Electrical Performance Improvement of Cross-linked Polyethylene Cables using Inorganic Fillers

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ABSTRACT

Since 1970, the cross-linked Polyethylene (XLPE) insulated power cables have been used worldwide. This insulation possesses very good electrical, mechanical and thermal characteristics in medium and high voltage networks. Many studies and researches have been carried out to improve XLPE characteristics by adding inorganic filler. Therefore, the presenting work aims to study the electrical, thermal properties of XLPE after adding inorganic filler in different percentages and tested under various thermal conditions.

KEYWORDS

XLPE cables; inorganic filler; dielectric strength; TGA; electrical and thermal properties.

I. INTRODUCTION

Among the growing technologies for the 21st century are high, medium, and low voltage power cables. They have become a staple of modern power systems engineering, in which underground transmission and distribution (T&D) systems have become the only acceptable way of providing electrical service in urban areas that meets customer expectations for reliable service[1].

Distribution and transmission must be done with a high degree of reliability and safety over a very long period of time. Depending on the application, external environmental factors, such as, ground water level, type of ground or voltage levels, different types of cables are used. The electrical properties of the cables are significantly influenced by the insulation. Factors like heat and flame resistance; moisture resistance; mechanical toughness; flexibility; and the usage life determine the insulation. Cables with impregnated insulation, such as paper insulated covered cables (PILC), were installed until the late 60's and are still being installed in some areas. The development of polyethylene (PE) in 1941 triggered a dramatic change in the insulation of cables for the transmission and distribution of electrical energy. There are three major types of power cables insulation which are in wide use today: (a) Cross-linked polyethylene(XLPE) or tree-retardant Cross-linked polyethylene (TR-XLPE). (b) Thermoplastic polyethylene (TPE). (c) Polyvinyl chloride (PVC) [2].

Since the advent of synthetic polymer development, PE has been used as an insulation material, and in most countries the use of polyethylene was limited to the Cross-linked version (XLPE). XLPE is considered to be the material of choice due to its ease of processing and handling, excellent electrical properties, high dielectric strength, moisture resistance and high resistance to chemicals and solvents [3-4]

Inorganic fillers have been recently introduced to improve XLPE insulation for cables .Several studies aimed to improve electrical performance of XLPE high voltage cables using inorganic fillers [5-11].Thermal properties were also investigated in different researches for XLPE loaded with inorganic filler [12-13].

This research aims to investigate the electrical insulating properties of different blends of XLPE loaded with inorganic filler such as $CaCO_3$.It focuses on trying to find an appropriate weight percentage composition of such blend in order to enhance the dielectric strength of the insulation in different temperature conditions and thermal properties such as Thermogravimetric analysis (TGA) as well .Also, some mechanical properties of the blend were investigated such as elongation at break.

II. EXPERIMENTAL PROCEDURE

A. Blend preparation

The XLPE preparation was carried out in the National Research Center, Polymers and Pigments Dept. in Egypt. XLPE was made from High-density polyethylene (HDPE). HDPE was mixed with dicumyl peroxide 4-methoxy phenol 3% weight percentage (3 wt %) as cross linked agent in absence of filler to prepare XLPE according to (ASTM F876 - 10e1). $CaCO_3$ with different ratios (20, 30 and 50 wt %) was mixed with XLPE using an electrical heat chamber of Barbender Plasticoder model (C.W. pra, instrument,INC.50 Hackensack,230 Volt, 40Amp).Table 1 shows different XLPE blends concentrations.

Table 1 Blends formulations

Blend symbol	*Filler added to XLPE*	*Filler weight %*
A	*without filler*	*0*
B	*$CaCO_3$*	*20*
C	*$CaCO_3$*	*30*
D	*$CaCO_3$*	*50*

B. Dielectric Breakdown Strength Test