannate), *Electrochemical Impedance Spectroscopy* (kecekapan perencatan: 93.91 pada 6 g zink-tannate), *Potentiodynamic Polarisation* (kecekapan perencatan: 95.08 pada 6 g zink-tannate), analisis dan juga ujian *fouling* menggunakan penilaian *in vitro* anti-biofilm (perencatan biofilm: 97.26 pada 35 mg/ml zink-tannate). Selain itu, penambahan sebatian zink nitrat ke dalam tannin bakau telah dijumpai mengurangkan kelarutan tannin di dalam air laut. Jumlah keseluruhan *polyphenol* (tanin) yang melarut dari cat yang diformulasikan dengan zink-tannate ke dalam air laut adalah 0.012 mg berbanding dengan cat yang diformulasikan dengan tannin tulen, 0.030 mg pada 25 hari dalam ujian rendaman. Pendek kata, gabungan tanin bakau dan zink nitrat (zink-tannate) meningkatkan sifat anti karat cat epoksi dan menghasilkan potensi anti tumbuhan mesra alam yang berharga. Keluli lembut yang dicat dengan menggunakan 6 g zink-tannate memberi lebih banyak kesan kakisan perencatan dan anti tumbuhan di dalam air laut berbanding dengan keluli lembut yang lain. Oleh itu, penambahan zink-tannate ke dalam cat epoksi konvensional telah terbukti berkesan sebagai perencat tetapi ia sangat bergantung kepada rumusan yang disediakan.