UNIVERSITI TEKNIKAL MALAYSIA MELAKA

THE STUDY OF SUPER HYDROPHOBIC COATING BASED ON COCONUT OIL FOR PIPING SURFACES IN POWER PLANT

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A research submitted in compliance with the qualifying standard for the Bachelor of Manufacturing Engineering Technology (Process and Technology) with Honours

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DEDICATION

Specially dedicated to my beloved parents, my brothers

to all family members, lecturers and friends.

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ABSTRACT

A super hydrophobic coating for piping surfaces in a power plant was developed based on coconut oil extraction because in the power industry the need for super hydrophobic coating was increased rapidly, due to cost-effectiveness and environmentally friendly. The super hydrophobicity of the coating is self-cleaning, preventing blockage and extending the pipe life span. The coconut oil is extracted from coconut water by boiling process. A huge volume of environmental friendly resins can be formed from coconut oil. The usage of different percentage of coconut oil as the environmental friendly synthesized with solvent and hardener to form super hydrophobic coating. The result of adhesion test (ASTM D3359-02) will be taken to identify which percentages of environmental friendly resin mixture have the strongest adhesion force. For scratch resistance Test (ASTM D3363) we can analyze which coating that have the highest scratch resistance. Next, water droplet test (ASTM D2247-15) will be been conducted to measure the contact surface angle on each different percentage of environmental friendly resin mixture specimens. It will revealed which sample produce a high super hydrophobic effect. Lastly, Scanning electron microscope (SEM) will be used in order to capture the images and surface roughness of each sample.

ABSTRAK

Salutan super hidrofobik ke atas permukaan paip di loji janakuasa dibangunkan berasaskan pengekstrakan minyak kelapa atas kerana permintaan yang tinggi dari industri tenaga, berikutan kos yang murah dan mesra alam. Salutan super hidrofobik juga memiliki ciri pembersihan diri, mencegah penyumbatan dan memperluaskan jangka hayat paip. Minyak kelapa diekstrak dari air kelapa dengan proses pendidihan. Jumlah besar resin mesra alam boleh dicupta daripada minyak kelapa. Penggunaan peratusan minyak kelapa yang berbeza sebagai resin mesra alam disintesis dengan pelarut dan pengeras bagi membentuk lapisan super hidrofobik. Hasil uji lekatan (ASTM D3359-02) akan diambil untuk mengenal pasti peratusan campuran resin mesra alam sekitar yang manakah mempunyai kekuatan lekatan terkuat. Untuk ujian rintangan awal (ASTM D3363) kita boleh menganalisis lapisan yang mempunyai rintangan tahan calar tertinggi. Seterusnya, ujian titisan air (ASTM D2247-15) akan dijalankan untuk mengukur sudut permukaan sentuhan pada setiap peratusan campuran resin mesra alam yang berbeza. Ia akan mendedahkan sampel yang menghasilkan kesan super hidrofobik yang tinggi. Akhir sekali, Pengimbasan mikroskop elektron (SEM) akan digunakan untuk menangkap imej dan permukaan setiap sampel.

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LIST OF SYMBOLS AND ABBREVIATIONS

IUPAC	-	International Union of Pure and Applied Chemistry
-CH3	-	A Methyl group
C6H6	-	Benzene
Si-OH	-	Silanol
Si-OCH3	-	Tetramethyl orthosilicate
POME	-	Palm oil effluent
LHR	-	Low heat rejection engines
LO	-	Linseed oil
SO	-	Soybean oil
CCO	-	Coconut oil
AGO	-	Argemone
PEA	-	Polyesteramide
ZnO	-	Zinc oxide
AOM	-	Active oxygen method
VCO	-	Virgin coconut oil
WCA	-	Water contact angle
CVD	-	Chemical vapor deposition
LRT	-	Lightweight roof tile
TOP	-	Waste cooking oil bio-polymer composite
TES	-	Tetracthoxysilane
SEM	-	Scanning electrom microscope
OM	-	Optical microscope

CHAPTER 1

INTRODUCTION

1.1 Introduction

A coating is a protecting layer applied to an object's surface, commonly called the substrate. Decorative, functional, or both may be the objective of implement the coating. The coating also can be a complete coating that fully covers the substrate, or it can also cover sections of the substrate. A product tag on many drink cans is an instance of all these kinds of coatings, one side has a functional general layer and the other side has one or more ornamental coatings in an appropriate design to shape sentences and pictures (Felton et al, 2013).

Paints and lacquers are coatings that have most duplex usage that are to protect the substrate also to be decoration, although some painter only for decoration, and painting on most industrial pipeline is presumably only for the purpose of to protect from corrosion (Stuart C, 2013). Functional coatings may be used to change the substrate's surface properties, such as adhesion, wettability, resistance to corrosion, or wear resistance. In other cases, such as the manufacture of semiconductor devices, the coating adds a completely new function. The function such as magnetic response or for more electric conductive and constitutes an essential part of the final product (Robin R, 2016).

1.2 Problem Statement

The usage of coconut oil as environmentally friendly resin is more eco-friendly compared with synthetic resin that based on a chemical. Epoxy products are potent skin sensitizers. Often, skin contact with individual components or mixed product ready for use leads to allergic contact dermatitis. Contact dermatitis is usually expressed in the hands or forearms and sometimes in the face (T.Spee, 2006). Besides that, it has a side-effect such as cancer and brain cell damage in a long-term exposure via inhalation (M.K.Viaene, 2002). The greater the risk, the longer the exposure. Someone can work with a chemical for half an hour a day, for example, while another person is exposed for eight hours a day.

Someone may be exposed for one month, while another person may be exposed for 20 years. Other than that, the superhydrophobic effect in the coating also provided self-cleaning characteristic to the coating. The quantity for cleaning compulsory can be deduct by self-cleaning or easy to clean surfaces. In particular, it can reduce labor costs and extend the durability of a material in the case of industrial cleaning. The primary environmentally benefits are expected to be lower energy costs and less use of cleaning detergents (M.A.Aegerter, 2008). The cost of coconut oil also cheaper compared with synthetic resin that based on chemical that not only dangerous and a silent-killer, it also more costly compared with the environmentally friendly resin

1.3 Objectives

The main objectives of this study are:

a) To synthesis the formulation of superhydrophobic coating based on coconut oil.
b) To evaluate the physical and mechanical test of superhydrophobic coating based on coconut oil.

1.4 Significant of Study

The significant in this study are:

a) The superhydrophobic coating is based on coconut oil for power plant piping surfaces and the self-cleaning characteristics applied to the piping system by the superhydrophobic coating.

b) The superhydrophobic coating based on coconut oil is eco-friendly and reduced the hazardous chemical usage on piping system coating that effect the environment then increased the safety of worker and workplace.

1.5 Scope of Study

The study scope focuses on the different percentage of coconut oil being formulated and synthesized. It covers the mechanical and physical test.

a) Mechanical Test :

- Adhesion test (ASTM D3359-02)

b) Physical Test:

- Water droplet test (ASTM D5964-04)
- Scratch test (ASTM D3363)
- Scanning Electron Microscope (ASTM E2809 – 13)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Coating is the slim layers of a covering chemical, placed or implemented to any object's surface, generally to enhance its properties that are critical and to design a protective shield against surface deterioration due to its backlash with its environment. The surface that is applied to the coating is called a substrate. The coating serves to protect the substrate from degradation due to environmentally electrochemical reactions (Fristad, W. E. ,2000).

Self-cleaning and self-healing may have been coatings. In most situations, experimental methods are used to analyse the reliability of these coatings. Major variables like resilience of coatings under various conditions of exposure, resistance to abrasion, resistance to friction, extreme temperatures and electrical resistance. The aggregate reliability of the system depends on the performance of the coating film and the interface between the film and the parent material (Balaguru, P., and Chang, P., 2003).

Carbon steel is the most extensively used material in power plants, oil refineries and petrochemical plants, and several other types of industrial and manufacturing facilities for piping networks and materials. After all, carbon steel accounts for almost 85 percent of

all annual worldwide steel production. Due to its ready availability and relatively low cost, it is used so universally. However, corrosive chemicals and other environmentally factors can lead to severe destruction and degradation of carbon in certain applications (McKetta, 1992). Coatings have many uses in power plant piping system. They are used for corrosion control, chemical resistance, heat resistance, temperature control, identification decoration, camouflage, fire retardation, noise control, anti-fouling protection and many other reasons (Lloyd, M. S., 1996).

2.2 The Types of Surface Coating

2.2.1 Epoxy Coating

Epoxy coating was less economical than heat-curated powder coatings for heavy duty operation on steel substrates. These processes offer good and outstanding durability for a solid protective coating. Several epoxy coatings are established as an emulsion in water and can be washed without solvents. They have been used in manufacturing and automotive processes because they are more heat-resistant than latex and alkyd-based paints. Due to UV exposure, recognized as "chalking out," epoxy coating start to degrade (Bayliss, D.A.; Deacon, D.H. 2002)

There are two forms of epoxy resin that are natural resin and synthetic resin. Organic or plant resins are valued for the creation of varnishes and bonding agent. They are also strongly rated for the synthesis of other organic compounds as raw ingredients and provide aroma and fragrance elements (Coppen and Hone, 1995). Synthetic resin is a substance resemblance to natural crop resins with an exciting properties. It is a sticky liquid that can permanently dry. Otherwise, they are chemically very different from the different plant-secreted resin compounds. (Cripps, David, 2014).

2.2.2 Alkyd Coating

Alkyd resin paints are alkyd resin normal temperature of room drying paints based on polybasic acid substrates such as phthalic anhydride and polyhydrous ethanol altered with various oils or fatty acids as the main coating element. It can be modified with several type of resin such as silicone resins, epoxy resins, styrene monomer to enhance paint suitability. These are labelled as Modified Alkyd Resin Paints and Oil Modified Alkyd Resin Paints (Frank N. Jones ,2005).

The features of this aspect of paints are tough coatings, good weather resistance and therefore good colour, colour retention, good density, good water resistance, solvent resistance and cost efficient (Frank N. Jones , 2005)

2.2.3 Polyester Coating

Unsaturated polyester resin is a prepolymer based on unsaturated acids such as maleic anhydride and divalent alcohol such as ethylene glycol, propylene glycol. This dissolved in a slight excess of the double bond equivalent in reactive monomers such as styrene monomer is polyester resin paint. For example, by placing cobalt naphthenate peroxide as a catalyst to ethylene glycol polyester and maleic anhydride, reactive monomer bridge bonded in the double bond of maleic acid forms insoluble paint coating.

This is a two-component paint where a catalyst is mixed immediately before painting. In this situation, the monomer of styrene acts as a solvent that gives the paint fluidity and as a bridge bonding agent becomes the element of paint coating. This paint is therefore a non-solvent paint. The polyester paint can derive thick coating with just one application and there is no volatilization of the solvent, has hard coating with good chemical resistance and wear resistance, poor adhesion with large volumetric deformation when hard, paint coating is weak in elastic deformity and easily scratched, significantly

loses luster result of exposure (Francesca Cappitelli & Claudia Sorlini 2008). Synthetic resins are chemical product of interest similar to natural resins extracted from plant. They are slimy liquids that capable to completely harden. They are chemically very different from the different plant-secreted resin compounds.

2.3 Components of Surfaces Coating

A coating can contain as few as three or four ingredients or as many as 20 or 30 ingredients, depending on the formulation. The three main components of a coating are the resin, pigment and solvent as shown in Figure 2.4 (Jeans, S. W., 1996). Resin and solvent comprise the liquid portion of a coating and referred to as the film solids, since they are the materials left after the coating has dried (Martens, C. R., 1968)

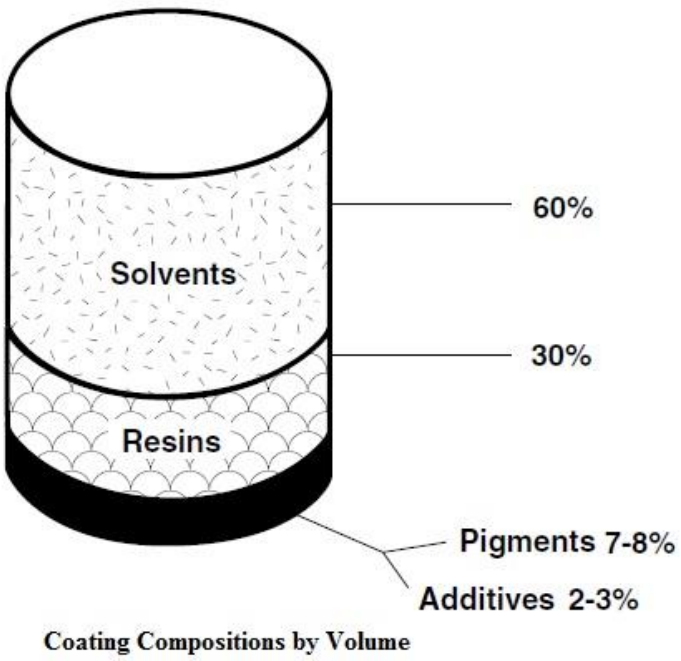

Figure 2.1: Coating composition by volume. (Jeans, S. W., 1996)

2.3.1 Solvent

In its application, solvents are applied to the paint. The solvent's main function is to facilitate the application of the coating. Frequently, a solvent is chosen based on its potential to dissolve binder components which is resins and its evaporation rate. Solvents dissolve or disperse the resin, provide flow-out and levelling during application, and control adhesion and durability of the dry film (Lambourne, R., 1987). One of the examples of solvents is toluene. Toluene is a pure white, moveable fluid with a well-known aromatic smell that is mildly milder than benzene. The name toluene originated from an organic resin and was noticed in the decomposition goods by heating this resin (Dickson, E., 2006).

Toluene is heavily used in organic compound production and as a solvent as raw resources. The use of toluene as a solvent has decreased in surface coatings, predominantly due to numerous of environmentally and health regulations. It is exchanged by other solvents such as esters and ketones, and the product formulation is changed to use whether thoroughly solid or water-based emulsion systems. It is easily transmitted through the body from the gastrointestinal and cardiovascular systems. Toluene is spread across the whole body with high lipid substance in tissues. It is metabolized in the liver, predominantly in hippuric acid and benzoyl glucuronide, which are quickly digested in the urine (Sean, E., and Masahiro, I., 2010).

a) Turpentine

Turpentine also referred as turpentine spirit, turpentine oil, wood turpentine and colloquial turpentine (*Mayer, Ralph, 1991*) , is a liquid harvested from live plants chiefly pines, resin distillation. It is particularly used as a solvent and as a source of substances for organic synthesis goods. Turpentine forms of terpenes with smaller volumes of carene,

camphene, dipentene and terpinolene, primarily alpha-pinene and beta-pinene monoterpenes. (Mayer, Raplh, 1991). The word turpentine (via French and Latin) originates from the Greek word terebinthine, the name of a tree species, the terebinth tree (Barnhart, R.K. 1995). Mineral turpentine or other petroleum distillate is used to swap turpentine (Dieter Stoye, 2002).

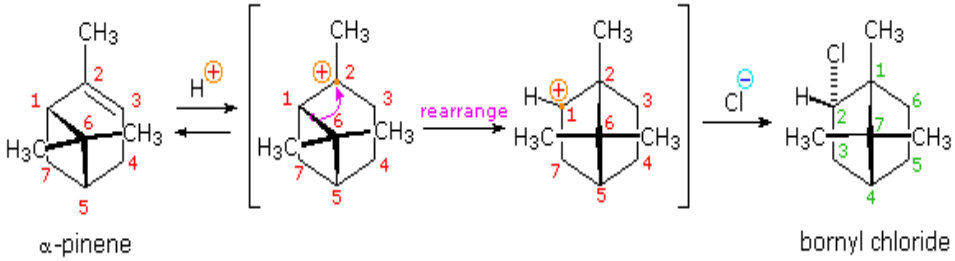

Figure 2.2: Turpentine Chemical Reactions (William Reusch, 2013)

b) Toluene

Toluene is a colourless, waterproof liquid with the paint thinner-related odour. It is a mono-substituted derivative of benzene, made up of a group of -CH3 attached to a phenyl group. As such, methylbenzene is its structural name of the International Union of Pure and Applied Chemistry. It's a hydrocarbon. Toluene is extensively used as a feedstock and solvent in industry (Hogan, C. Michael,2011). Worldwide toluene sales amounted to approximately US$ 24.5 billion in 2013. Toluene is often to create a medical purposes inhalation as a solvent in a common glue (McKeown, Nathanael J, 2015) and has the potential to lead severe neurological damage (Streicher, H. Z, 1981).

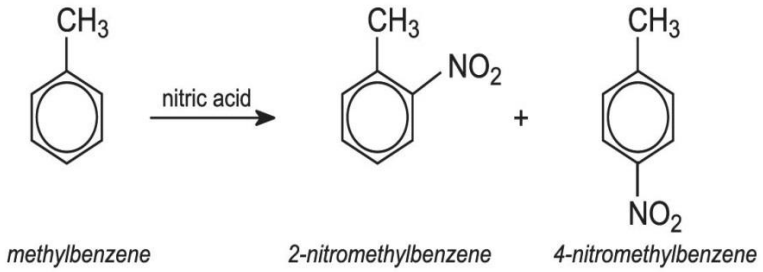

Figure 2.3: Toluene Chemical Reaction (Essential Chemical Industry,2016)

c) Benzene

With the chemical formula C6H6, benzene is an important organic chemical compound. The molecule of benzene consists of sextuple of carbon atoms attached in a ring with single atom of hydrogen attached to each. Because benzene contains only atoms of carbon and hydrogen, it is categorised as hydrocarbon (Arnold, D, 1958). Benzene is one of the petrochemical components and an organic component of crude oil. Due to the cyclic constant pi linkage between the carbon particles, benzene is categorized as a scented hydrocarbon. It is sometimes abbreviated Ph–H. Benzene is a liquid with a sweet smell which is colorless and extremely flammable. It is primarily used A catalyst for the manufacturing of chemicals that generate billions of kilos of a complicated framework, like ethylbenzene and cumene. It is a precious petrol element since benzene has a significant amount of octans (Breslow R, 1990).