Comparative Study on LLDPE, LDPE Nano Dielectric for application in HVDC cables: Dielectric response, Electrical and Thermal properties

Nageshwar Rao Burjupati; Central Power Research Institute, Bangalore, India, nageshburjupati@gmail.com
Kandiban R; Central Power Research Institute, Bangalore, India, kandiban.r@gmail.com
Ashwin Parthasarathy.C; Central Power Research Institute, Bangalore, India, ashwinpart@gmail.com

ABSTRACT

This paper presents a comparative study of electric, dielectric and thermal properties on LLDPE, LDPE metal oxide nano composites. The nano dielectric samples were prepared by using surface treated MgO and SiO_2 as fillers in the Polyethylene (LLDPE, LDPE) base matrix. The nano dielectrics have shown improved properties in comparison with plain LDPE and LLDPE. The permittivity value has increased with increasing frequency.

KEYWORDS

Dirana, spectroscopy, FTIR, LDPE, LLDPE.

INTRODUCTION

HVDC transmission is gaining importance due to various advantages like long distance and bulk electric power transmission. They are more economical with improved stability and reliability. In recent times, HVDC extruded cables are the preferred options for underground bulk electric power transmission, but the design of HVDC cable insulation is the challenging task due to its dependency of its dielectric properties on temperature, electric field distortion due to accumulation of space charges in the insulation [1-3]. Nano dielectrics has become the popular subject of research and considerable progress has been made to mitigate space charge accumulation and enhanced charge decay in nano filled materials as compared with micro filled materials [4]. Though promising improvements in these properties have been made, it is not always the case that nano dielectrics are preferable as electrical insulation [5]. Nano dielectrics are prepared by adding a small quantity of inorganic fillers to improve the properties of base polymer like LLDPE, LDPE MDPE, and HDPE etc. These nano dielectrics are characterized by the fact that they have interfaces with enormous specific surface between polymers and Nano fillers and that, such interface tend to determine whole properties of the polymer nano composites [6-8]. Electrical and dielectric properties are made by determining the properties like permittivity, dielectric loss, etc, space charge measurement, surface & volume resistivity measurements, breakdown strengths etc. Further, measurement of contact angle helps one to understand the hydrophobicity of the material. Surface chemical heterogeneity and roughness are the key parameters that affect the wettability of a solid dielectric [9]. The study of dielectric response of PE-nano dielectric in the frequency domain and polarization and depolarization current measurements in time domain is scanty which is very much necessary to understand its long term performance and its reliability in HVDC extruded power cables. Preliminary studies on LDPE nano composites at low voltage (140 Vrms) carried out by the authors [10] indicated the influence of surface treatment on dielectric response. However, it is very much necessary to understand the dielectric response at higher voltages (1400 Vrms) in order to ascertain its suitability for high voltage applications and its beharious at elevated temperatures. A study was undertaken in the laboratory of CPRI to understand the electrical, dielectric and thermal properties of low density polyethylene (LDPE) and Linear Low density Polyethylene with surface treated nano fillers. The results were presented and discussed.

EXPERIMENTAL STUDIES

Materials Used

Low density polyethylene (LDPE) and linear low density polyethylene (LLDPE) of 2g/10 per min melt flow index and nanoparticles of less than 50 nm size and purity 99% were used in the present study. Nano MgO, Magnesium oxide < 50 nm particle size (BET): (Product number 549649), and Silicon dioxide nano powder (spherical, porous), 5 – 15 nm particle size (TEM) (Product number 637246) were procured from Sigma Aldrich, USA. Methyl, ethyl, hexadecyl and octyl silanes were obtained from Sigma Aldrich (USA) and all other solvents like ethyl alcohol, heptane were obtained locally.

Nano filler surface modification

Tri-ethoxy(Octyl) Silane, Tri-methoxy-methyl silane, Hexadecyl trimethoxy silane were used for silane treatment of nanoparticles. A quantity of 25 g of nanoparticle was first introduced into the mixture of water/heptane and the temperature was kept at 353 K. Further, 10% by volume of silane was added into the above mentioned solution and continuously stirred for 5 h at 353 K. The resultant product was filtered and washed many times using a mixture of water/ethanol and dried in oven. The details are published earlier [11].

Preparation of Nanocomposites

LDPE and LLDPE nano dielectric samples were prepared by mixing nano fillers in either LDPE or LLDPE base polymer along with antioxidant (Irganox) for thermal stability. The mixture was compounded using twin screw Brabender extruder at 100° C, 100 rpm for 10 minutes. Further, the LDPE and LLDPE metal oxide compounds were cut into small pieces and pressed under a plate vulcanizer at 140 ˚C for 10 minutes to produce thin plaques of 100 micron and 200 micron. Finally the samples of LDPE, LLDPE and its nano composite were put in vacuum oven at 100° C for 24 hours so as to make uniform initial thermal and mechanical conditions.

Characterization of Nano Composites:

The LDPE metal oxide nanocomposites was characterized by measuring surface & volume resistivity in accordance with guidelines stipulated in standard ASTM D257-07 [12].