BREAKDOWN PROPERTIES OF THERMOPLASTIC POLYPROPYLENE AND LINEAR LOW DENSITY POLYETHYLENE BLENDS

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A project report submitted in partial fulfilment of the
requirements for the award of the degree of
Master of Engineering (Electrical Power)

School of Electrical Engineering
Faculty of Engineering
Universiti Teknologi Malaysia

JANUARY 2020

DEDICATION

To my beloved parents, lecturers, and friends who have guided and inspired me through this education journey. Heartfelt gratitude to their constant support, belief, encouragement, and motivation.

ACKNOWLEDGEMENT

First of all, I would like to express my deepest gratitude and appreciation towards my supervisor, Ir. Dr. Lau Kwan Yiew who willing to spend his precious time in guiding me and sharing his knowledge. Thanks for his support and encouragement when I felt lost in conducting this project.I am also grateful for the help of assistant engineer of Institute of High Voltage and High Current (IVAT), Mr Mohamad Syahrin Mohamad who always give technical support. I would like to appreciate for the help offered by my friends, Miss Nor Hashimah Binti Ismail and all my friends who had given me so many insightful advice and constructive suggestions. I would like to extend all my sincere thanks to all of them. Finally, a big thank you to my parents who had given me their constant support. This would not be complete without their motivation and encouragement.

ABSTRACT

Polymers have always been used as insulators in high voltage industry. Polyethylene and polypropylene are widely used due to their suitability of mechanical and electrical properties to be used as insulators. The purpose of this study was to investigate the breakdown properties of polypropylene and linear low density polyethylene blends. In this project, five different compositions of thermoplastic polymer blends composed of polypropylene (PP) and linear low density polyethylene (LLDPE) were formulated through melt blending method. The breakdown strength of polymer blends with the composition of 100% PP, 80% PP and 20% LLDPE, 50% PP and 50% LLDPE, 20% PP and 80% LLDPE and 100% LLDPE was investigated and analyzed. The results obtained were analysed using Weibull software. The results indicated that the use of appropriate PP and LLDPE blends had enhance their breakdown performances. These improvements showed the potential of the blends to be used as power cable insulators.

ABSTRAK

Polimer sering digunakan sebagai penebat dalam bidang industri voltan tinggi. Polietilena dan polipropilena digunakan secara meluas kerana kesesuaian sifat mekanikal dan elektrik untuk digunakan sebagai penebat. Tujuan kajian ini adalah untuk mengkaji sifat pecah tebat campuran polipropilena dan polietilena ketumpatan rendah linier. Dalam projek ini, lima komposisi polimer termoplastik yang berlainan yang terdiri daripada polipropilena (PP) dan polietilena ketumpatan rendah linier (LLDPE) telah dirumuskan melalui kaedah pencampuran cair. Kekuatan pecah tebat polimer campuran dengan komposisi 100% PP, 80% PP dan 20% LLDPE, 50% PP dan 50% LLDPE, 20% PP dan 80% LLDPE dan 100% LLDPE akan disiasat dan dianalisis. Keputusan yang diperoleh dianalisis menggunakan perisian Weibull. Keputusan menunjukkan bahawa kekuatan pecah tebat campuran polimer telah meningkatkan prestasi pecah tebatnya. Penambah baikan terhadap sifat polimer ini membolehkannya menjadi salah satu pilihan sebagai penebat kabel kuasa.

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LIST OF ABBREVIATIONS

ASTM	-	American Society for Testing and Materials
HVAC	-	High Voltage Alternating Current
HVDC	-	High Voltage Direct Current
LLDPE	-	Linear Low Density Polyethylene
MLE	-	Maximum Likelihood Estimation
PP	-	Polyproplyene
SiC	-	Silicon Carbide
XLPE	-	Cross-linked Polyethylene

LIST OF SYMBOLS

α	-	Alpha parameter of Weibull distribution
β	-	Beta parameter of Weibull distribution
kV	-	Kilo Volt
mm	-	Millimetre
%	-	Percentage

CHAPTER 1

INTRODUCTION

1.1 Problem Background

Electrical insulation materials are materials which provide an electrical insulation barrier or prevent the flow of current within a device or end-product such as motors, generators, coils and transformers. The development of new electrical insulation systems has become more challenging due to the increase demand of high voltage level [1]. The failure of the insulating material will cause short circuit to occur which will lead to flashover and it might cause unwanted accident happen.

Different form of insulating materials such as solid, liquid, vacuum and gases are used depending on the limitation or environmental criteria of the power equipment. In high voltage applications, polymers are widely used in the insulation systems due to its good performance of mechanical, electrical and thermal properties [2]. Besides that, its low production cost also become one of the advantages of being chosen as an insulator. Polymer material can be easily manipulated and changing its properties by adding fillers or addictives.

Currently, a lot of study and research have been done on breakdown strength of various polymer compounds such as polyethylene and polypropylene compound, low density polyethylene and high density polyethylene compound, high density polyethylene and polypropylene compound or the addition of fillers such as magnesium oxide (MgO) and Silicon Carbide (SiC). From previous research, it is found that some of the mixture of polymer blends has significantly increase the performance of mechanical properties such as Young modulus, materials stiffness, elongation limits as well as electrical properties likes breakdown voltage and others [3].

In year 1960s, XLPE polymer was used as insulation of 3 distribution cables at the range of 3 kV to 6 kV. With the advancement of technology, it currently used as an insulator for 275 to 500 kV high voltage cables. However, it cannot be recycled and cause pollution to the environment and thus in this study, the breakdown strength of polymer blends with different composition of PP and LLDPE was investigated.

1.2 Problem Statement

Cross-linked polyethylene (XLPE) insulator has been widely used as a cable insulator in power cables for many years due to its good performances of electrical breakdown and mechanical strength. However, it has difficulty to be recycled after replacement of new cables and removal which leads to environmental issues [4]. Accordingly, a huge amount of unused XLPE insulated cable bring concerns both economically and environmentally and causes a lot of researches and investigations being carried out to develop a recyclable insulating materials to be used in power cable. Recently, polypropylene (PP) and linear low density polyethylene (LLDPE) are being investigated and developed as insulating material used in power cables.

In insulation materials, the polymers are always being modified through mixing with different polymers at different weight ratio to improve the physical and mechanical properties of the final product. PP has a good resistance to electricity and high flexural strength. However, the properties of polypropylene and linear low density polyethylene blends are not well explored that might give different result with different compositions.

1.3 Objectives

The objectives of the research are:

(a) To formulate thermoplastic polymer blends with different compositions of polypropylene and linear low density polyethylene.

(b) To investigate the breakdown properties of polypropylene and linear low density polyethylene blends.

(c) To analyze the correlation between polypropylene and linear low density polyethylene blends formulation and breakdown strength.

1.4 Scope

Polypropylene and polyethylene have been widely use in the designing of insulators in various applications since they offer a great combination of physical, chemical, mechanical, thermal, and electrical properties. This project focused on the breakdown properties with different compositions of polypropylene and polyethylene. Polypropylene used was polypropylene (PP) homo-polymer whereas polyethylene used was linear low density polyethylene (LLDPE). Five polymer blends were used as project sample, which composed of 100% PP, 80% PP + 20% LLDPE, 50% PP + 50% LLDPE, 20% PP + 80% LLDPE and 100% LLDPE. The sample was tested for both HVAC and HVDC breakdown testing to observe and investigate breakdown properties for each sample and the samples were then analyzed using Weibull distribution analysis.

1.5 Contribution

The work gave the following contribution:

a) Determination of blending composition percentage between PP and LLDPE through melt blending process.

b) Improved understanding on the breakdown strength of polymer blends with different composition of PP and LLDPE.

c) Evaluation of dielectric strength distribution using Weibull software.

1.6 Project Timeline

Figure 1.1 below shows the project timeline for project 1 presented in Gantt chart form:

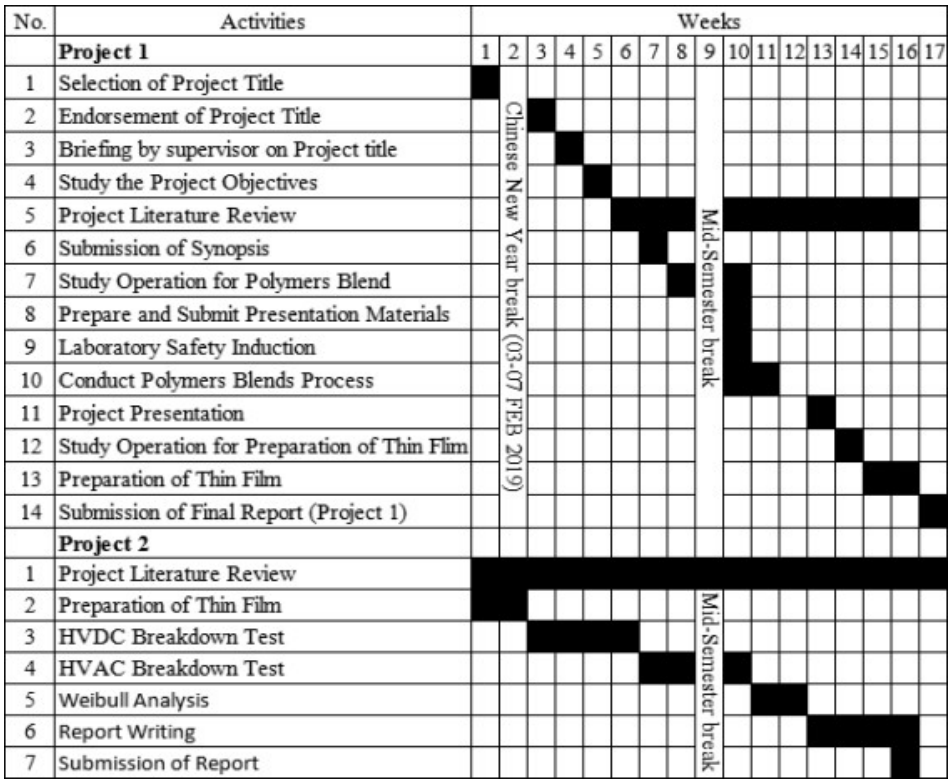

Figure 1.1 Project schedule for Master Project 1 and 2

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