PARTIAL DISCHARGE CHARACTERISTICS OF PALM-BASED OIL AND MINERAL OIL AS DIELECTRIC MATERIAL

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By the name of Allah S.W.T, the One who created us and all praises only to Him. For beloved my family who always give me strength and encouragement during hard time and also my supervisor that always give a brilliance ideas. May Allah bless us.

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ABSTRACT

The purpose of this study experimentally is to investigate the partial discharge characteristics of Palm-based oil and mineral oil as dielectric material and to make a comparison between it. Mineral oil as an important insulating material in power system has been used more than 150 years. The world's energy requirement has been dominated by petroleum oil for centuries in many application fields, including transportation, household, and electricity. Also, mineral oil application in power system equipment can be potentially hazardous to the environment especially when there are any incidents during operational time like transformer explosion, which may cause a spill of oil to the soil or water stream. Due to the concerns about the reducing petroleum resources and the environmental issues, the alternative insulating oil with biodegradable characteristics has been attracted lots of attentions for a couple of decades. In this thesis, the dielectric properties of a type of mineral oil and a type of palm oil were investigated. Palm Fatty Acid Ester (PFAE) have been known because of its potential as alternative oils that would replace mineral oil such as Hyrax. The purpose of this project is to identify the effect of electrical stress and ageing time on electrical properties of PFAE, FR3 and Hyrax. The experimental processes have been conducted to determine the effect of partial discharge activities due to electrical stress and the ageing time.

ABSTRAK

Tujuan kajian ini adalah untuk mengkaji secara eksperimen ciri-ciri pelepasan separa berasaskan minyak sawit dan minyak mineral sebagai bahan dielektrik dan untuk membuat perbandingan di antara minyak tersebut. Minyak mineral sebagai bahan penebat yang penting dalam sistem kuasa telah digunakan lebih daripada 150 tahun. Keperluan tenaga dunia telah dikuasai oleh minyak petroleum selama berabad-abad dalam bidang aplikasi, termasuk pengangkutan, rumah, dan elektrik. Selain itu, permohonan minyak mineral dalam peralatan sistem kuasa boleh berpotensi berbahaya kepada alam sekitar terutamanya apabila terdapat apa-apa kejadian semasa operasi seperti pengubah meletup, yang boleh menyebabkan tumpahan minyak ke tanah atau aliran air. Disebabkan oleh kebimbangan mengenai sumber-sumber petroleum yang makin berkurang dan isu-isu alam sekitar , alternatif penebat minyak dengan ciri-ciri mesra alam telah menarik perhatian banyak pihak untuk beberapa dekad ini. Dalam tesis ini , sifat-sifat dielektrik sejenis minyak mineral dan sejenis minyak sawit telah dikaji. Lemak Sawit Asid Ester (PFAE) telah dikenali kerana potensinya sebagai minyak alternatif yang akan menggantikan minyak mineral seperti Hyrax. Proses eksperimen telah dijalankan untuk menentukan kesan aktiviti pelepasan separa akibat tekanan elektrik dan masa penuaan.

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LIST OF ABBREVIATION

PFAE	-	Palm Fatty Acid Ester
RBDPO	-	Refined, Bleached and Deodorized Palm Oil
FR3	-	Environtemp Fire Resistant Natural Ester
BDV	-	Breakdown Voltage
PD	-	Partial Discharge
AC	-	Alternating Current

CHAPTER 1

INTRODUCTION

1.1 Background

The role of electrical insulation is critical for the proper operation of electrical equipment. Power equipment cannot operate without energy losses, which lead to rises in temperature. It is therefore essential to dissipate the heat generated by the energy losses, especially under high load conditions. Failing to do so results in premature aging, and ultimately to failure of the equipment. Several billion liters of insulating liquids are used worldwide in power equipment such as transformers (power, rectifier, distribution, traction, furnace, potential, current), circuit breakers [1][2], etc.

Insulation is materials that are used on electricity supply networks to support, separate conductors at high voltage. Insulation is one of the most important parts in high voltage apparatus. Electrical insulating liquids are used abundantly in variety components of power system networks such as transformer, circuit breaker and switches [3]. The insulation intended to separate electrical conductor without passing current through them.

Insulation liquid can act as acoustic dampening media in power equipment such as transformers. More importantly, they provide a convenient means of routine evaluation of the condition of electrical equipment over its service life. Liquids play a vital role in maintaining the equipment in good condition (like blood in the human body). They are responsible for the functional serviceability of the dielectric (insulation) system, the condition of which can be a decisive factor in determining the life span of the equipment [4].

Petroleum-based oil, so-called mineral oil, has been the main insulating liquid in industrial power systems since the 1900s because of its good aging behavior, low

viscosity, ready availability, and low cost [5]. Despite having its own advantages, petroleum-based mineral oil are also has an adverse effect in some circumstances. This type of oil is actually giving a bad effect on the environment. Among the creators of the activists, this type of oil will bring environmental damage to the ecosystem in the event of spills and leaks. In addition, this type of oil is non- renewal sources since it is exist only inside the earth.

Driven by the desire for a safer nonflammable and environmentally acceptable insulating liquid for use in power equipment, many researchers have investigated other alternatives oil such as vegetables oil. Unfortunately, vegetable oil is unsuitable for use in electrical equipment such as transformer because of unsuitability of susceptibility to oxidation [6].

Currently, several liquids insulating material has been introduced which are from natural type and that are biodegradable and friendly to environment such as Soya-bean oil, Coconut oil and Palm oil. Malaysia is one of the biggest palm oil production in world, which is we have indigenous source of palm oil. The oil such as Refined Bleached and Deodorized Palm Oil (RBDPO), Palm Oil Fatty Acid Ester (PFAE), Crude Palm Oil (CPKO) and Crude Palm is the sample of palm oil. These samples of oil are safe and environment friendly renewable resources also are widely used and have substantial resources.

1.2 Problem Statement

It is about 85% of the energy used in the world comes from fossil fuel [7] which is known as the main resource of mineral oil (Figure 1-1). Now, the existence of mineral oil in the world has been reduced as the time goes by and probably it will not occupy our needs for the next generation.

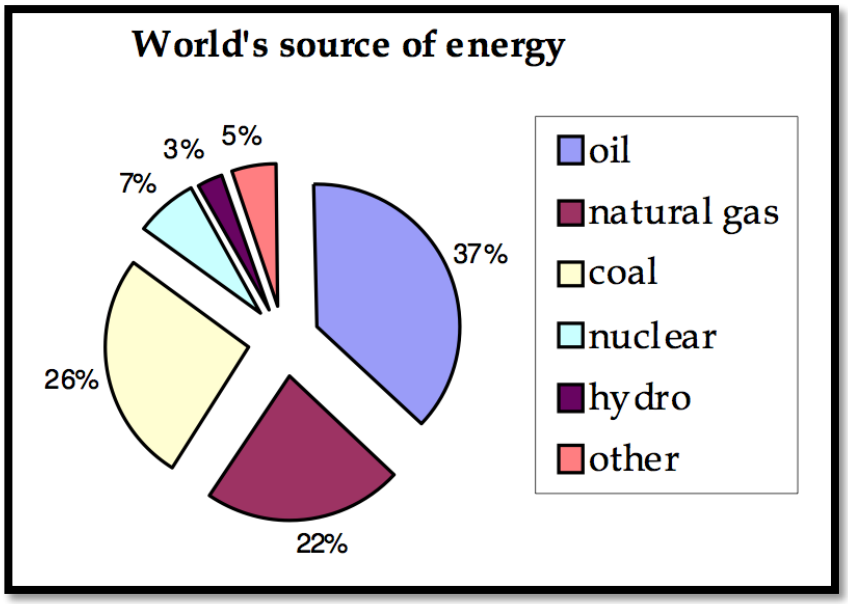

Figure 1-1: World's Source of Energy

Former British petroleum geologist proposed for world oil and gas liquid as in Figure 1-2. The optimum of world oil production happened at around 2007-2008 and the production will be depleted afterward. It is important to find alternative oil sources that have similar dielectric characteristics with the existing one and probably can increase the performance of related equipment.

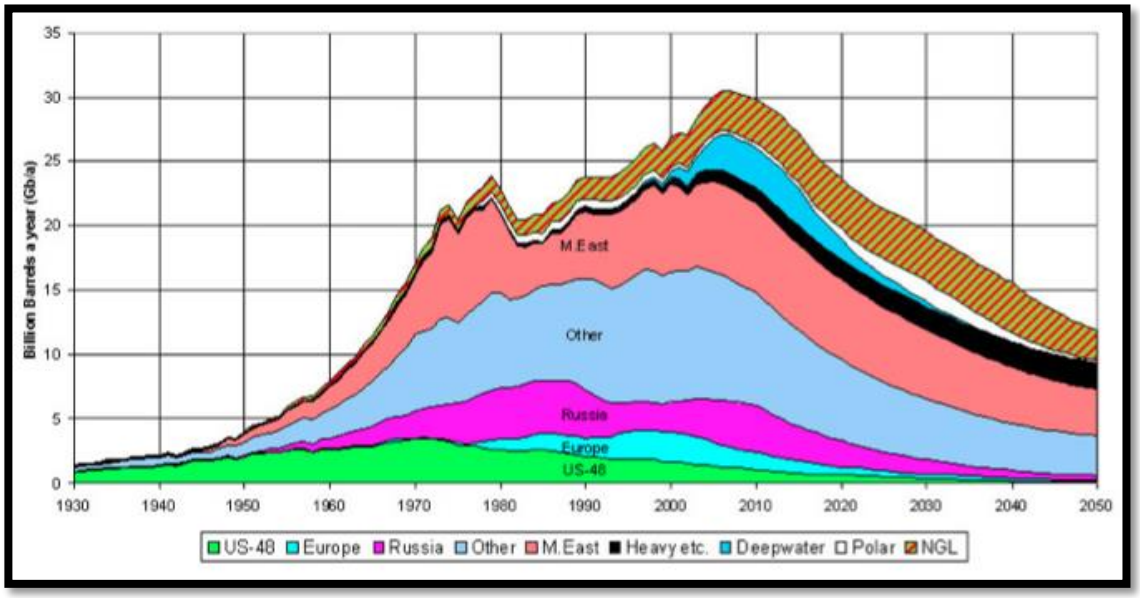

Figure 1-2: Collin Campbell's 2004 scenario for world oil and gas liquid

Petroleum-based mineral oil has been used as a liquid material in power transformer and other high voltage devices because of its excellent dielectric properties. Due to environment consideration, mineral oil application in high voltage system can bring hazardous towards environment especially when there is incidents occurs such as explosion of transformers which may cause a spill of oil to the soil [8].

That will be disturbing the plantation and bad impact to economical situation, and it is also non-renewable source. Recently, many researchers contribute of finding the other oil to replace mineral oil but its need to biodegradable to environment and have better or similar dielectric characteristics with the existing one that probably can increase the performance of related high voltage equipment.

1.3 Objective

In this thesis, a comparative study will be conducted between mineral oil and palm-based oil to investigate partial discharge characteristic of palm-based oil due to voltage stress and ageing time. The objective of this master thesis project to analyze experimentally on electrical properties of mineral oil (Shell Diala B) and palm-based oil, such as thermal ageing process and voltage application. Generally, the measurements in this thesis project follow the international standards (IEC).

1.4 Scope of Project

The scopes of the project:

i. Find and understand regarding literature review
   Cover all study of insulation oil, recent development research, past research work and method.

ii. Find characteristics of palm-based oil as a new electrical insulate liquid
   Characteristic of liquid insulation, partial discharge method such as voltage application.

iii. Prepared the sample of palm-based oil and mineral oil

Sample used in experiment: Mineral oil; Shell Diala B, Palm-based oil Refined Bleached Deodorized Palm Oil (RBDPO), Palm Oil Fatty Acid Ester (PFAE)

iv. Experimental work preparation (Setup, Hardware & Software)
The data is collected experimentally using DDX-9101 Partial Discharge Detector

v. Perform Experimental work
Experiment is tested at UTM IVAT lab for analyzing result.

The scope is included observation parameter and ageing time. Sample used for this project is pure refined bleached and deodorized palm oil (RBDPO), Palm Fatty Acid Ester (PFAE) and Shell Diala B. For observation parameter, this project focused to partial discharge characteristic. Partial discharge characteristics are partial discharge voltage application and partial discharge activities. For the aging time, the time used for the experiments is one hour and will be repeated with additional one hour for each test.

1.5 Thesis Overview

This thesis is divided into five chapters, which include all aspects of investigating the three types of insulating oil. Chapter 1 introduces the important background of palm-based insulating oil as an alternative for electrical devices and also a little about mineral oil currently used. Then, the basic knowledge for several experimental activities in this thesis project will be discussed in Chapter 2. The methodology of three types of oil will be described in Chapter 3; the accelerated aging process, the breakdown voltage measurement, the dielectric losses measurement, and the relative permittivity measurement. In Chapter 4 the measurement results are analyzed. The dielectric properties of the mineral oil and the synthetic ester oil are compared. In Chapter 5 conclusions are presented based on this work.

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