VOL. 11, NO. 8, APRIL 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

AC AND IMPULSE TEST ANALYSIS ON LLDPE-NR FOR DIFFERENCE AMOUNT OF SIO2 NANOFILLER

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ABSTRACT

Nanocomposite has a good electrical performance. Material that had been utilized in this research is only the Silicon dioxide, SiO_2. Natural rubber (NR) consumption is due to the nature of interphase impact and viscoelastic matrix form multiple interphase with Linear Low-Density Polyethylene (LLDPE) was mixed with different amounts of SiO_2 with Alternating Current and Impulse Test. LLDPE composition and the natural rubber ratio of 80:20 was used as the base polymer. These basic polymers are combined with SiO_2 of 1%, 3%, 5% and 7%. The parameters used are the thickness of the sample. Three thicknesses of sample used were 1.5 mm, 3 mm and 4.5 mm. This research was conducted to study the characteristics of polymer nanocomposite, SiO_2. Based on this experiment, the increase in weight percentage nanofiller LLDPE and natural rubber also gives rise to the level of conductivity of the insulation. In addition, the weight percentage nanofiller used also affects the rate of change in conductivity of the insulation, the lower level. Besides, the thicker the sample, the higher the level of conductivity of the insularity.

Keywords: Polymer nanocomposites LLDPE-NR SIO_2.

INTRODUCTION

Polymer nanocomposites are defined as polymers in which small amounts of nanoparticles or nanofillers are homogeneously dispersed in the polymer matrix but only in several weight percentages. Addition of just another few percent of the nanofillers have profound the impact or changes on physical, chemical, mechanical and electrical properties of the polymers (Tanaka, 2004). Insulation material also shows interesting characteristics using a polymer nanocomposite (Jamail *et al.* 2014). Such changes are often favourable for engineering purposes.

Polymeric nanocomposites are demonstrating very interesting properties as insulating materials. The dispersion of nanoscopic inorganic particles can actually enhance properties of original materials such as the thermal stability, the mechanical strength, the electrical strength, the resistance to the action of partial discharges and the resistance to the inception of electrical treeing.

Nanocomposites dielectrics are a new class of dielectric materials containing one phase at the nanometre scale. This material with excellent properties had begun to attract researcher in the field of dielectrics and electrical insulation to further the implementation of the polymers worldwide. Several interesting results to indicate foreseeable future have been discovered and described in materials and processed on the paper together with basic concepts and future direction.

An AC electrical strength test campaign was performed on different Low Density Polyethylene (LDPE) nanocomposite. Such materials were obtained by the dispersion of inorganic nanoparticles, which having different ratio and surface nature of silicon oxide. All the considered nanofillers have been organically modified in order to obtain a good dispersion and an efficient interfacial interaction. The investigation of the nanocomposite material would show a higher electrical strength than the pure LDPE (Guastavino *et al.* 2006).

Polymer nanocomposites

Polymer nanocomposites are materials in which nanoscopic inorganic particles, normally, when disseminated 10-100 A at least one dimension into the organic polymer matrix causing dramatically increased the performance properties of the polymer (Jamail et.al., 2013). To have more understanding about nanodielectrics in general, further studies were done toward future research and development of the material (Frechette, 2004). A lot of research was conducted to study the polymer nanocomposite dielectric properties (Singha *et al.* 2008), (Zhang *et al.* 2005),(Roy *et al.* 2005)(Iyer *et al.* 2011).

Systems in which the inorganic particles are the individual layers of a lamellar compound most typically a smectite clay or nanocomposites of a polymer (such as nylon) embedded among layers of silicates exhibit dramatically altered physical properties relative to the pristine polymer. For instance, the layer orientation, polymer-silicate nanocomposites exhibit stiffness, strength and dimensional stability in two dimensions (rather than one). Due to the nanometre length scale which minimizes scattering of light, nanocomposites are usually transparent. Polymer nanocomposites represent a new alternative to conventionally filled polymers. Because of their nanometre sizes, filler dispersion nanocomposites exhibit markedly improved properties when compared to the pure polymers or their traditional composites. These include increased modulus and strength, outstanding barrier properties, improved solvent and heat resistance and decreased flammability.

The characterization of polymer nanocomposite are composition and compositional homogeneity (chemical homogeneity), structure (including crystal system where possible atomic coordinates, bonding and ultra structure) and identification and analysis of defects and impurities influencing the properties of the materials. Characterization, therefore, describes all those features of composition and structure of a material that would suffice for reproducing the material.

Nanocomposite polymer provides excellent impact as insulation material (Jamail, Piah and Muhamad, 2012). It also increasingly adopted for replacing conventional insulation to provide enhanced performances such electrical and mechanical properties. It also improved the properties of the original material such as thermal stability, mechanical strength, electrical strength, resistance to the action of partial discharges and electrical treeing resistance to initiation can occur with the dispersion of inorganic nanoscopic particles. In this work two different LDPE nanocomposites are considered. Such materials were obtained by the dispersion of particles having different aspect ratios and surface nature. Structure microscopic much affect electrical conduction of composite, including the density, crytallinity of the composite, the size of the filler and the morphology of interface between the base material and the filler. Polymer nanocomposite can change one or some of its dielectric properties, that's means it can be used as nanodielectric (Fre *et al.* 2013).

Linear low-density polyethylene (LLDPE)

Linear low-density polyethylene (LLDPE) is a substantially linear polymer (polyethylene), with significant numbers of short branches, commonly made by copolymerization of ethylene with long-chain olefins[28]. Linear low-density polyethylene differs structurally from conventional low-density polyethylene (LDPE) because of the absence of long chain branching. The linearity of LLDPE results from the different manufacturing processes of LLDPE and LDPE. In general, LLDPE is produced at lower temperatures and pressures by copolymerization of ethylene and such higher alpha-olefins as butene, hexene, or octene. The copolymerization process produces a LLDPE polymer that has a narrower molecular weight distribution than conventional LDPE and in combination with the linear structure, significantly different rheological properties.

LLDPE has higher tensile strength and higher impact and puncture resistance than does LDPE. It is very flexible and elongates under stress. It can be used to make thinner films, with better environmental stress cracking resistance. It has excellent resistance to chemicals and electrical properties. However, it is not as easy to process as LDPE, has a lower gloss, and narrower range for heat sealing.

LDPE and LLDPE have unique theological or melt flow properties. LLDPE is less shear sensitive because of its narrower molecular weight distribution and shorter chain branching. During a shearing process, such as extrusion, LLDPE remains more viscous and, therefore, harder to process than an LDPE of equivalent melt index. The lower shear sensitivity of LLDPE allows for a faster stress relaxation of the polymer chains during extrusion, and, therefore, the physical properties are susceptible to changes in blow-up ratios. In melt extension, LLDPE has lower viscosity at all strain rates. This means it will not strain harden the way LDPE does when elongated.

Silicon dioxide, SiO_2 Nanofiller

Silicon dioxide, also known as silica is a chemical compound that is an oxide of silicon with the chemical formula SiO_2(Andritsch *et al*. ,2013). It has been known since the ancient times. Silica is most commonly found in nature as quartz, as well as in various living organisms. Silicon dioxide is one of the most complex and most abundant families of materials, existing both as various minerals and being produced synthetically. Notable examples include fused quartz, crystal, fumed silica, silica gel, and allergies. Silicon dioxide is obtained by mining and purification of the resulting mineral. Quartz comprises more than 10% by mass of the earth's crust.

Sample preparation

LLDPE used in this study is a commercial linear low density polyethylene from Titan Chemical, Malaysia. It has a density of 0.918 g/cm3, a melt index of 25g/l0 min. NanoparticIe of silicon oxide (Si02) is from China with a particle size of about < 50nm was used as filler. This nano scale filler has a nearly spherical shape with a specific surface area of about 100 m2/g. The filler was dried before use. Natural rubber (NR) grade Standard Malaysian Rubber (SMR) CV 60 supplied by Taiko Plantations was used for blending and mixing with LLDPE and nanofiller. Polyethylene nanocomposites were prepared by melt mixing at 165°C using a Brabender mixer with chamber size of 50 cm^3. The mixer has a high shear force and the screw speed was controlled at 35 rpm with the mixing time of 2 min (Jamail *et al.* 2013). The polymer nanocomposites were finally prepared into square shape of 10 cm x 10 cm with the thickness of 3 mm by hot melt pressing at 1 tone pressure at 170 °C for 10 min. Four types of LLDPE-NR nanocomposite square shaped with a diamension of 10 cm x 10 cm were prepared with concentrations of nanofiller of 1, 3, 5 and 7% with respectively. Table-1 shows the compound formulation and designation of LLDPE-NR/Si02.

HVAC test

HVAC test using alternating current and high voltage. Besides that, the AC Test is known as the low-frequency test. In this test, the insulation system needed to have the ability to withstand higher than the usual alternating voltage (AC) are present on the power system in extraordinary circumstances. Conditions that are not normal can be in the form of continuous power frequency or voltage is temporary or Tov. Erecting the higher voltage levels exposing equipment with high voltage or current

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stresses. The main concern in insulating or separating the equipment from the potential and earthed structure. Voltage frequency range is set at 50 or 60 Hz (country dependent) for continuous and from 10 < f <500 Hz to test Tov. Typically, the type of high voltage testing will depend on:

- The type of equipment installed
- The voltage rating
- The localization in which is to be located

Table-1. Compound formulation and designation of LLDPE-NR/SIO_2.

Test sample	LLDPE (%)	Constituent composition (%) Natural Rubber (SMR CV 60)	Nanofiller (%)	Designation
LLDPE + natural rubber	80	20	0	Si1
LLDPE + natural rubber + SiO_2	80	20	1	Si2
	80	20	3	Si3
	80	20	5	Si4
	80	20	7	Si5

The HVAC generator mainly is to generate the HVAC voltages. To increase voltage, generator uses a transformer. Usually, they are three common types of HVAC generator or we call that testing transformer which are the straight, cascaded and resonant testing transformers. In contrast with the power transformer that generating the three phase voltages, the testing transformer in the laboratory normally generates a single phase high voltage. At the same voltage rating, testing transformers typically have a much lower kVA rating than the power transformers. This lower kVA rating is due to the usual short duration testing and smaller current produced. So, cooling of the windings will not be a main problem. Also the flux density in the testing transformer is kept lower than the power transformer. This to avoid high magnetizing current that contain harmonics that may distort the output test voltages. Testing transformer also more compact in design with well insulated high-voltage windings. The HVAC straight transformer uses a similar concept as the normal step-up transformer.

HV impulse test

An impulse voltage is a unidirectional voltage, which, rises rapidly to a maximum value and falls to zero instantly. The maximum value is called the peak value of the impulse voltage. The impulse voltage is specified by this value. Small oscillations which have amplitude less than 5% of the peak value of impulse voltage are tolerated. A mean curve should be considered in case of oscillations in the wave shape. Full impulse voltage can be defined as an impulse voltage which develops without causing flash over or puncture.

Chopped impulse voltage can be defined as flash over or puncture occurs which causes a sudden collapse of the impulse voltage. A full impulse voltage is characterized by its peak value and by the wave front and wave tail, which is its two time intervals. The wave front time of an impulse wave is defined as the time taken by the wave to reach to its maximum value starting from zero value. Generally it is difficult to identify the start and peak points of the impulse wave and so the wave front time is specified as 1.25 times (t2 – t1), where t2 is defined as the time for the impulse wave to reach its 90% of the peak value and t1 defined as the time to reach 10% of its peak value. Since (t2 – t1) represents 80% of the wave front time, to give total wavefront time, it is multiplied by 1.25 to give the total wave front time. The point where the line CB intersects the time axis is known to be the nominal starting point of the impulse wave.The nominal wave tail time is the point on the wave tail where the voltage is 50% of the peak value and between the nominal starting point t0 in example wave fail time is expressed as (t3 – t0) (Wadhwa, 2007). Figure-1 shows the full impulse voltage.

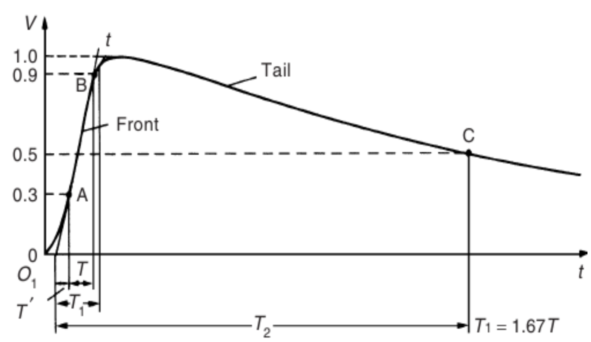

Figure-1. Full impulse voltage.

HVAC test analysis

Based on the experiment, the thickness of the sample was declared as the parameter. The samples are 1.5 mm, 3.0 mm and 4.5 mm thick. The air gap is 4 cm. Each experiment was performed three times to ensure the data accuracy. Apart from the thickness of the sample nanofiller percentage were included in respect to the thickness of the sample. Besides that, due to the constraints of the equipment, distance between the two electrodes was set at 4 cm in each experiment. Therefore, an air gap was considered in the test cell between the electrodes and the sample. Thus, the experiment was conducted to determine the sample characteristics inclusive an air gap.

Based on the Table-2 and Figure-2, show that a higher percentage nanofiller used in insulation materials had made the characteristics of the material more strong. In this case, the decision was made based on sample voltage. The main purpose of the experiment was to study the characteristics of the sample. However, apart from the sample voltage, to further strengthen the decision, two things were taken, the primary voltage and sample current. Table-2 and Figure-2 show that percentage nanofiller of 7% were the highest values for sample voltage. It had been shown that 7% with nanofiller was the best compared with 1%, 3% and 5% with nanofiller. This means, based on experiments that had been carried out, based on the three sample thickness, 7% with nanofiller was better than the percentage of nanofiller 1%, 3% and 5%. It was clear that the total weight percentage of nanofiller that had been affects the important characteristics of the material.

Table-2. Comparisons between percentages of nanofiller.

Nanofiller Percentage	Sample Voltage of 1.5 mm (kV)	Sample Voltage of 3.0 mm (kV)	Sample Voltage of 4.5 mm (kV)
1%	50.51	52.61	56.65
3%	52.81	54.55	58.21
5%	57.06	58.30	59.45
7%	58.43	58.90	60.07

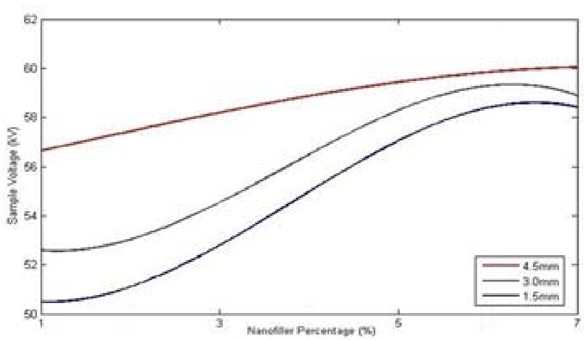

Figure-2. Comparisons between percentages of nanofiller.

HV impulse test analysis

Based on this experiment, to ensure accurate results, the experiment was conducted three times and average the results were used as the result analysis. The parameters that was used for this experiment was similar to AC Test parameter, which was thickness of the sample. Thickness that used for this experiment was divided into three, 1.5 mm, 3.0 mm and 4.5 mm. Then, for the Impulse Test was used 1.5 cm for the air gap and 2 cm for the sphere gap. This means that, in addition to studying the characteristics between the percentages of nanofiller, the thickness of the sample was also tested. In addition, due to the constraints of the equipment in the lab, the distance between the two electrodes was set by 4 cm. Therefore, there had an air gap in the test cell. Thus, the experiment was conducted as well as had an air gap.

Based on the Table-3 and Figure-3, this means that the higher of the nanofiller used in insulation materials, the stronger of the characteristics of the material. In this case, the decision was made based on sample voltage. The main purpose of the experiment is to study the characteristics of the sample. However, apart from the sample voltage, to further strengthen the decision, two things were taken, the primary voltage and sample current. The sample voltage of weight percentage of nanofiller 7% was the highest results. It had been showed that 7% of nanofiller was the best compared with weight percentages of nanofiller 1%, 3% and 5%. This means that, based on experiments that had been carried out, based on the three sample thickness also give the results that 7% of nanofiller was more better than the percentage of nanofiller 1%, 3% and 5%. It was clear that the total weight percentage of nanofiller that had been affects the important characteristics of the material.

Table-3. Comparisons between percentages of nanofiller.

Nanofiller Percentage	Sample Voltage of 1.5 mm (kV)	Sample Voltage of 3.0 mm (kV)	Sample Voltage of 4.5 mm (kV)
1%	32.98	33.02	34.42
3%	34.53	34.62	35.81
5%	36.08	36.80	38.81
7%	37.97	38.24	39.51

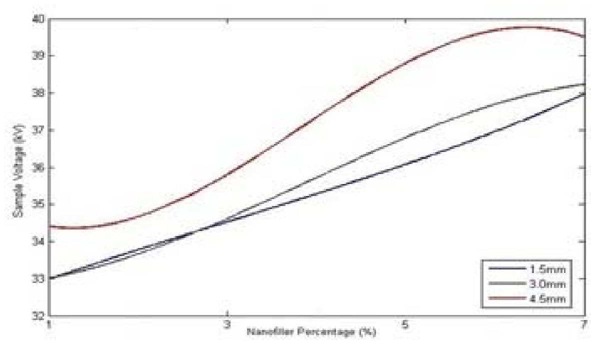

Figure-3. Comparisons between percentages of nanofiller.

CONCLUSIONS

The aim of this experiment is to discover the characteristic properties of LLDPE-NR with silicon dioxide (SiO_2) nanocomposites using high voltage AC test and also Impulse Test. The characteristics properties it is important to make sure the insulation is stronger and more durable. Thus, the experiment conducted to find new alternatives that can be applied to produce better quality insulation.In addition, this experiment proved that the insulation that mixed with nanofiller was able to survive longer than the existing insulation.

Besides that, the main purpose of this experiment is to study the characteristic of LLDPE NR/SiO_2 insulation properties. SiO_2 is able to reinforce the characteristics of the existing insulation. Through these experiments, the presence of SiO_2 in insulation is necessary because of the characteristics possessed by SiO_2 allows the insulation to be higher quality in terms of strength and time frame.

Furthermore, based on this project, the differentiation in percentages of LLDPE silicon dioxide (SiO_2) nanocomposites was also understood. In addition, knowledge of Ac Test and Impulse Test had been gained. Moreover, the results obtained from the AC Test and Impulse Test had determined the strength of the LLDPE-NR based polymer whether it is stronger with just polymer itself or with the content of SiO_2 nanofiller.This experiment had been running successfully and achieved all the objectives.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the Universiti Tun Hussein Onn Malaysia for financial support (IGSP Grant vot U252), UTHM High Voltage Laboratory and Taiko Plantation Sdn Bhd as a supplier of Natural Rubber.

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