THE EFFECT OF CALCIUM CARBONATE AND CALCINED CLAY MICRO FILLER MATERIALS ON THE ELECTRICAL CHARACTERISTICS OF POLYVINYL CHLORIDE FOR CABLE INSULATION

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ABSTRACT

Polyvinyl Chloride (PVC) is widely used as cable insulation for low voltage application. In order to strengthen the electrical properties of the material, some additives have to be added. In this project, various fillers were compounded with PVC. The main parameters that have been studied were dielectric strength, and the dispersion of PVC molecules. The polymer structure of PVC was altered after undergo high voltage stress and it can be related to the breakdown voltage value. The type of fillers that were used in this experiment is Calcium Carbonate NCC-P 1T, Neolite SP, and Calcined Clay. Firstly the density of each test objects was measured using density meter and the value obtained must within the SIRIM specification. Then the dielectric strength test was done under AC stress to observe the breakdown properties. It is observed from the tests that when the density or Specific Gravity (SG) of test sample increased, the breakdown voltage also increased. But after the highest value, the dielectric strength started to show degradation characteristic event though the density is kept increasing. This phenomenon occurred to all formulation of filler materials. The experimental results also show that PVC compounded with 10 wt% of Calcium Carbonate Neolite SP produces the highest breakdown voltage and excellent dispersion. PVC cost also can be reduced by the addition of filler material. The analysis depicted that PVC combined with 10 wt% of $CaC0_3$ Neolite SP provides the best profile of cost saving.

ABSTRAK

Polyvinyl Chloride (PVC) digunakan secara meluas sebagai penebat bagi kabel elektrik voltan rendah. Untuk meningkatkan keupayaan elektrik bahan tersebut, beberapa bahan tambahan perlu ditambah. Dalam kajian ini, PVC yang digunakan sebagai penebat telah dicampur dengan beberapa agen tambahan. Beberapa ujikaji seperti ukuran ketumpatan, ketahanan elektrik, dan ujikaji molekul PVC telah dilakukan bagi melihat kesan pencampuran. Di antara agen-agen tambahan yang digunakan bersama PVC ialah seperti batu kapur (Kalsium Karbonat) dan tanah liat. Spesimen-spesimen dikelaskan melalui nilai kandungan agen tambahan. Struktur polimer PVC berubah selepas dikenakan voltan tinggi dan perbezaan ini mempunyai kaitan dengan kejatuhan nilai voltan . Ujikaji ketumpatan dilaksanakan terlebih dahulu bagi memastikan campuran PVC dan agen tambahan sentiasa berada dalam piawaian SIRIM. Spesimen yang dihasilkan daripada pelbagai formula telah diuji ketahanan elektrik menggunakan arus ulang-alik (AC). Kemudian, struktur polimer sampel-sampel tersebut dianalisa melalui mikroskop elektron. Daripada kajian ini juga, didapati apabila ketumpatan sesuatu sampel bertambah, ketahanan elektrik juga meningkat. Akan tetapi pada sesuatu tahap tertentu, apabila ketumpatan bahan di naikkan, ketahanan elektrik akan turun. Fenomena ini berlaku kepada semua formulasi bahan tambahan. Melalui ujikaji ini, pencampuran PVC dengan 10 wt% Kalsium Kabonat Neolite SP mempunyai ketahanan elektrik yang tertinggi dan kebolehan untuk menyerap yang terbaik ke dalam polimer PVC berbanding dengan formulasi bahan-bahan tambahan yang lain. Kos untuk menghasilkan penebat kabel juga dapat dikurangkan dengan kaedah pencampuran ini. Campuran PVC dengan 10 wt% $CaC0_3$ Neolite SP telah memberikan profile terbaik bagi penjimatan kos.

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Minerals used as fillers in plastic compounds have traditionally been used to reduce material costs by replacing a portion of the polymer with a less expensive material. However, nowadays many functional fillers or mineral modifiers are required to modify processing characteristics or finished part properties.

Fillers penetrate and infiltrate materials. But, there are hardly any cases in which the surrounding material penetrates the filler's outside boundary. Their impregnating and quenching activity can be translated into their ability to react or interact with the surrounding material **[1]**. Thus, the word filler adequately describes the filler's potential to perform in multi component systems.

Few types of additives used in Polyvinyl Chloride (PVC) formulations are mainly plasticizers, stabilizers, lubricants and fillers. Fillers have vital roles in modifying the properties of various polymers and reducing the cost of their composites.

The effect of fillers on properties of composites depends on their level of degree of dispersion, aggregate size, surface characteristics, loading, and shape, particle size **[2]**. Low electrical strength could lead to failure of cable due to over voltage.

According to the thermoplastic industry, 70% of the total production is accounted for by the large volume and low cost commodity resins such as PVC **[1]**. Hence, PVC is the most commonly used insulating materials for low and medium voltage, which is around 3.3 kV. Due to high loss and dielectric constant characteristics, Polyvinyl Chloride is inapplicable for high voltage appliance. Consequently, the breakdown voltage strength and the dispersion of PVC polymer become one of the focal point of studies.

1.2 Problem statement

The insulator in electric cable provides isolation between conducting area and the outer surface. Other than that, it provides protection to equipment and human. The ideal case of insulator is, it will not breakdown or “ruptured” in the sense where the property’s is inversed. But in practice, this condition never sustained because every material have its own breakdown voltage limit.

Referring to previous statement; since PVC is widely used as an insulator in electrical cable, this project will focus on the effect of fillers when compounded with PVC and the testing related to dielectric strength. Furthermore, imperative study on the cost reduction also will be done since when filler’s is used, the amount of PVC material also decreased.

1.3 Objective of Study

The objectives of this project are:

1. To examine breakdown Dielectric strength test of pure PVC, and PVC compounded with various type of fillers when alternating current is been applied. Then verify whether the results shown better performance from previous test.

2. The test sample will be further analyzed by using Scanning Electron Microscope (S.E.M) for its density and dispersion.

3. Analysis and detail discussion about the electrical characteristics of PVC when mixed with filler materials.

1.4 Scopes of Study

There are six scopes in this study.

1. Test samples preparation. PVC is amalgam with various types of fillers such as Calcium Carbonate 1T (normal grade), Neolite SP Calcium Carbonate (micro-filler) and Calcined Clay (micro-filler).

2. Measure the specific gravity (SG) or density using Metller Toledo density meter. All the results have to be within the Malaysia Standard for electric cable specification (1.45(+/-) 0.5 SG)

3. Analyzed the characteristic of test specimens which are blended with different level of filler concentration (5wt%, 10wt%, 15wt%, 20wt%, and 25wt%) under AC voltage stress.

4. To examine the filler's dispersion on the PVC specimens using SEM

5. Comparison of breakdown voltage (AC Dielectric Test) results with previous test by Lim **[2].**

6. Cost comparison of PVC and PVC compound with filler for cable manufacturers.

1.5 Methodology

Generally this research work consists of laboratory experimental testing on the density measurement, dielectric strength, and filler's dispersion. There are several research methodologies for this laboratory work in order to obtain the result:-

1. Literature reviews to understand and identify the properties and functions of Calcium Carbonate and Calcined Clay as a filler material for PVC.

2. Understand the principle operation and function of electrical characteristics which will be tested.

3. Samples preparation

4. Measure the specific gravity using Mettler Toledo Density meter. The density value obtained must comply with SIRIM specification.

5. Examined the dielectric strength by applying AC and DC stress to test samples.

6. Analyzed the dispersion of fillers in PVC polymer using SEM

7. Detail discussion and conclusion for every experiment results.

The methodology is shown in figure 1.1.

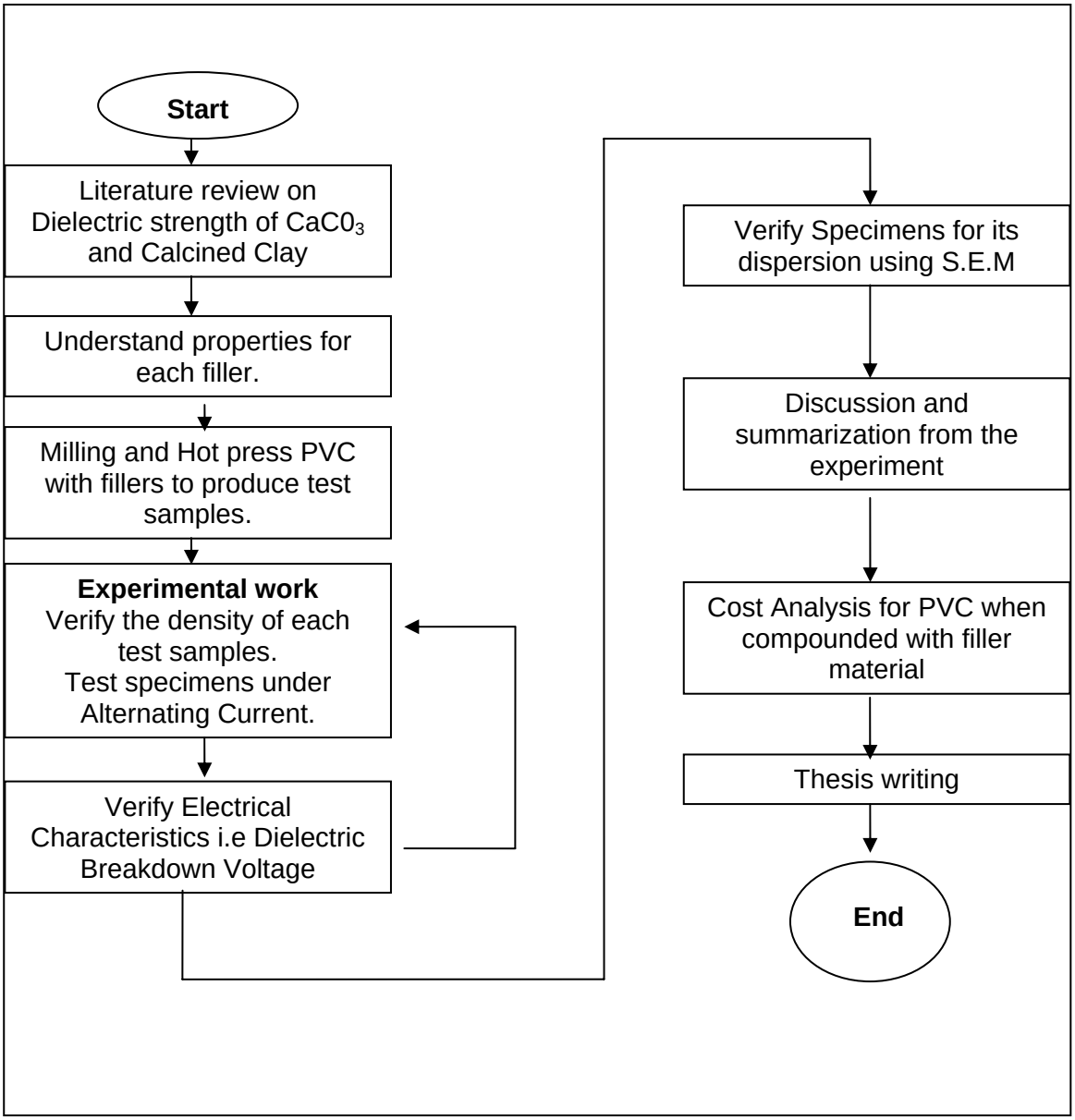

Figure 1.1 Flow chart of the research

1.6 Thesis Structure

There are 6 chapters for this report. The details for each report are listed as below.

Chapter 1: Introduction

Chapter 2: PVC and Filler Material Applications

Chapter 3: Experimental Procedures

Chapter 4: Results and Analysis

Chapter 5: Discussions

Chapter 6: Conclusion and Recommendation

Chapter 1 provides overall outline of the project which are consists of objectives, scopes of study, and methodology.

Chapter 2 describes the theory for every testing involved and explanation on filler materials.

Chapter 3 described the process of samples preparation and the experiment procedures

Chapter 4 summarized the results from experiments such as density measurement, dielectric strength, and the dispersion of molecules in PVC sample.

Chapter 5 contains detail observation and description from every test result. Also included, the case study of the cost for PVC cable and PVC compounded with filler materials.

Chapter 6 concludes the project according to the results achieved and suggested recommendations for future works.

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