THERMAL EXPERIMENTAL DIELECTRIC CHARACTERIZATION OF COST-FEWER LOW-DENSITY POLYETHYLENE NANOCOMPOSITES

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Abstract. *Polymer properties can be experimentally tailored by adding small amounts of different fillers, but they are expensive with respect to the classical polymer materials. This paper has been studied the enhancement and controlling of electric and dielectric properties of low-density polyethylene (LDPE) polymer materials by cost-fewer nanoparticles. Certain percentages of clay and fumed silica nanoparticles have been enhanced electric and dielectric properties of low-density polyethylene nanocomposite. Dielectric spectroscopy has been measured the electric and dielectric properties of low-density polyethylene with and without nanofillers at various frequencies (10 Hz–100 kHz) and temperatures (20 °C, 40 °C and 60 °C). Also, it has been investigated the optimum percentages of nanofillers with respect to nanofillers type, filler concentration and temperature for enhancing electric and dielectric characterization of low-density polyethylene. Experimental measurements have been carried out on dielectric breakdown strength of new polyethylene nanocomposites materials under variant electric fields (uniform, and non-uniform) and variant temperatures. It has been specified the effective nanofillers factors on dielectric breakdown strength of polyethylene nanocomposites materials.*

Keywords

Dielectric properties, dielectric strength, low-density polyethylene, nanocomposite, nanoparticles, polymers.

1. Introduction

Polymer nanocomposites have attracted wide interest with regard to enhancing polymer properties and extending their utility in recent years. The nanocomposite material which the nanofillers are evenly distributed in the polymer material attracts attention as an insulating material because the properties of the original material can be drastically improved by adding a few percent of nanofillers. Low-density polyethylene (LDPE) is widely used as an insulating material for power cables. Electrical insulating polymers are usually modified with inorganic fillers to improve electrical, mechanical, thermal properties. Generally, inorganic fillers are dispersed non-uniformly in the polymer matrix, and the irregular interfaces are usually electrically weak spots. It is well known that electrical properties of insulating polymer composites depend strongly on their microstructures. In particular, the size and shape of the fillers, the dispersion of the fillers, the filler-filler, filler-matrix interactions including interfacial strain, directly affect the electrical properties of composites [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11].

Nanoparticles/polymer composites are now of considerable interest for their specific electrical properties. It is recognized that the interfaces between the host dielectric and the nanometric particles can strongly influence the dielectric properties of the composite material as a whole. Since interfaces dominate dielectric situations at this level, nanodielectrics and interfaces become inextricable. Low frequency polarization is a type of polarization concerning to interface polarization, and it strongly relates to the space charge storage and transportation in dielectric materials [12], [13], [14], [15], [16]. Also, it has been extend for studying dielectric characterization of cenosphere filled low-density polyethylene composites, the effect of filler distribution on the dielectric constant is examined and the observed differences are attributed to the differences in two kinds of interfaces present: one formed between the touching cenosphere particles and the other formed between LDPE and cenosphere [17]. Electrical and electronic properties of thin films of variant nanocomposites were characterized with respect to their thermal properties and so, the fabrication procedures [18], [19], [20], [21].

As of now, work is underway to examine the physical properties of nanocomposite materials composed of nanoparticles of metals and their compounds stabilized within a polymeric dielectric matrix .In recent years polymer nanocomposites have attracted wide interest with regard to enhancing polymer properties and extending their utility. It has been found that the dielectric properties have a close relationship with the interfacial behavior between the nanofillers and the polymer matrix in such nanocomposites [22], [23], [24], [25], [26], [27], [28], [29]. The electric and optic properties of these materials have been demonstrated to be highly dependent on the size, structure, and concentration of the nanoparticles, as well as on the type of polymeric matrix [30], [31], [32], [33], [34], [35]. Great expectations have focused on costless nanofillers. However, it has been concerned in this paper about the effect of types of cost-fewer nanofillers on electrical properties of polymeric nanocomposite. With a continual progress in polymer nanocomposites, this research depicts the effects of types and concentration of cost-fewer nanoparticles in electrical properties of industrial polymer material. Experimental results have been discussed the effects of Clay and Fumed silica nanofillers with various volume fractions and temperatures on electric and dielectric properties of Low-density Polyethylene (LDPE).

2. Experimental Setup

2.1. Nanofillers

Clay is nanometer, and its spherical particle shape (Dia.: 10 nm) is the most important characteristic for polymer applications. The reason of selection clay nanofillers is due to having a greater effect on properties such as viscosity, stiffness and strength, using clay as nanofillers give high levels of flame retardancy to the produced composite. Cost-fewer clay nanoparticles are catalyst to be the best filler among nanofillers industrial materials. On the other wise, fumed silica is a fluffy white powder with an extremely low-density. Also, fumed silica powder is used in paints and coatings, silicone rubber and silicone sealants, adhesives, cable compounds and gels, printing inks and toner, and plant protection.

Tab. 1: Dielectric properties of pure and nanocomposite materials.

Materials	**Dielectric constant at 1 kHz**	**Resistivity [Ω·m]**
Pure LDPE	2.3	10^{14}
LDPE + 1 %wt Clay	2.23	10^{15}
LDPE + 5 %wt Clay	1.99	$10^{15} - 10^{18}$
LDPE + 10 %wt Clay	1.76	$10^{18} - 10^{20}$
LDPE + 1 %wt Fumed Silica	2.32	10^{13}
LDPE + 5 %wt Fumed Silica	2.39	$10^{13} - 10^{11}$
LDPE + 10 %wt Fumed Silica	2.49	$10^{11} - 10^{9}$

2.2. Base Matrix

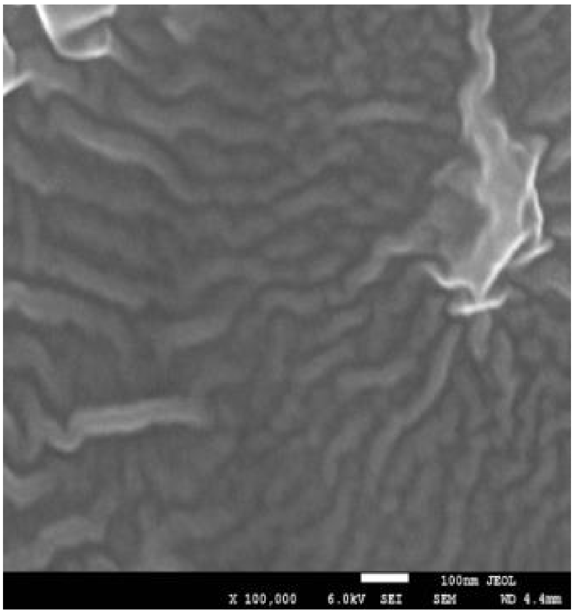
LDPE is a thermoplastic made from petroleum, and it is unreactive at room temperatures, except by strong oxidizing agents, and some solvents cause swelling. It can withstand temperatures of 80 °C continuously and 95 °C for a short time. This polymer material is a commercially available material already in use in the manufacturing of high-voltage (HV) industrial products. Thus, industrial materials studied here is low-density polyethylene that has been formulated utilizing variant percentages of nanoparticles of clay and fumed silica. Pure and fabricated nanocomposites (variant percentages of mass-weight (wt.) of nanoparticles mixed and penetrated inside polymer matrix) have been measured their electric and dielectric properties after manufacturing and detailed as shown in Tab. 1.

2.3. LDPE Nanocomposites

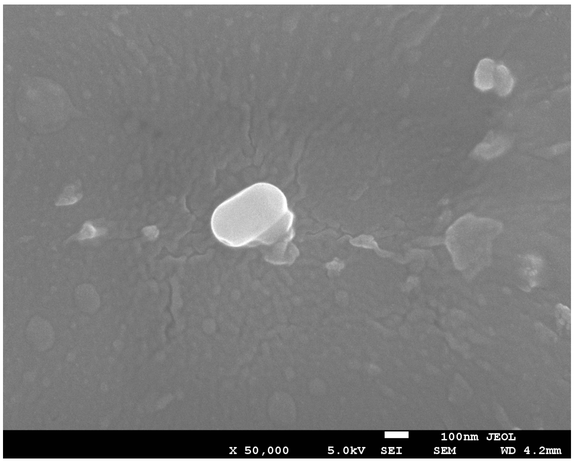
It has been prepared and fabricated by using recent nanotechnology procedures and devices for melting low-density polyethylene, mixing and penetrating nanoparticles inside the base matrix (LDPE) by modern ultrasonic devices. The distribution of nanoparticles within the polymer matrix has been detected by using scanning electron microscope (SEM) as shown in Fig. 1, that illustrates Clay/LDPE nanocomposites and Fumed silica/LDPE nanocomposites illustrate penetration of nanoparticles inside low-density polyethylene.

2.4. Measurement Devices

Figure 2 shows HIOKI 3522-50 LCR Hi-tester device that measured characterization of nanocomposite insulation industrial materials, it has been used for measuring electrical parameters of nanometric solid dielectric insulation specimens at various frequencies. Specification of LCR is Power supply: 100 V, 120 V, 220 V or 240 V (±10 %) AC (selectable), 50/60 Hz, and Frequency: DC, 1 MHz to 100 kHz, Display Screen: LCD with backlight / 99999 (full 5 digits), Basic Accuracy:



(a) Clay/LDPE nanocomposites



(b) Fumed silica/LDPE nanocomposite

Fig. 1: SEM images for LDPE nanocomposites.

Fig. 2: HIOKI 3522-50 LCR Hi-tester device.

Z: ±0.08 % rdg. θ:±0.05°, and External DC bias ±40 V max. (option) (3522-50 used alone ±10 V max./ using 9268 ± 40 V max.).

3. Results and Discussion

Dielectric Spectroscopy is a powerful experimental method to investigate the dynamical behavior of a sample through the analysis of its frequency dependent dielectric response. This technique is based on the measurement of the capacitance as a function of frequency of a sample sandwiched between two electrodes. The $\tan\delta$, and capacitance [C] were measured as a function of frequency in the range of 10 Hz to 10 kHz at variant temperatures for all the test samples.

3.1. Dielectric Characterization of LDPE Nanocomposites at Room Temperature (20 °C)

Figure 3 shows loss tangent ($\tan\delta$) of the tested samples as a function of frequency for Clay/ Low-density polyethylene nanocomposites at room temperature (20 °C). The measured loss tangent contrasts on increasing the loss tangent with increasing the percentage of clay nanoparticles up to 1 %wt, specially, at low frequencies but it is decreasing with increasing clay nanoparticles percentage up to 10 %wt, specially, at high frequencies. Whatever, Fig. 4 contrasts on the measured loss tangent that increases with increasing percentage of fumed silica nanofillers in the nanocomposite up to 10 %wt especially at high frequencies. On the otherwise, Fig. 5 contrasts on capacitance of Clay/LDPE nanocomposites samples versus frequency at room temperature (20 °C), the measured capacitance decreases with increasing percentage

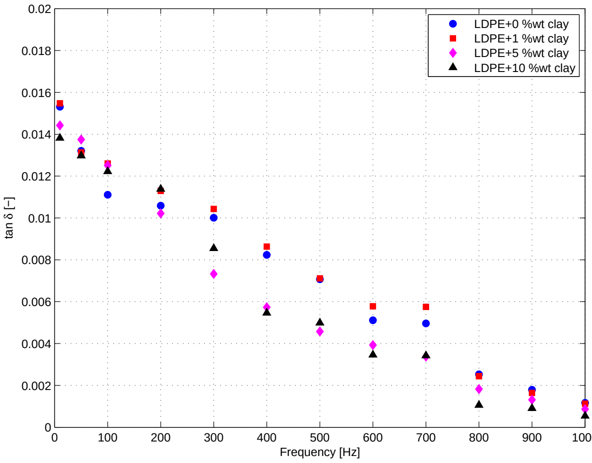


Fig. 3: Measured loss tangent of clay/LDPE nanocomposites at room temperature (20 °C).

of clay nanofillers in the nanocomposite up to 5 %wt but the measured capacitance of Low-density polyethylene nanocomposites increases with increasing the clay percentage of nanofillers up to percentage of 10 %wt. Whatever, Fig. 6 shows that the measured capacitance are closed with increasing the percentage of fumed silica nanofillers in the nanocomposite especially at high frequencies.

It is cleared that nanoparticles have been changed electric and dielectric polymer properties. The dielectric properties of insulating polymer nanocomposites have been investigated in the frequency domain from 0.1 Hz to 1 kHz. Also, it has been found that the dielectric properties have a close relationship with the interfacial behavior between the fillers and the polymer matrix in such composites.

3.2. Dielectric Characterization of LDPE Nanocomposites at Temperature (40 °C)

There are effects of rising temperatures on nanoparticles inside the suggested nanocomposites, it is cleared that, rising temperature of nanocomposite materials changes nanofillers temperatures that changing dielectric behavior over the normal conditions.

Figure 7 gives the loss tangent as a function of frequency for Clay/ LDPE nanocomposites samples under testing at temperature (40 °C). It is noticed that the loss tangent of Clay/ LDPE nanocomposites increases with increasing percentage of clay nanofillers in the nanocomposite up to 1 %wt, after that the loss tangent of Clay/ LDPE nanocomposites decreases with increasing percentage of clay nanofillers in the nanocomposite up to 10 %wt.

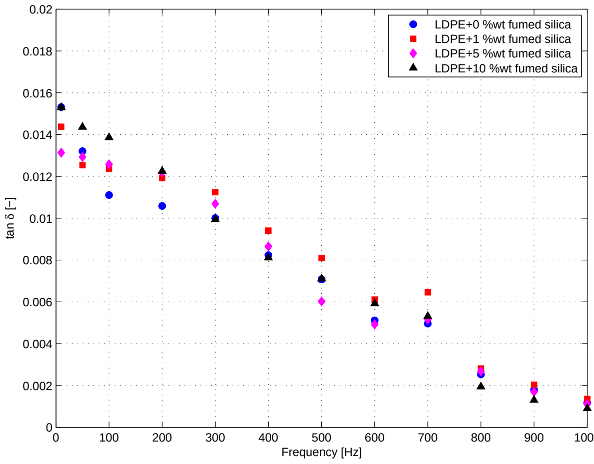


Fig. 4: Measured loss tangent of Fumed Silica/LDPE nanocomposites at room temperature (20 °C).

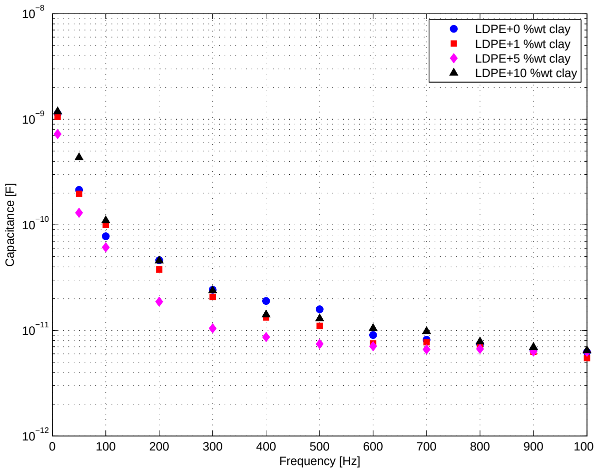


Fig. 5: Measured Capacitance of Clay/LDPE nanocomposites at room temperature (20 °C).

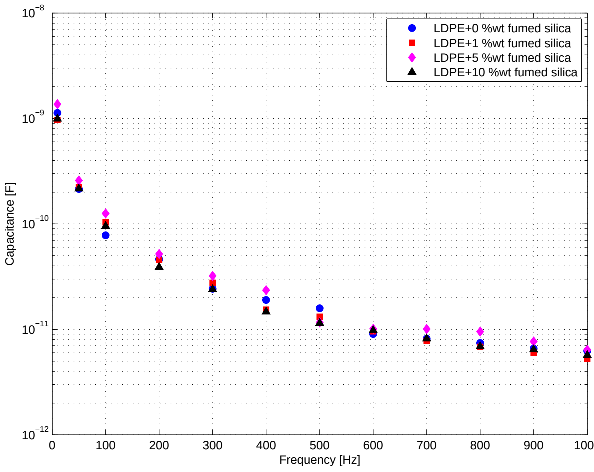


Fig. 6: Measured Capacitance of Fumed Silica/LDPE nanocomposites at room temperature (20 °C).

Similarly, Fig. 8 depicts that the same behavior of clay nanoparticles inside low-density polyethylene

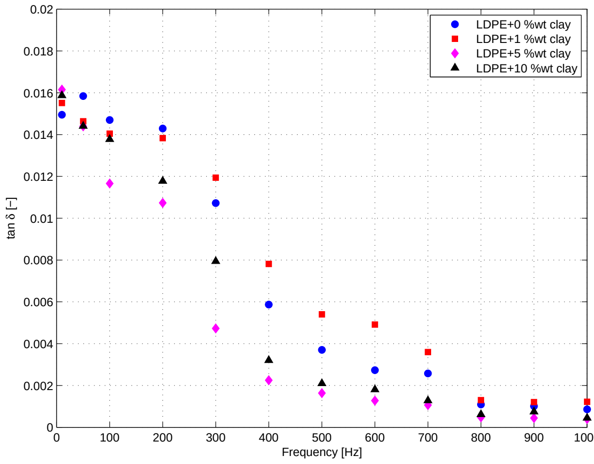


Fig. 7: Measured loss tangent of Clay/LDPE nanocomposites at certain temperature (40 °C).

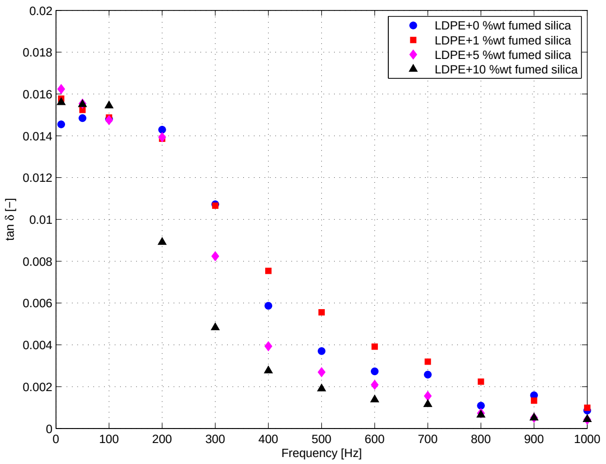


Fig. 8: Measured loss tangent of Fumed Silica/LDPE nanocomposites at certain temperature (40 °C).

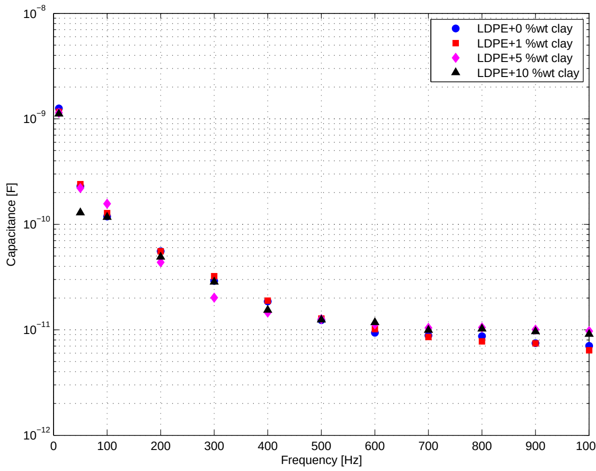


Fig. 9: Measured Capacitance of Clay/LDPE nanocomposites at certain temperature (40 °C).

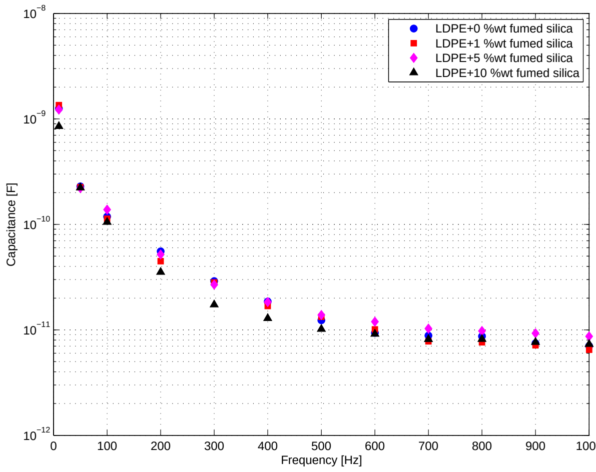


Fig. 10: Measured Capacitance of Fumed Silica/LDPE nanocomposites at certain temperature (40 °C).

as similar as increasing percentage of fumed silica nanofillers in the low-density polyethylene nanocomposite up to 10 %wt.

On the otherwise, Fig. 9 shows the tested samples capacitance as a function of frequency for Clay/LDPE nanocomposites at temperature (40 °C); the measured capacitance increases with increasing clay nanofillers percentage up to 1 %wt but it decreases with increasing clay nanofillers percentage up 10 %wt. Noting that, Fig. 10 shows the measured capacitance of Fumed silica/LDPE nanocomposites follow the same behavior of Clay/LDPE nanocomposites.

3.3. Dielectric Characterization of LDPE Nanocomposites at Temperature (60 °C)

Awarded to the effects of high-temperature values on nanoparticles inside the nanocomposites, Fig. 11 shows the relation between loss tangent versus the applied

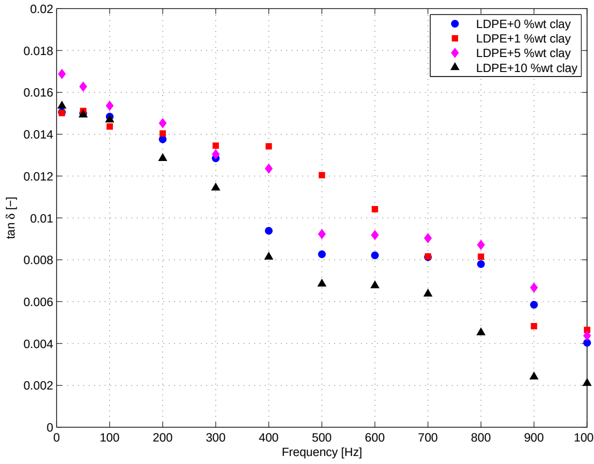


Fig. 11: Measured loss tangent of Clay/LDPE nanocomposites at certain temperature (60 °C).

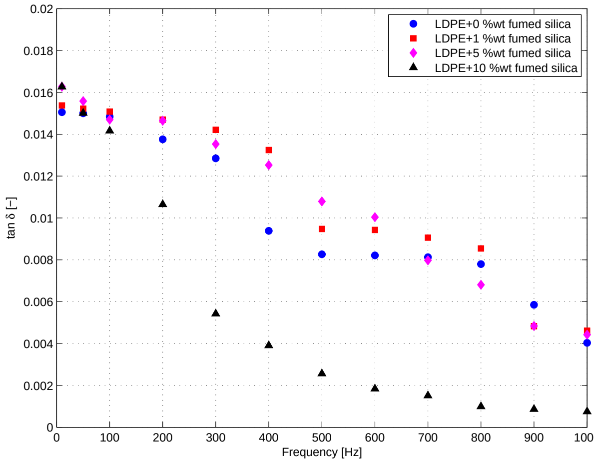


Fig. 12: Measured loss tangent of Fumed Silica/LDPE nanocomposites at certain temperature (60 °C).

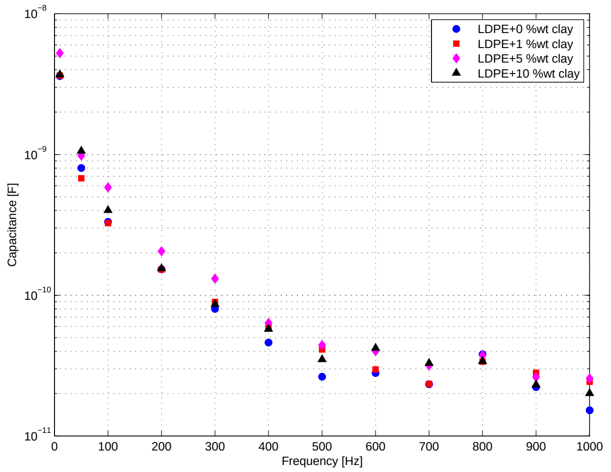


Fig. 13: Measured Capacitance of Clay/LDPE nanocomposites at certain temperature (60 °C).

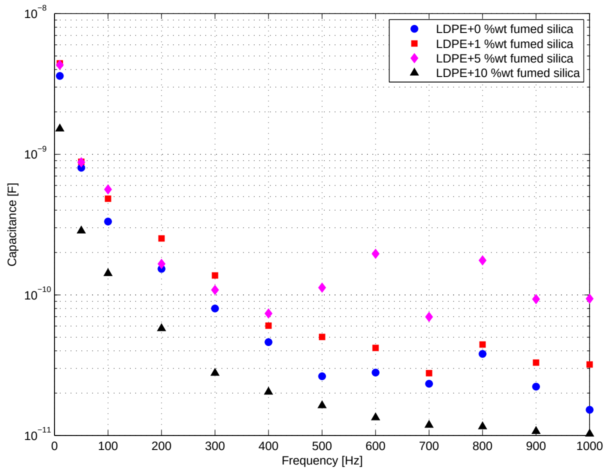


Fig. 14: Measured Capacitance of Fumed Silica/LDPE nanocomposites at certain temperature (60 °C).

voltage frequency for Clay/LDPE nanocomposites at a given temperature (60 °C). The measured loss tangent of Low-density polyethylene nanocomposite increases with increasing clay percentage nanofillers up to 5 %wt, especially, at low frequencies. After that, the loss tangent of Clay/LDPE nanocomposite decreases with increasing clay percentage nanofillers up to 10 %wt, specially, at high frequencies. Also, Fig. 12 shows that the measured loss tangent of Fumed silica/LDPE increases with increasing fumed silica nanoparticles percentage up to 5 %wt, especially, at low frequencies. But, it decreases with increasing fumed silica nanoparticles percentage up to 10 %wt.

Figure 13 depicts capacitance versus the applied voltage frequency for Clay/ LDPE nanocomposites at temperature (60 °C); The measured capacitance decreases with increasing clay nanofillers percentage up to 1 %wt, then, the measured capacitance increases with increasing clay percentage nanofillers up to 10 %wt. Although, Fig. 14 shows that the measured capacitance increases with increasing fumed silica percentage nanofillers up to 5 %wt, after that, the capacitance of Fumed silica/LDPE nanocomposites decreases with increasing fumed silica nanofillers percentage (5 %wt–10 %wt). This is obvious that, rising temperature of nanocomposite materials raises nanofillers temperatures that changing dielectric behavior with respect to normal conditions.

3.4. Comparative Study for Thermal Characterization of LDPE Nanocomposite Materials

With respect to results of the effect of temperature and types of nanofillers on the electric characterization, in the beginning, adding fumed silica increased permittivity of the new nanocomposite materials whatever, adding clay has decreased permittivity of the new Nanocomposite materials as tabulated in Tab. 1.

With comparing results for depicting the effect of raising concentration of clay and fumed silica nanofillers are pointed out in Fig. 3, Fig. 4, Fig. 5, Fig. 6 at room temperature (20 °C), the measured loss tangent depends on increasing the certain percentages of nanoparticles, specially, the measured loss tangent characteristics varies between low and high frequencies. On the otherwise, the measured capacitance varies with increasing percentage of clay nanofillers inside the nanocomposite, whatever, the measured capacitance are closed with increasing the percentage of fumed silica nanofillers in the nanocomposite especially at high frequencies.

For high thermal conditions, at temperature 40 °C as shown in Fig. 7, Fig. 8, Fig. 9, Fig. 10, the loss tangent of Clay/ LDPE nanocomposites increases with increasing percentage of clay nanofillers in the nanocomposite up to 1 %wt, after that the loss tangent of Clay/ LDPE nanocomposites decreases with increasing percentage of clay nanofillers in the nanocomposite up to 10 %wt. And so, fumed silica nanofillers follow the same behavior of clay nanoparticles inside low-density polyethylene up to 10 %wt. With rising samples temperature up to 60 °C, it can be noticed that the effects high temperature values on nanoparticles inside the nanocomposites and so, the effect of raising concentration of nanofillers is pointed out in Fig. 11, Fig. 12, Fig. 13, Fig. 14 i.e the measured capacitance decreases and increases at a certain values of clay or fumed silica nanofillers percentage up to 10 %wt, This is obvious that, rising temperature of nanocomposite materials effects on nanofillers heating temperatures which changing dielectric behavior over the normal conditions. Finally, the importance of adding nanofillers of clay or fumed silica can be concluded in controlling in increasing or decreasing the dielectric strength of pure LDPE by using nanotechnology techniques. Also, increasing environment temperature of nanocomposite materials causes nanofillers heating temperatures that changing dielectric behavior over the normal conditions.

4. Conclusion

Adding the clay is decreasing the permittivity of new nanocomposite materials and the effects of adding small amount of clay nanoparticles percentage to Low-density polyethylene decreases capacitance and loss tangent depending on thermal nanoparticles temperatures, on the otherwise, adding fumed silica is increasing the permittivity of new nanocomposite materials and the effects of small amount of fumed silica nanoparticles percentage to Low-density polyethylene increases capacitance and loss tangent with respect to thermal nanoparticles temperatures.

Thermal stability of new nanocomposites occurs at small amounts clay or fumed silica nanoparticles but adding large amounts these nanoparticles to Low-density polyethylene will be reverse dielectric behavior characteristics gradually. This is obvious that rising temperature of nanocomposites materials effects on nanoparticles temperatures which changing dielectric behavior over the normal conditions.

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References

[1] TOKORO, T., M. NAGAO and M. KOSAKI. High-Field Dielectric Properties and ac Dissipation Current Waveforms of Polyethylene Film. *IEEE Transactions on Electrical Insulation.* 1992, vol. 27, no. 3. pp. 482–487. ISSN 0018-9367. DOI: 10.1109/14.142710.

[2] ARAOKA, M., H. YONEDA and Y. OHKI. Dielectric Properties of New-Type Polyethylene Polymerized Using A Singlesite Catalyst. In: *IEEE 6th International Conference on Conduction and Breakdown in Solid Dielectrics.* Vasteras: IEEE, 1998. pp. 493–497. ISBN 0-7803-4237-2. DOI: 10.1109/ICSD.1998.709332.

[3] NAWAWI, Z., K. T. SIRAIT and M. NAGAO. Surface Resistance Effect on Dielectric Breakdown Characteristic of LDPE Film. In: *IEEE Proceedings of The 6th International Conference on Properties and Applications of Dielectric Materials.* Xian: IEEE, 2000, pp. 1073–1075. ISBN 0-7803-5459-1. DOI: 10.1109/ICPADM.2000.876419.

[4] HOSIER, I. L., A. S. VAUGHAN and S. G. SWINGLER. The Effects of Measuring Technique and Sample Preparation on the Breakdown Strength of Polyethylene. *IEEE Transactions on Dielectrics and Electrical Insulation.* 2002, vol. 9, iss. 3, pp. 353–361. ISSN 1070-9878. DOI: 10.1109/TDEI.2002.1007697.

[5] ZHANG, C., T. MORI, T. MIZUTANI and M. LSHIOKA. Effects of manufacturing technology on electrical breakdown and morphology of thin films of low-density polyethylene blended with polypropylene copolymer. *IEEE Transactions on Dielectrics and Electrical Insulation.* 2003, vol. 10, iss. 3, pp. 435–443. ISSN 1070-9878. DOI: 10.1109/TDEI.2003.1207469.

[6] DANG, Z., S. YANG, F. LIZHEN, C. NING, N. CEWEN and Z. SHUJIN. Dielectric properties of carbon fiber filled low-density polyethylene. *Journal of Applied Physics.* 2003, vol. 93, iss. 9, pp. 5543–5545. ISSN 0021-8979. DOI: 10.1063/1.1562740.

[7] HONG, J. I., L. S. SCHADLER, R. W. SIEGEL and E. MARTENSSON. Rescaled electrical properties of ZnO/low-density polyethylene nanocomposites. *Applied Physics Letters.* 2003, vol. 82, iss. 12, pp. 1956–1958. ISSN 0003-6951. DOI: 10.1063/1.1563306.

[8] AMAN, A., M. M. YAACOB, M. A. ALSAEDI and K. A. IBRAHIM. Polymeric composite based on waste material for high voltage outdoor application. *International Journal of Electrical Power & Energy Systems.* 2012, vol. 45, iss. 1, pp. 346–352. ISSN 0142-0615. DOI: 10.1016/j.ijepes.2012.09.004.

[9] SARATHI, R. and R. UMAMAHESWARI. Understanding the partial discharge activity generated due to particle movement in a composite insulation under AC voltages. *International Journal of Electrical Power & Energy Systems.* 2013, vol. 48, iss. 1, pp. 1–9. ISSN 0142-0615. DOI:10.1016/j.ijepes.2012.11.017.

[10] MCCALLEY, J. D. and V. KRISHNAN. A survey of transmission technologies for planning long distance bulk transmission overlay in US. *International Journal of Electrical Power & Energy Systems.* 2014, vol. 54, iss. 1, pp. 559–568. ISSN 0142-0615. DOI: 10.1016/j.ijepes.2013.08.008.

[11] SILVA, D. A., E. C. M. COSTA, J. L. FRANCO, M. ANTONIONNI, R. C. JESUS, S. R. ABREU, K. LATHI, L. H. I. MEI and J. PISSOLATO. Reliability of directly-molded polymer surge arresters: Degradation by immersion test versus electrical performance. *International Journal of Electrical Power & Energy Systems*. 2013, vol. 53, iss. 1, pp. 488–498. ISSN 0142-0615. DOI: 10.1016/j.ijepes.2013.05.023.

[12] YAMAMOTO, Y., M. IKEDA and Y. TANAKA. Electrical Properties and Morphology of Polyethylene Produced with a Novel Catalyst. *IEEE Transactions on Dielectrics and Electrical Insulation*. 2004, vol. 11. iss. 5, pp. 881–890. ISSN 1070-9878. DOI: 10.1109/TDEI.2004.1349794.

[13] ZHANG, C., R. MASON and G. C. STEVENS. Dielectric Properties of Epoxy and Polyethylene Nanocomposites. In: *IEEE Proceedings of International Symposium on Electrical Insulating Materials*. Kitakyushu: IEEE, 2005, pp. 393–396. ISBN 4-88686-063-X. DOI: 10.1109/ISEIM.2005.193571.

[14] DONG, X., Y. YIN, Z. LI and X. JIANG. Low Frequency Polarization Behavior of Nano-Ag/Low-density Polyethylene Composite. In: *8th International Conference on Properties and applications of Dielectric Materials*. Bali: IEEE, 2006, pp. 932–935. ISBN 1-4244-0189-5. DOI: 10.1109/ICPADM.2006.284330.

[15] ULZUTUEV, A. N. and N. M. USHAKOV. Investigation of the Charge Localization Processes in the Metal Polymeric Materials Based on the Low-density Polyethylene Matrix with Stabilized Nanoparticles. In: *4th International Conference on Advanced Optoelectronics and Lasers*. Crimea: IEEE, 2008, pp. 435–437. ISBN 978-1-4244-1973-9. DOI: 10.1109/CAOL.2008.4671988.

[16] HINATA, K., A. FUJITA, K. TOHYAMA and Y. MURATA. Dielectric Properties of LDPE/MgO Nanocomposite Material under AC High Field. In: *IEEE Conference on Electrical Insulation and Dielectric Phenomena*. Kansas City: IEEE, 2006, pp. 313–316. ISBN 1-4244-0546-7. DOI: 10.1109/CEIDP.2006.311932.

[17] SHARMA, J., N. CHAND and M. N. BAPA. Effect of cenosphere on dielectric properties of low-density polyethylene. *Results in Physics*. 2012, vol. 2, iss. 1, pp. 26–33. ISSN 2211-3797. DOI: 10.1016/j.rinp.2012.03.003.

[18] CHEN, X., S. WEI, A. YADAV, R. PATIL, J. ZHU, R. XIMENES, L. SUN and Z. GUO. Poly(propylene)/Carbon Nanofiber Nanocomposites: Ex Situ Solvent-Assisted Preparation and Analysis of Electrical and Electronic Properties. *Macromolecular Materials and Engineering*. 2011, vol. 296, iss. 5, pp. 434–443. ISSN 1439-2054. DOI: 10.1002/mame.201000341.

[19] CHOUIT, F., O. GUELLATI, S. BOUKHEZAR, A. HARAT, M. GUERIOUNE and N. BADI. Synthesis and characterization of HDPE/N-MWNT nanocomposite film. *Nanoscale Research Letters*. 2014, vol. 9, iss. 1, pp. 1–6. ISSN 1556-276X. DOI: 10.1186/1556-276X-9-288.

[20] GOYAL, R. K. and J. N. SAHU. Fabrication of advanced poly(etheretherketone)/ clay nanocomposites and their properties. *Advanced Materials Letters*. 2010, vol. 1, iss. 3, pp. 205–209. ISSN 0976-3661. DOI: 10.5185/amlett.2010.8151.

[21] ABRON, K., M. U. B. WAHIT and S. BAHRAEIAN. A study on thermal and electrical properties of high density polyethylene/high density polyethylene grafted maleic anhydride/montmorillonite/polypyrrole blend. *Scientific research and essays*. 2011, vol. 12, iss. 6, pp. 6285–6292. ISSN 1992-2248. DOI: 10.5897/SRE11.1084.

[22] JAMAIL, N. A. M., M. A. M. PIAH and N. A. MUHAMAD. Effects of SiO2 nanofillers on Polarization and Depolarization Current (PDC) of LLDPE-NR nanocomposite insulating materials. In: *IEEE International Conference on Power and Energy*. Kota Kinabalu: IEEE, 2012, pp. 707–711. ISBN 978-1-4673-5017-4. DOI: 10.1109/PECon.2012.6450306.

[23] THABET, A. Influence of Cost-Less Nanoparticles on Electric and Dielectric Characteristics of Polyethylene Industrial Materials. *International Journal of Electrical Engineering and Technology*. 2013, vol. 4, iss. 1, pp. 58–67. ISSN 0976-6545.

[24] THABET, A. Experimental Investigation on Thermal Electric and Dielectric Characterization for Polypropylene Nanocomposites using Cost-fewer Nanoparticles. *International Journal of Electrical Engineering and Technology*. 2013, vol. 4, iss. 2. pp. 1–12. ISSN 0976-6545.

[25] GOUDA, O., A. THABET, Y. A. MUBARAK and M. SAMIR. Nanotechnology Effects on Space Charge Relaxation Measurements for Polyvinyl Chloride Thin Films. *International Journal of Electrical Engineering and Informatics*. 2014, vol. 6, no. 1, pp. 1–12. ISSN 2085-6830.

[26] THABET, A. Experimental Investigation on Thermal Dielectric Characterization for New

Cost-fewer PMMA Nanocomposites. *International Journal of Electrical Engineering and Informatics*. 2014, vol. 6, no. 4, pp. 1–12. ISSN 2085-6830.

[27] THABET, A. Experimental enhancement for dielectric strength of polyethylene insulation materials using cost-fewer nanoparticles. *International Journal of Electrical Power & Energy Systems*. 2015, vol. 64, iss. 1, pp. 469–475. ISSN 0142-0615. DOI: 10.1016/j.ijepes.2014.06.075.

[28] ZHANG, C., R. MASON and G. C. STEVENS. Dielectric properties of epoxy and polyethylene nanocomposites. In: *Proceeding of International Symposium on Electrical Insulating Materials*. Kitakyushu: IEEE, 2005, pp. 393–396. ISBN 4-88686-063-X. DOI: 10.1109/ISEIM.2005.193571.

[29] DONG, X., Y. YIN, I. ZHE and X. JIANG. Low Frequency Polarization Behavior of Nano-Ag/Low-density Polyethylene Composite. In: *8th International Conference on Properties and applications of Dielectric Materials*. Bali: IEEE, 2006, pp. 932–935. ISBN 1-4244-0189-5. DOI: 10.1109/ICPADM.2006.284330.

[30] WANG, X., H. Q. HE, D. M. TU, C. LEI and Q. G. DU. Dielectric Properties and Crystalline Morphology of Low-density Polyethylene blended with Metallocene Catalyzed Polyethylene. *IEEE Transactions on Dielectrics and Electrical Insulation*. 2008, vol. 15, iss. 2, pp. 319–326. ISSN 1070-9878. DOI: 10.1109/TDEI.2008.4483448.

[31] ISHIMOTO, K., T. TANAKA, Y. OHKI, Y. SEKIGUCHI, Y. MURATA, and M. GOSYOWAKI. Comparison of Dielectric Properties of Low-density Polyethylene/MgO Composites with Different Size Fillers. In: *IEEE Conference on Electrical Insulation Dielectric Phenomena*. Quebec: IEEE, 2008, pp. 208–211. ISBN 978-1-4244-2548-8. DOI: 10.1109/CEIDP.2008.4772819.

[32] KUZNETSOVA, I. E., B. D. ZAITSEV and A. M. SHIKHABUDINOV. Elastic and Viscous Properties of Nanocomposite Films Based on Low-Density Polyethylene. *IEEE Transactions on Ultrasonic, Ferroelectrics, and Frequency Control*. 2010, vol. 57, iss. 9, pp. 2099–2102. ISSN 0885-3010. DOI: 10.1109/TUFFC.2010.1658.

[33] SHENGTAO, L., Y. GUILAI, N. FENGYAN, B. SUNA, L. JIANYING and Z. TUO. Investigation on the Dielectric Properties of Nanotitanium Dioxide-Low-density Polyethylene Composites. In: *IEEE International Conference on Solid Dielectrics*. Postdam: IEEE, 2010, pp. 1–4. ISBN 978-1-4244-7945-0. DOI: 10.1109/ICSD.2010.5568106.

[34] CIUPRINA, F., I. PLESA, P. V. NOTINGHER, P. RAIN, T. ZAHARESCU and D. PANAITESCU. Dielectric Properties of LDPE-SiO2 Nanocomposites. In: *IEEE International Conference on Solid Dielectrics*. Postdam: IEEE, 2010, pp. 1–4. ISBN 978-1-4244-7945-0. DOI: 10.1109/ICSD.2010.5568097.

[35] FANG, P., X. QIU, W. WIRGES and R. GERHARD. Polyethylene-naphthalate (PEN) Ferroelectrets: Cellular Structure, Piezoelectricity and Thermal Stability. *IEEE Transactions on Dielectrics and Electrical Insulation*. 2010, vol. 17., iss. 4, pp. 1079–1087. ISSN 1070-9878. DOI: 10.1109/TDEI.2010.5539678.

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