PRELIMINARY STUDY ON EFFECT OF TEMPERATURE ON HYDROPHOBIC COATING ON METAL

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A report submitted
in fulfillment of the requirement for the degree of
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DECLARATION

I declare that this project report entitled “Preliminary study on effect of temperature on hydrophobic coating on metal” is the result of my own work except as cited in the references

Signature :

Name : NUR IZZATI BINTI KUSNAN

Date :

APPROVAL

I hereby declare that I have read this project and in my opinion this report is sufficient in terms of scope and quality for the award of degree of Bachelor of Mechanical Engineering (Structure & Materials)

Signature :

Supervisor's Name : PROF. DR. GHAZALI BIN OMAR

Date :

DEDICATION

To my beloved mother and father

ABSTRACT

Hydrophobic coating has become an important approach in coating technology because it can prevent the surface from harmful effect of water and moisture in the environment. It inhibits high water repellency compared to other coatings. In this study, aluminum substrate has been used to analyze the effect of temperature on the hydrophobic coating to solve the problem in automotive industry, where aluminum that used as a vehicle frame and body is leads to the corrosion and oxides when it contact with water and direct sun even it was coated using polymer based paint to improve it mechanical strength. Therefore, the objectives of this study are to study the effect of temperature for polymer surface on hydrophobic properties at different temperature and time, to analyze the effect of temperature on surface morphology and surface roughness and to perform correlation of these microstructure properties with hydrophobicity of polymer surface. There are two different experiment were conducted which are heat treatment with varies the temperature and heat treatment with varies the times to analyze the effect of temperature on hydrophobic coating by measuring the contact angle, surface roughness, surface morphology and correlation of these microstructural properties with hydrophobicity of the surface. The measurement of the contact angle was done using MSP-3020 Digital Microscope Software, where the digital microscope is connecting to the computer and the analysis on the surface morphology and surface roughness were done using Alicona Infinite Focus G^4. The result indicates that, to produce hydrophobic surface, the temperature of the heat treatment must until reach optimum value with shorter time of exposure to create high surface roughness with complex surface morphology which is at temperature 175°C at times is 5 minutes to 10 minutes. This is because at high temperature, the analysis of the surface morphology shows the surface roughness significantly increases the microstructure change and increases the value of the contact angle, it contributes in hydrophobicity. Before and after this condition, where the temperature of the heat treatment is lower and the longer duration of time exposure to the heat treatment the contact angle starts decreasing and no longer remains as a hydrophobic surface.

ABSTRAK

Lapisan hidrofobik telah menjadi satu pendekatan yang penting dalam teknologi salutan kerana ia dapat menhalang permukaan daripada kesan berbahaya air dan kelembapan dalam persekitaran. Ia dapat menghalang kelekatan air yang tinggi berbanding dengan salutan yang lain. Dalam kajian ini, aluminium substrat telah digunakan untuk menganalisis kesan suhu ke atas lapisan hidrofobik untuk menyelesaikan masalah dalam industri automotif, di mana aluminium yang digunakan sebagai bingkai dan badan kenderaan mengalami kakisan dan oksida apabila ia terdedah secara langsung kepada air dan matahari walaupun ia telah disalut menggunakan cat berasaskan polymer untuk memperbaiki kekuatan mekanikalnya . Oleh itu, objektif kajian ini adalah untuk menkaji kesan suhu kepada permukaan polimer ke atas sifat-sifat hidrofobik pada suhu dan masa yang berbeza, untuk menganalisa kesan suhu ke atas permukaan morfologi dan kekasaran permukaan dan untuk menhasilkan perkaitan antara ciri-ciri mikrostruktur ini dengan sifat hidrofobik permukaan polimer. Terdapat dua eksperimen yang berbeza telah dijalankan iaitu rawatan haba dengan berbeza suhu dan rawatan hada dengan pilihan masa untuk menganalisis kesan suhu ke atas lapisan hidrofobik dengan mengukur sudut sentuh, kekasaran permukaan, permukaan morfologi dan hubung kait antara ciri-ciri mikrostuktur ini dengan sifat hidrofobik permukaan. Pengukuran sudut sentuh telah dilakukan dengan menggunakan Perisian MSP-3080 Mikroskop Digital, di mana mikroskop digital telah disambung ke komputer dan analisis mengenai permukaan morfologi dan permukaan kekasaran dilakukan menggunakan Alicona Infinite Focus G^4. Hasil keputusan menunjukkan bahawa, untuk menghasilkan permukaan hidrofobik, suhu rawatan haba mesti mencapai suhu yang optimum dengan masa pendedahan yang lebih singkat untuk menhasilkan permukaan yang kasar yang lebih tinggi dengan permukaan morfologi yang kompleks iaitu pada suhu 175°C dan pada waktu 5 minit ke 10 minit. Ini kerana, pada suhu yang tinggi, analisis permukaan morfologi menunjukkan kekasaran permukaan meningkat dengan ketara, perubahan mikrostruktur dan meningkatkan nilai sudut sentuh, ia menyumbang dalam sifat hidrofobik. Sebelum dan selepas keadaan ini, di mana suhu rawatan haba yang rendah dan masa pendedahan pada rawatan haba yang lama, sudut sentuh mula berkurang dan permukaan tersebut tidak lagi berada dalam keadaan hidrofobik.

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In the name of Allah the Most Gracious Most Merciful

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USB = Universal Serial Bus

LIST OF SYMBOL

A = sliding angle

H = Hysteresis

R_A = Surface Roughness

CHAPTER 1

INTRODUCTION

1.1 Background

Superhydrophobic coating is inspired by the unique structure of the Lotus leaf refers to self-cleaning mechanism, where the image of water droplet on the Lotus leaf is as shown in Figure 1.1. This is known as “lotus effect”, which is occurred only due to low energy surface topography with hierarchical morphology. A hierarchical morphology allows the formation of air pockets that reduced the contact area between an applied water droplet and the surface (Satish et al, 2013). A superhydrophobic surface are water repellent with large water static contact angle, (CA) above 150° and low sliding angle lower than 10° (Xiuyong et al, 2014). The superhydrophobic provides the surface with various used in many applications such as self-cleaning, anti-biofouling, anti-icing, drag-reducing, and corrosion resistance (Xiuyong et al, 2014).

Figure 1.1: Droplet of water on Lotus leaf (Bharat, B., and Yong, C. J., 2011)

Whereas, hydrophobic coating is the earlier stage of water repellent coating before achieve a superhydrophobic coating. According to Bharat and Yong (2011) states that hydrophobic is usually used to define the contact of a solid surface with any liquid. The surface will have low energy and build of non-polar molecules. The properties of the hydrophobic coating can be improved to become a superhydrophobic are by increasing the surface roughness and lower the surface energy. According to Kubiak and Mathia (2014), the contact angle of hydrophobic coating is greater than 90° and lowers than 150°. This coating has very good wettability properties.

Various strategies have been develops for coating technologies to aluminum material to prevents it's from harmful effects of water and moisture in the environment. Hydrophobic coating exhibit high water repellency compared to other coatings. The water molecule will roll with a slight applied force from the coating surface. Existing coating that applied on the aluminum material is polymer based paint like spray paint, where in certain duration of times, the painting unable to protect the material any longer when it's exposed to water and harsh environment. Aluminum is widely used in many industrial fields as a basic material because of its good properties in excellent thermal and electrical conductivity but poor in corrosion resistance even it was coated using polymer based paint to improve their mechanical properties. Therefore, aluminum with hydrophobic coating can improved corrosion performance for aluminum material.

The properties of hydrophobic and superhydrophobic coating such as contact angle, surface morphology and the surface roughness can be analyzed on the substrates temperature of the thin film hydrophobic coating. High temperature resistance is one of the main criteria for hydrophobic coating to protect the coating from undergoes oxidation and

resistance to the corrosive. Therefore, effect of temperature on the coating is important to be analyzing because temperature can give impact on the microstructure of the coating, crystalline quality of the coating and the grain size of the coating.

In this work, the samples will be tested over the different temperature and different time of the sample exposure to the heat treatment in order to investigate the effect of temperature of hydrophobic coating on the metal substrate. The contact angle of water will be measure using digital microscope. The surface roughness and the surface morphology of the surface sample are measured and analyzed using Alicona Infinite Focus G^4. All the result obtained will be evaluates to perform the correlation of this microstructure properties with hydrophobicity of the material.

1.2 Problem Statement

Superhydrophobic and hydrophobic coating has the application of water proofing, self-cleaning, anti-corrosion, and anti-icing. These hydrophobicity concepts have been applied in textiles, paints, electric devices, automotive industry and car glass. Vehicle frame and body in automotive industry usually made from metals like aluminum. The vehicle frame was coated with polymer based paint like spray paint to avoid corrosion and oxides when it contact with water and direct sun. However after certain times, the painting cannot protects the vehicles frame and body anymore when it's exposed to water and harsh environment. Therefore, the best solution to solve this problem by doing a heat treatment on polymer surface to improve its mechanical properties and its hydrophobicity to obtain self-cleaning and anti-corrosion behaviors coating to be applied on the vehicles frame.

1.3 Objective

The objectives of this project are as follows:

1. To study the effect of temperature for polymer surface on hydrophobic properties at different temperature and time.
2. To analyze the effect of temperature on surface morphology and surface roughness.
3. To perform correlation of the microstructure properties with hydrophobicity of polymer surface.

1.4 Scope of Project

Only use same sand paper grit which is 2000 grit. Besides, the study only focuses on effect of temperature on polymer surface on aluminum as a substrate.

1.5 General Methodology

The work procedures that need to be done to achieve the objective in this project are listed below.

1. Problem statement

   The problem will be analyze and investigate to find the best solution in this project.

2. Literature review

   Journals, articles, or any materials and equipment regarding the project will be reviewed.

3. Identification

   Substrate with polymer coatings will be identified to be tested in the different temperature and time.

4. Sample preparation

   Each sample for each experiment will be prepared in specific measurement. Total sample for each experiment are 20 samples for heat treatment with varies temperature and 18 total samples for heat treatment with varies time. Total overall samples are 56 samples.

5. Testing the sample

   Sample will be tested with different temperature and different duration time for heat treatment for each experiment.

6. Analysis and result

   Analysis will be presented on how the temperatures affect the polymer surface on hydrophobicity properties on aluminum substrate according to their contact angle, surface roughness, surface morphology and the correlation of these microstructural properties with hydrophobicity of the polymer surface.

7. Suggestion and recommendation

   Suggestion will be proposed based on the analysis.

8. Report writing

   A report on this study will be written at the end of the project.

The methodology of this study is summarized in the flow chart as shown in Figure 1.2 below.

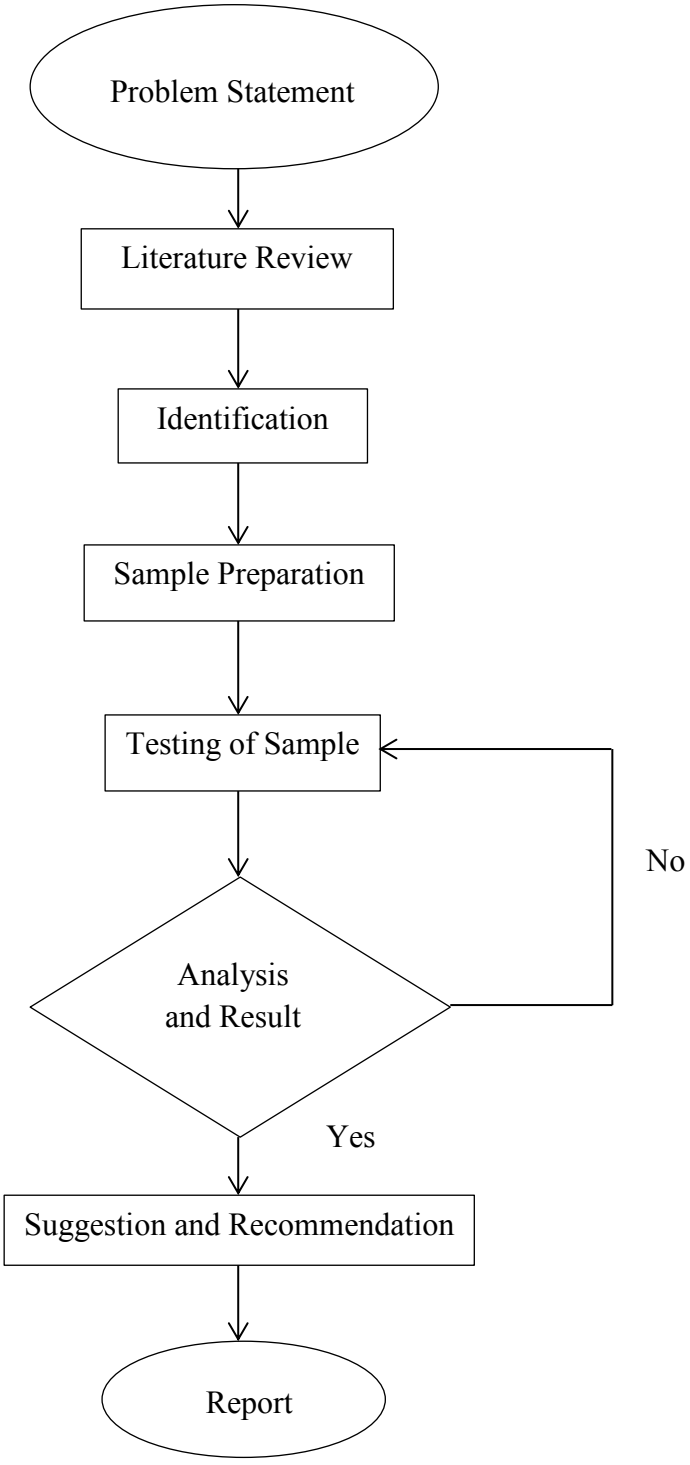

Figure 1.2: Flow Chart of the methodology

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter presents the review cases study of effect of temperature of hydrophobic coating on aluminum substrate. It includes the hydrophobicity properties which is superhydrophobic and hydrophobic. This review also provides the properties that are used to analyze effect of temperature, which are contact angle, surface roughness, surface morphology and correlation of these microstructural properties with hydrophobicity of the polymer surface. The review is collected from the recent and past journals and references books that have been studied to understand the related topic area of this project. In addition, the review also regarding the function of structural characterization utilizing for this project which is digital microscope and Alicona Infinite Focus measurement.

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2.2 Hydrophobicity Properties

Hydrophobicity is the physical property of a surface that avoids water. Generally, carbon and hydrogen atoms are the only molecules in the hydrophobic surface. This surface cannot interact favorably with water and repeal water that make a contact with the surface (Ravi, 2016).

2.2.1 Definition of Hydrophobicity

Superhydrophobic coating is a coating that exhibit extremely high water repellency. The degree to which a solid repels a liquid depends on two factors; surface energy and surface morphology. Once the surface energy is lowered, hydrophobicity is enhanced. In superhydrophobic coating, the surface morphology plays an important role in wettability. The main parameter to characterize wetting is the static contact angle, which is the angle that a liquid makes with a solid. There are several factors that can influence the contact angle such as surface energy, surface roughness, and its cleanliness (Bharat and Yong, 2010). Roughening a coating not only enhances its hydrophobicity due to the increase in the solid-liquid interface but also when air is trapped on a rough surface between the surface and the liquid droplet (Adel et al, (2014).

The surface with contact angle between 150° to 180° is called superhydrophobic. Figure 2.1 shows the different contact angle for superhydrophilic, hydrophilic, hydrophobic and superhydrophobic. It exhibit very low water contact angle, smaller than 10°. This causes the water droplet rolling and bouncing from the surfaces. It also will remove contaminants on the surface due to self-cleaning properties of superhydrphobic coating. Water drop are able to capture the dust and dirt particle, while moving on the surface, and can easily remove particle contaminants from the solid surface (Bernagozzi et al, 2013).

Many method have been develops to formulate a superhydrophobic coating such as electrospinning technique, layer-by-layer, electrochemical deposition, spray coating, and sol-gel method. These methods is in conduct by follows two strategies; constructing