CHAPTER

4

PARTIAL DISCHARGE IN POLYETHYLENE NANOCOMPOSITES

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4.1 INTRODUCTION

Electrical power has been a primary source for supporting the entire crucial aspect. Generally, those aspects mostly include daily life, health services, banking, security instruments, manufacturing, transportation control system, and social media networking, which are highly dependent on electrical power supplies. Since the population increases rapidly and technologies improve quickly, electrical demand also grows significantly. In order to meet the demand, the power system requires generating, transmitting, and delivering energy enormously. The power system requires a high-voltage system to deliver electrical power through transmission and distribution lines. High voltage is applied to reduce losses during transmission and distribution processes. To ensure the reliability of the power system, good performance of high voltage apparatus insulation systems is highly necessary.

Polymeric insulating materials are commonly used as high-voltage insulation owing to their outstanding breakdown strength endurance under the condition of electrical stress. Polyethylene is being recommended for electrical insulation applications because of some

advantages reasons. They have good dielectric strength, low qualities of relative permittivity and low dielectric loss tangent (Lau, 2013). A thermoplastic polymer made entirely of carbon and hydrogen is called polyethylene. It is produced from ethylene monomer. Since it can be manufactured using most techniques, low-density polyethylene (LDPE) is very durable, inexpensive, and has excellent mechanical and thermal properties, making it a good choice for insulating system materials (Tian et al., 2012). With such significant characteristics and features, LDPE polymers are widely employed as insulating materials for cables such as power cables and their related accessories (Khalil & Gastli, 1999). Chemically speaking, LDPE materials have a straightforward structure (Tian et al., 2012). The substance avoids the polymer molecules produced by crystallisation by having a non-linear chemical chain with several tiny branches. Due to its decreased crystallinity, chemically inert and superior resistance to alkalis and acids, LDPE was judged to be more flexible (Awang, 2019). However, traditional polymeric materials can suffer from partial discharge (PD) events, leading to insulation degradation and eventual system failure. To address these issues, the use of polymeric nanocomposites incorporating nanofillers has been proposed to improve the performance of these materials.

The breakdown of solid insulation due to discharges that may develop in the interior spaces and cavities of the dielectric is known as PD, a topic that is currently attracting a lot of attention. The fundamental reason for this is that it has an impact on the material's life versus stress properties. The PDs energy losses add to the cavity walls continuous deterioration and the gas ongoing evolution. The cumulative effects of PD lead to disintegration in the end. In actual practice, PD cannot be eliminated entirely; instead, a predetermined threshold is defined based on the projected operational life of the equipment. The discharge initiation level must be raised, which requires meticulous quality control during insulation preparation and processing techniques.

Studies from the past and the present have demonstrated that adding nanoparticles to polymers has a bright future because of the benefits they may provide. The fundamental benefit of using nanoparticles as

additives is that a bigger surface area is provided when the particles size decreases. The interaction zone or surface region is referred to the filler and polymer matrix's interfacial region.

Silicon dioxide (SiO_2) is a chemical compound comprising silicon-bonded oxides with the strongest covalent bond known as a gigantic covalent bond. Typically, silanes are condensed to synthesize SiO_2 nanoparticles using the Stöber method, which results in nanoparticles with an amorphous silicon and oxygen network. The degree of condensation affects the density of SiO_2 nanoparticles. SiO_2, also known as silica, has been used widely as nanoparticles in polymer nanocomposites due to its outstanding properties in terms of hardness and stable molecular structure.

Since SiO_2 is frequently found in nature as quartz, it can also be used as nanoparticles in the large-scale polymer nanocomposites production (Musa et al., 2015). The maturity of the synthesis process of the SiO_2 nanoparticles has led this nanoparticle to be used widely in most polymer nanocomposite studies. The silica surface is adaptable and simple to modify for the attachment of particular functional groups. Likewise, earlier studies showed that the addition of SiO_2 nanoparticles with uniform dispersion to the polymer matrix improved the polymer-based insulating materials dielectric properties: Breakdown strength and PD resistance (Kurnia et al., 2022; Nasib et al., 2020; Tanaka et al., 2011).

Agglomeration is one of the main problems when using SiO_2 nanoparticles as a filler in polymer nanocomposites. Therefore, the SiO_2 nanoparticles surface needs to be modified using an appropriate surface modification technique to address the nanoparticles agglomeration in the polymer matrix. Surface modifications mechanism on SiO_2 nanoparticles can be chemically categorized into two stigmas: Silane-terminated and hydroxyl-terminated. These categories of chemical stigma represented the chemical structure on the nanoparticles surface, whether consisting of a silane coupling agent for silane-terminated SiO_2 nanoparticles or a hydroxyl group for the hydroxyl-terminated SiO_2 nanoparticles.

The chemical stigma category is selected according to the application, suitability, and strategy to disperse the nanoparticles within the polymer