EVALUATION OF CURCUMA DOMESTICA LOIR AND ALPINIA GALANGA EXTRACT AS AN ECO-FRIENDLY CORROSION INHIBITOR FOR CARBON STEEL IN 0.5 M HCl MEDIUM

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in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this thesis entitled "Evaluation of *curcuma domestica loir* and *alpinia galanga* extract as an eco-friendly corrosion inhibitor for carbon steel in 0.5 M HCl medium" is the result of my own study except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology with Honours.

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DEDICATION

This study is devoted to my beloved parents who have given my strength when I thought of giving up, always providing their moral, spiritual, emotional and financial support.

Not forget to my sibling, sister and brother, relatives, mentor and supervisor Dr. Mohd Fauzi Bin Mamat, friends and classmates who shared their words of advice and encouragement to finish this study.

Last but last, i dedicated this book to the almighty god "Allah", thank you for the guidance, strength, power of mind, protection, skills and for giving a healthy life.

ABSTRACT

Carbon steel is most often used to meet the needs of steel users. The material has great flexibility and it is best shown by the numerous applications of steel. As we all know, metal corrosion is one of the most disruptive phenomena, causing massive economic damage in the automobile, marine, oil and gas, and aerospace industries in particular. Corrosion inhibitors are compounds that are added to or applied to a corrosive medium in small amounts on metal surfaces, lowering the corrosion tendency. Sometimes there are limits to the use of typical corrosion inhibitors because they are based on harmful compounds for human health, such as treatments using chromium. Recent approaches benefit from organic components derived from expired pharmaceuticals, green inhibitor extracts and even plant extracts. The main aim of this study is to evaluated of *curcuma domestica loir* and *alpinia galanga* extract as eco-friendly corrosion inhibitor for carbon steel in 0.5 M HCl medium. The objectives are to investigate the influence of the immersion period on the inhibition efficiency of the green inhibitors. To evaluate the inhibition efficiency of *curcuma domestica loir* and *alpinia galanga* extract as plant-based green inhibitor for low carbon steel in an acidic medium. To compare the performances of the selected green inhibitors in preventing corrosion in low carbon steel. For this research we had used low carbon steel as substrate has immerse in 0.5 M HCl added with *curcuma domestica loir* and *alpinia galanga* extract. Immersion test sample has been divided into three sample which is HCl added with turmeric and galangal extract. Each sample contain six low carbon steel specimen and has observed within 7, 14, 21, 28 and 35 days. The specimen has been takeout followed by the week that we have decided and the result has been calculated by weight loss measurement and corrosion rate. Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray (EDX) has been analyzed in this study. The SEM study of the low carbon steel surface has then establish the effect on corrosion inhibition of the environmentally friendly inhibitor. The results at days 35 of total weight loss measurement for three solution is 1.14gram, 0.731gram and 0.795gram, corrosion rate for three solution is 0.0154mm/year, 0.0099mm/year and 0.0107mm/year and inhibitor efficiency for turmeric is 35.87% and galangal is 30.26% has been proven to reduce the rate of corrosion of carbon steel by adding a turmeric and galangal environmentally friendly inhibitor. The efficiency of the inhibition has thus been increased when the turmeric and galangal extract concentration are increases. The low carbon steel observation surface SEM and EDX analyzes showed that specimen surfaces in 0.5 M HCl solution had a lot more corroded pitting, compared to the turmeric and galangal medium on specimen surfaces. The green inhibitor is to be used in systems of oil and gasses, such as boilers, pipelines, pressure tanks and pressure vessels. The best green inhibitor is turmeric, based on the maximum value of corrosion rate and highest value of inhibitor efficiency.

ABSTRAK

Keluli karbon paling kerap digunakan untuk memenuhi keperluan pengguna keluli. Bahan ini mempunyai fleksibiliti yang hebat dan paling baik ditunjukkan oleh banyak aplikasi keluli. Seperti yang kita semua ketahui, kakisan logam adalah salah satu fenomena yang paling mengganggu, menyebabkan kerosakan ekonomi yang besar pada industri automobil, laut, minyak dan gas, dan aeroangkasa khususnya. Inhibitor kakisan adalah sebatian yang ditambahkan atau digunakan pada medium yang menghakis dalam jumlah kecil pada permukaan logam, menurunkan kecenderungan kakisan. Kadang-kadang terdapat had penggunaan perencat kakisan khas kerana ia berdasarkan sebatian berbahaya untuk kesihatan manusia, seperti rawatan menggunakan kromium. Pendekatan terkini mendapat manfaat daripada komponen organik yang berasal dari farmaseutikal yang sudah habis tempoh, ekstrak perencat hijau dan juga ekstrak tumbuhan. Tujuan utama kajian ini adalah untuk menilai ekstrak curcuma domestica loir dan alpinia galanga sebagai penghambat kakisan mesra alam untuk keluli karbon dalam medium 0.5 M HCl. Objektifnya adalah untuk menyiasat pengaruh tempoh rendaman terhadap kecekapan penghambatan penghambat hijau. Untuk menilai kecekapan penghambatan curcuma domestica loir dan alpinia galanga ekstrak sebagai penghambat hijau berasaskan tumbuhan untuk keluli karbon rendah dalam medium berasid. Untuk membandingkan prestasi perencat hijau terpilih dalam mencegah kakisan pada keluli rendah karbon. Untuk penyelidikan ini, kami telah menggunakan keluli karbon rendah kerana substrat telah merendam dalam 0,5 M HCl yang ditambahkan dengan curcuma domestica loir dan alpinia galanga ekstrak. Sampel ujian rendaman telah dibahagikan kepada tiga sampel yang ditambahkan HCl dengan ekstrak kunyit dan lengkuas. Setiap sampel mengandungi enam spesimen keluli rendah karbon dan telah diperhatikan dalam 7, 14, 21, 28 dan 35 hari. Spesimen telah diambil diikuti oleh minggu yang telah kami putuskan dan hasilnya telah dihitung dengan pengukuran penurunan berat badan dan kadar kakisan. Mikroskop elektron pengimbas (SEM) dan Sinar-X penyebaran tenaga (EDX) telah dianalisis dalam kajian ini. Kajian SEM permukaan keluli rendah karbon kemudian membuktikan kesan penghambatan kakisan penghambat mesra alam. Hasil pada hari ke-35 dari jumlah pengukuran penurunan berat spesimen untuk tiga penyelesaian adalah 1.14gram, 0.731gram dan 0.795gram, kadar kakisan untuk tiga larutan adalah 0.0154mm/tahun, 0.0099mm/tahun dan 0.0107mm/tahun dan kecekapan penghambat untuk kunyit adalah 35.87% dan galangal adalah 30.26% telah terbukti dapat mengurangkan kadar kakisan keluli karbon dengan menambahkan penghambat mesra alam kunyit dan galangal. Oleh itu, kecekapan penghambatan telah meningkat apabila kepekatan ekstrak kunyit dan lengkuas meningkat. Analisis permukaan pemerhatian keluli rendah karbon SEM dan EDX menunjukkan bahawa permukaan spesimen dalam larutan 0.5 M HCl mempunyai lubang yang lebih berkarat, berbanding dengan medium kunyit dan lengkuas pada permukaan spesimen. Inhibitor hijau harus digunakan dalam sistem minyak dan gas, seperti dandang, saluran paip, tangki tekanan dan kapal tekanan. Inhibitor hijau terbaik adalah kunyit, berdasarkan nilai maksimum kadar kakisan dan nilai kecekapan perencat tertinggi.

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LIST OF SYMBOLS AND ABBREVIATIONS

SEM	-	Scanning Electron Microscopy
EDX	-	Energy Dispersive X-Ray
W_0	-	Weight absence of inhibitor
Wi	-	Weight presence oh inhibitor
I.E(%)	-	Percent inhibitor efficiency
Mm/yr	-	Milimeter per year
HCl	-	Hydrochloric
FTIR	-	Fourier transform infrared spectroscopy
G	-	Gram
L	-	Litre
mL	-	Mililitre
Gl	-	Gram per litre
M		Mol/L

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CHAPTER 1

INTRODUCTION

1.1 Background Study

The material is great flexibility is best shown by the numerous applications of steel. Carbon steel is mostly applied for steel customer demand. The good examples are sheets for low carbon steel, medium carbon structural stainless steel and plates used in all types of building, high carbon railways and wires for hundreds of products at all carbon levels. Combined characteristics that cannot be met with carbon steels begin when costly alloys are added (Page, 2020). Carbon steel is one of the most important types of steel, the carbon-iron alloy with a total weight of up to 2.1%. It represents 90% of the world's steel production. Five sub-categories are also included in the main category of carbon steel: Low-carbon steels: a carbon content of less than 0.015%. Special low-carbon steels: 0.015% to 0.05% carbon. Low carbon steels: carbon from 0.05% to 0.19%. Medium-carbon instruments: 0.2% to 0.49% carbon. High carbon steels: over 0.5% carbon. Each is particularly ideal for various applications and techniques (Masteel UK ltd, 2018). One of the issues that affected carbon steel is corrosion.

Corrosion is a major issue and its negative impact on the industry. A further big problem for industrialists and researchers is efforts to improve the risk of corrosion. Several efforts to control the problem of corrosion have been made, which plays a crucial role in the use of corrosion inhibitors. In addition, corrosion is also a threat to the environment and to manufacturing processes and instead has become a global issue, with the deleterious effects of the corrosion process (S. O. Ajeigbe, 2017).

Besides, the phrase 'degradation' is more common, though corrosion can also occur in materials other than metals, such as ceramics or polymers. Corrosion damages solids, appearance, and liquid and gas permeability, materials and buildings. In an oxidizing environment, carbon steel is subject to rust. In comparison to a reduction environment, carbohydrates will also erode to a higher general oxidation rate. An increase in the general rate of corrosion takes the corrosion impact into consideration (S. O. Ajeigbe, 2017).

In its action, corrosion is harmful, persistent and insidious. The effect on both large and small industries is threatening. That is almost impossible to entirely prevent and eliminate, so it is regulated by the only powerful antidote (Muhammad A. Hassan,2017). Hence, corrosion inhibitors are chemical compounds that minimize, slow down or avoid corrosion of the metal when applied in small quantities to the conditions in which the metal can corrode. Corrosion inhibitors' efficacy depends on the safety of the metals or alloys and the severity of the corrosive circumstances, inhibitors of corrosion are substances delivered to a manufacturing and product in a minute quantity to reduce metal corrosion. Organic compounds are the major inhibitors (S. O. Ajeigbe, 2017).

In order to overcome the problem entirely, the natural plant was used as green inhibitor as a result of corrosion in the building sector. The green inhibitor claims that the metal's surface is more corrosion resistant. Green plants reduce the corrosion rate better and are cost-effective in every aspect of the corrosion issue. The assessment of the efficiency of corrosion inhibitors in plant extract includes an increased nature of antioxidants, a more significant impact in the treatment of degradation processes. Last but not least, the implementation of green inhibitors is one of the finest protective alternatives for metals and alloys against corrosion. Biological inhibitors cause environmental damages and so contain no green corrosion inhibitors for heavy metals or any other pollutants. Plant products are cheap, easily available and environmentally friendly (S. O. Ajeigbe, 2017).

In this study, low carbon steel was used as a substrate and to simulate an acidic environment which is 0.5 M HCl solution. Moreover, two types of green inhibitor which is *curcuma domestica loir* and *alpinia galanga* extract are been used in this study. In the 0.5 M solution evaluated by HCl both extracts can be fully dissolved. *Curcuma domestica loir* and *alpinia galanga* extract is effective to build a compact barrier film at low carbon steel or solution surfaces that effectively isolates the corrosive medium from low-carbon steel reactive areas. To conducting a number of experimental methods to check the barrier film anti-corrosion mechanism of the turmeric and galangal extract from mechanical testing, visual inspection, weight loss measurement, corrosion rate and inhibitor efficiency on the low-carbon steel or resolution interface.

1.2 Problem Statement

Many studies are being conducted in order to avoid massive losses caused by metal corrosion. As we all know, metal corrosion is one of the most disruptive phenomena, causing massive economic damage in the automobile, marine, oil and gas, and aerospace industries in particular. The application and the usage of alternative materials and component design can also include the use of an effective of corrosion inhibitor in accordance with the kinds and life expectancy of the metal. The most common application of the inhibitor is also the toxicity and consequent harm to human health and the environment of the substances. Apart from that, the necessity of designing and producing green inhibitors from nearly cheap plants, leaves, safe and biodegradable. Hence, that can effectively delay corrosion and it is also necessary to investigate the effectiveness of inhibitor under severe conditions, such as acidic medium that might occur to a carbon steel.

1.3 Objective of Study

The aim of this study is to evaluated of *curcuma domestica loir* and *alpinia galanga* extract as an eco-friendly corrosion inhibitor for carbon steel in 0.5 M HCl medium. Specifically, the objectives are as follows:

i. To investigate the influence of immersion period on the inhibition efficiency of the green inhibitors.

ii. To evaluate the inhibition efficiency of *curcuma domestica loir* and *alpinia galanga* extract as plant-based green inhibitor for low carbon steel in acidic medium.

iii. To compare the performances of the selected green inhibitors in preventing corrosion on low carbon steel in acidic medium.

1.4 Scope of Study

The scope of this research are as follows:

i. To study the greatest green inhibitor formulation to be applied to oil and gas sectors as a low carbon steel substratum corrosion inhibitor.

ii. Selection of suitable plants which is turmeric and galangal to be extracted as green organic inhibitor.

iii. Preparation of extraction of plants based green organic inhibitor.

iv. EDM wire cutting machines are used to cut material into 25 mm cylinder diameter.

v. To study the corrosion behaviour via immersion test in 0.5 M HCl.

vi. Divide the sample into 3 group which is 6 sample have been immersed inside 0.5 M HCl water and another 12 samples have been immersed in 0.5 M HCl with different inhibitor for immersion test.

vii. All samples were immersed in the 0.5 M HCl medium for 7 days, 14 days, 21 days, 28 days and 35 days.

viii. Using Scanning Electron Microscope (SEM) or Energy Dispersive X-Ray (EDX) to study the corrosion behavior on the substract after test.

1.5 Significant of Study

The results of the study have contributed to an important part of the contribution of the study. The results of the investigation provide some information about the contribution of the sample. Which further explain the significance and future advantages of the study. The aim of this study is to evaluate the *curcuma domestica loir* and *alpinia galanga* extract as an eco-friendly corrosion inhibitor for carbon steel in 0.5 M HCl medium. In order to cure rust in metal like carbon steel form, the effectiveness of these environmentally friendly corrosion inhibitors have been examined. *Curcuma domestica loir* and *alpinia galanga* extract is a desirable way of stowing and preventing certain materials before they are required to be correctly applied. The point is to reduce the amount of corrosive inhibitor in industrial oil and gas on a closed system structure such as the tank, the pressure vessel and the platform for pipelines. Also use non-poisonous, safe, affordable, and etc.

1.6 Organization of Study

Based on the objective previously presented on the approach proposed study is made up of (5) chapters, which contents are summarized as follows:

i. Chapter 1. Introduction. This chapter presents the background, research problems, objectives, scopes, significance and organization of study for the study.

ii. Chapter 2. Literature review. This chapter begins by introducing carbon steel and the many carbon steel varieties. Then follow an overview of corrosion and the subtopic of corrosion and corrosion on carbon steel. This chapter also discusses corrosion procedures, inhibitors of corrosion and types of inhibitors of corrosion. A brief description about the green inhibitor is also available. Similarly, the literature review summary is provided.

iii. Chapter 3. Research methodology. This chapter describes the approach established to determine the corrosion inhibitor formula for a procedure utilized in this investigation. It was then followed which addresses the approach employed in this investigation. The research methodology has also been detailed and explained. In addition, Chapter 3 describes the PSM 1 and PSM 2 methodology.

iv. Chapter 4. Result and discussion. In this chapter, need to focus on discussing the effect of corrosion inhibitor which extract is more efficiency based on the result. Also, need to observe the mechanical properties and corrosion behavior of low carbon steel. Furthermore, discusses the result and explained out of several tests performed and the calculation.

v. Chapter 5. Conclusion and recommendation. In this chapter, need to highlight the main conclusions together with accomplishments of the work done in this