

PARTIAL DISCHARGE CHARACTERISTICS ON EPOXY-BORON NITRIDE
NANOCOMPOSITE DUE TO AGEING TIME UNDER HIGH VOLTAGE
STRESS

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*Specially dedicated to my beloved parents
Awang Bin Hamid and Rahmah Bt Jaafar*

*And my siblings
Noor Azna Bt Awang
Noor Afifah Bt Awang
Muhamad Aizuddin Bin Awang
Noor Atiqah Bt Awang
For their supports and blessings*

*To my lecturers,
To all my friends, especially Shamsul Fahmi Bin Mohd Nor*

For all the supports, encouragement and understanding

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ABSTRACT

Recent works show that the polymer nanocomposites have huge attractions in high voltage equipment as an insulating material due to enhancement of polymer properties. One of the main phenomena that occur in polymeric insulating material is partial discharges. Partial discharge (PD) occurrence is known as an important factor that effects and shows signs of ageing of the insulation surface which leads failure of the insulation system. PD is a localized dielectric breakdown that occurs in a small portion of solid insulation under high voltage stress. These phenomena may effects of the insulator material which cause damage because it starts from the enclosed voids. This thesis presents the experimental investigation of PD characteristics in epoxy-nanocomposites as high voltage insulating materials. The tested samples of neat epoxy, epoxy-BN 2wt% and epoxy-BN 5wt% were prepared and investigated. The combination of epoxy and Boron Nitride (BN) would produce a good match of composite for electrical insulation. It would increase the polymeric insulation performance. PD characteristics tests were carried out on each sample based on the CIGRE Method II technique under high voltage stress of ageing time process based on the IEC 60270 standard. Moreover, the surface morphology of all samples by using the Olympus SZX16 optical microscope technique after ageing time process has been investigated. FESEM analysis had been used to investigate the micrograph of the sample surface and EDX analysis used to determine the chemical elements of each sample. Based on the PD results, the higher of weight percentage with BN filler will decrease the PD magnitude, PD number and the charge of PD compared to the neat sample. PD activities affected the degradation area of the sample surfaces. It had been discovered that the higher BN of filler amount caused less degradation area.

ABSTRAK

Kajian terkini menunjukkan polimer nanokomposit mempunyai tarikan secara meluas dalam peralatan voltan tinggi sebagai bahan penebat disebabkan dari penambahbaikan ciri-ciri polimer. Salah satu fenomena utama yang terjadi di dalam bahan penebat polimer ialah kejadian separa nyahcas. Kejadian separa nyahcas ini merupakan faktor penting yang dapat dikesan dan menunjukkan tanda penuaan pada permukaan penebatan yang mana menjurus kepada kegagalan pada sistem penebatan. PD dapat dikesan dengan tepat kerosakan dielektrik yang berlaku di sebahagian kecil penebat pepejal dibawah tekanan voltan tinggi. Fenomena ini memberi kesan pada bahan penebat yang menyebabkan kerosakan kerana ia bermula dari ruang kecil yang tertutup. Tesis ini membentangkan tentang kajian penyiasatan ciri-ciri kejadian separa nyahcas pada epoksi nanokomposit sebagai bahan penebat untuk voltan tinggi. Sampel yang diuji antaranya epoksi *neat*, epoksi-BN 2wt% dan epoksi-BN 5wt% telah disediakan dan disiasat. Gabungan epoksi dan Boron Nitride (BN) menghasilkan padanan yang baik untuk penebatan elektrik. Ia juga dapat meningkatkan prestasi penebat polimer. Pengujian pada ciri-ciri PD di setiap sampel dijalankan menggunakan teknik CIGRE Method II untuk proses penuaan dibawah tekanan voltan tinggi berdasarkan piawaian IEC 60270. Tambahan pula, morfologi permukaan untuk semua sampel dikaji menggunakan teknik mikroskop optik Olympus SZX16 selepas proses penuaan. Analisis FESEM digunakan untuk menyiasat mikrograf permukaan sampel dan analisis EDX dijalankan untuk menentukan elemen-elemen kimia yang terdapat pada setiap sampel. Berdasarkan keputusan PD yang diperolehi, semakin bertambah peratusan berat dengan pengisian BN menyebabkan magnitud PD, nombor PD dan cas PD berkurang berbanding sample *neat*. Aktiviti-aktiviti PD menjejaskan kawasan degradasi pada permukaan sampel. Ia telah mendapati bahawa semakin tinggi jumlah pengisian BN menyebabkan kawasan degradasi berkurang.

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LIST OF ABBREVIATIONS

PD	-	Partial Discharge
EP	-	Epoxy
BN	-	Boron Nitride
SEM	-	Scanning Electron Microscope
FESEM	-	Field Emission Scanning Electron Microscope
EDX	-	Energy Dispersive X-ray Spectroscopy
LDPE	-	Low Density Polyethylene
DC	-	Direct Current
AC	-	Alternative Current
HV	-	High Voltage
kV	-	Kilovolts
Hz	-	Hertz
pC	-	picocoulumb
mm	-	milimeter
wt	-	weight percentage

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Nowadays, partial discharge is the most important parameters in electrical insulation performance. It has always been a precursor as a major burden and become problems in the high voltage field. This electrical discharge occurs across a portion of the insulation between two of the electrodes. It can occur at void in solid insulation and gas bubbles in liquid insulation or around an electrode in a gas. The occurrence on partial discharge may alter the dielectric properties of these materials, making less effective as insulators [1]. Partial discharge activity is produced under normal working conditions in high voltage equipment where the insulation condition has deteriorated with age and it can impulsively from thermal over-stressing. Partial discharge is generally known as the predominant cause of long term degradation and cause failure of electrical insulation.

Polymer nanocomposites have attracted wide interest in this industry nowadays. It is the original structure that has been inserted by nanocomponent or nanofiller such as nanosilica and nanotitanium. This material is capable to provide the significant improvements in combined electrical, thermal and also the mechanical

properties. Polymer nanocomposite are defined as a composite in which small amounts of nanometer sized fillers are homogeneously distributed in polymers by several weight percentages (wt%) [2]. It is generally used as insulation material in high voltage system due to high breakdown strength under electrical stress.

1.2 Problem statement

Polymer insulators have a many applications, one of the reasons it is easy to fabricate in various shapes and also part though. It also widely investigates in term of filler and polymer base. The detection of ageing and degradation is very important parameter to measure the performance of insulator in various polymeric insulating materials. Moreover, partial discharge which occurs in the high voltage device such as polymer cable will to prevent and reduce.

Then, a new material has been developed known as polymer nanocomposite material by using epoxy resin and boron nitride as a filler. This combination of the nanocomposite material is the most suitable as they can provide excellent characteristic insulators. From the previous researchers, the effect boron nitride as a filler is not well understood. This project is provided in investigation of partial discharge testing not necessary to conduct of this study because of the equipment that difficult to be acquired. Then, the effect of the amount and content of boron nitride will investigate using the difference of weight percentage.

1.3 Objective

The objectives of this project have been classified as follows:

- i. To investigate of partial discharge characteristics of epoxy-Boron Nitride material as electrical insulation.
- ii. To investigate effects of nanofiller amount of Boron Nitride (BN) in the nanocomposite sample.
- iii. To investigate the number of PD, the PD charge magnitude, average of PD charge and surface morphology of the sample during ageing time under high voltage stress.

1.4 Scope of Study

In order to achieve the objective of this project, there are several scopes outlined, the literature review is needed to provide the best theory and understanding. The input knowledge can be obtained in various resources such as books, journals, internet, and papers. This project is focusing on studying the partial discharge characteristics also the selection and evaluation of the characteristics on fabricated epoxy-Boron Nitride as electrical insulator. The sample of epoxy nanocomposite includes epoxy neat, epoxy boron nitride 2wt% and epoxy boron nitride 5wt% with the thickness of 1mm.

By injecting voltage 5kV, 7kV and 10kV for each sample in 1hour ageing while 5kV of AC voltage in 5 hour ageing time process tested samples. The experimental of epoxy-nanocomposite samples had been conduct by using CIGRE Method II. This experiment is mainly conducted in IVAT laboratory using high voltage equipment such as a DDX-9101 Partial Discharge Detector and HV regulator also followed by IEC 60270 standard. The final scope covers to observe the morphology surface degradation of the sample by using an optical microscope after ageing process. FESEM and EDX analysis was used to observe the surface structure and chemical elements in that sample.

1.5 Thesis Outline

This thesis is divided into five chapters which discuss about partial discharge characteristics on boron nitride nanocomposite due to ageing time under high voltage stress.

Chapter 1: Introduction

This chapter describes the overview of this project that includes problem statement of this project, which described earlier in this chapter, followed by objectives and the scope of the project.

Chapter 2: Literature Review

Literature review contained all the basic knowledge about background of insulation material, partial discharge, polymer nanocomposite and boron nitride. Then, there are also brief a concept and context of regarding research materials. This chapter also summarizes the comparative studies were made based on previous research about partial discharge of polymer nanocomposites.

Chapter 3: Methodology

This chapter describes the methodology used in this project. The main content of this chapter is a detailed discussion on how the sample preparations were done and the experimental procedure was conducted in IVAT's laboratory for this project by measuring partial discharge during ageing time process.

Chapter 4: Results and Discussions

The experimental results of partial discharge characteristics for every sample of nanocomposites will be discussed thoroughly in this chapter. After that, the morphological characteristics of each sample using optical microscopy, FESEM and EDX technique will be shown and discussed properly.

Chapter 5: Conclusion and Recommendations

This chapter will conclude the work based on the result and discussion that obtained in chapter 4. Lastly, some recommendation is presented for future work improvement and development related from this project.

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