Effect of addition Lithium Fluoride on dielectric properties of High Density Polyethylene

Asrar Abdul Muniam **Ahmed Hashim**
Al-Mustansiriyah University, College of Science

Abstract

In the present work, effect of addition Lithium Fluoride on dielectric properties of high density polyethylene has been studied .For that purpose ,the HDPE samples with LiF additive have been prepared with volume different percentages and different thickness.The experimental results showed that the dielectric constant, dielectric loss, AC electrical conductivity are changed with change LiF content and frequency of applied electrical field.

الخلاصة

تم في هذا البحث دراسة تأثير إضافة فلوريد الليثيوم على الخواص العزلية للبولي اثيلين عالي الكثافة . ولهذا الغرض تم تحضير نماذج بإضافة LiF الى HDPE و بنسب حجمية مختلفة من هذه الأملاح مع البوليمر و بسماك مختلف .

أشارت النتائج الى ان ثابت العزل , الفقدان العزلي و التوصيلية الكهربائية المتناوبة تتغير بتغير النسبة الحجمية للملح المضاف و تردد المجال الكهربائي المسلط .

Introduction

Polymers have traditionally been considered as insulating materials by chemists and physicists alike . A conducting polymer is chewable and desirable . A light weight ready moldable, desirable conductive material has long been recognized as a worthwhile goal to work for[A.R.Blyth,1979,M. V. Ramos et al,2005].Researches, generally, have demonstrated that conductive polymers can be used as energy storage element in:[Seanor,1982, Alvarez et al,2008]

1- Capacitors and Secondary batteries .
2- As semiconductor material in schottky diode.
3- Insulated gate field effect transitions (FET) and light emitting diodes.
4- As conductive layer for electromagnetic shelding (EMI) and electrostatic protection.

Intensive studies have been carried out on conductive polymer composites owing to their potential applications as antistatic materials , self-regulating heaters , gas sensor, etc. It is found that the electrical performance of the materials is highly dependent on composites microstructure in addition to the nature of fillers[Shui et al,2004]. This paper deals with results of the effect of LiF on the dielectric constant , dielectric loss and electrical conductivity of the HDPE-LiF composites over a range of frequency.

Experimental work

The materials used in the paper are high density polyethylene as matrix and Lithium florid as a filler.

The electronic balanced of accuracy 10^{-4} have been used to obtain a weight amount of LiF powder and polymer powder . These mixed by Hand Lay up and the Microscopic Examination used to obtain homogenized mixture .The volume percentages of LiF which eguivalent weight percentages are (0,15.5,16.26,19.37,22.77,26.5,30.6,35.1and 37.09) vol% The Hot Press method used to pressure the powder mixture. The mixture of different LiF percentages has been compacted at temperature 120^{o}C under a pressure 100 par for 10 minutes . It is cooled to room temperature , the samples were disc shap of a diameter about 30mm and thickness ranged between (1.83-2.15) mm.

The dielectric properties of HDPE-LiF composites were measured using (Agilent impedance analyzer 4294A).

In the frequency range 40-1.5×10^{6} Hz at room temperature.The measured capacitance, C(w) was used to calculate the dielectric constant ,έ(w) using the following expression:

$$\text{………………………..(1)} \quad \frac{d}{A}\,\acute{\varepsilon}(w) = C(w)$$

Where d is sample thickness and A is surface area of the sample . whereas for dielectric loss ε"(w) :

$$\varepsilon''(w) = \acute{\varepsilon}(w) \times \tan\delta(w) \quad \text{……………..(2)}$$

Where tanδ(w) is dissipation factor .

Can be calculated using the following equation : σ_{ac} The AC conductivity ,

$$\sigma_{ac}(w) = \varepsilon_o w \varepsilon'' \quad \text{………………(3)}$$

Where εo is the permittivity of free space and w is the angular frequency .

Results

The variation of dielectric constant for HDPE-LiF composites of different LiF concentration as function of frequency at room temperature is shown in figure (1) , at lower frequency range the dielectric constant of composite depends on frequency . Between 40-100kHz the dielectric constant of composite increases by decreasing the frequency for all volume fraction of LiF compare to other frequencies , the dielectric constant is independent of frequency at higher frequency range for all volume fraction of composite . The value of dielectric constant increase with volume fraction of LiF.From high frequency dielectric analysis it is clear that the increase in dielectric constant is attribute to increase in dipolar contribution which arises from LiF and the dielectric constant of composite is less than dielectric constant of LiF. But of lower frequency range in addition to the dipolar contribution there must be some other

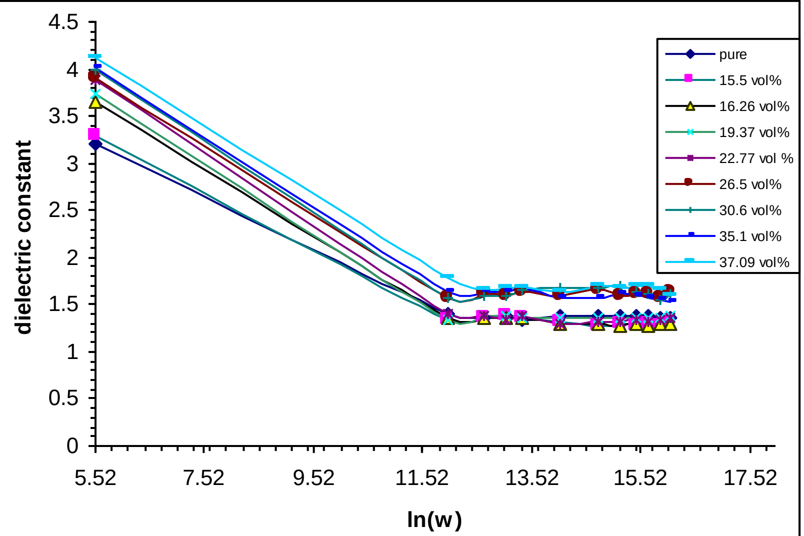

Figure (1) Variation dielectric constant with frequency for (HDPE-LiF) composite polarization contributes to increase in dielectric constant which also depends on the frequency. Since the dielectric constant depends on frequency , the possibility of existence of inter-phase has been ruled out . So the extra polarization arises from space charge polarization. At low frequency region in addition to polarization due to HDPE and LiF , the space charge polarization plays a major role in increasing dielectric constant of composite[Chiteme et al,2005, Hamzah et al, 2009]. The space charge polarization arises from the LiF/HDPE interfaces. The effect of LiF concentration on dielectric constant of HDPE-LiF composites at 100kHz is shown in figure (2). The dielectric constant increases with volume fraction of LiF at 100kHz Since the dielectric constant of LiF is greater than HDPE , we observed increase in dielectric constant with volume fraction of LiF. The increase in dielectric constant

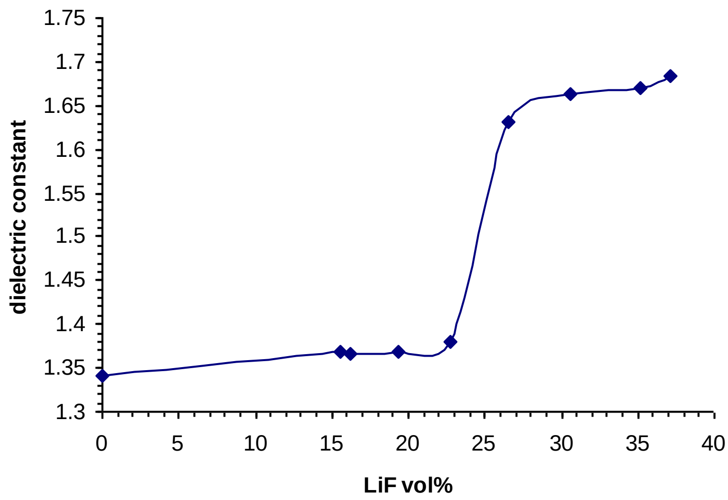

Figure (2)Variation dielectric constant with LiF concentration at 100kHz for (HDPE-LiF) composite

with volume fraction of LiF at 100kHz supports the fact of the space charge polarization contribution . The dielectric constant of composite increases with addition of LiF reflects the formation of capacitance network of LiF. As the volume fraction of LiF increases capacitance network also increases[Harun et al, 2008, Raghavendra et al,2008].

The variation of the dielectric loss of HDPE-LiF composites as a function of frequency at room temperature is shown in figure (3) , the values of ε'' are high for frequencies below 1kHz , and decreasing with frequency up to 25kHz and increases to reach maximum . At higher frequency ε'' starts to increase to even higher value . The osillatory behavior of ε'' may be due to some relaxation processes which usually occur in heterogeneous system. The relaxation peak at 100kHz is appears clealy in all low LiF concentration on specimens. The increasing of LiF concentration increases the height of the peak and increasing its broadness for these specimens. This is due to

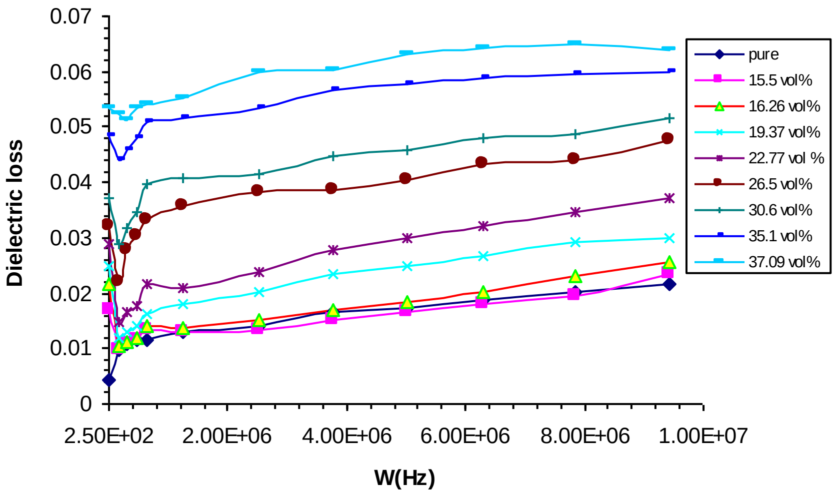

Figure (3) Variation of dielectric loss with frequency for (HDPE-LiF) composite

the overlapping of relaxation process which are attributed to some structural changes that take place in the composite as result of filler addition . The increasing of the peak height of ε'' with increasing LiF concentration indicates the enhancement of conductivity in these specimens , i.e. enhancement of losses . The decrease of ε'' in low frequency region is attributed to interfacial polarization caused by the heterogeneous nature of the system, while the sharp increase of ε'' , at high frequency region is due to setting of ohmic conductivity of charge carrier [Raghavendra et al,2007, Pillal,1980, Satapathy et al,2008] . The variation of AC electrical conductivity of HDPE-LiF composites as a function of the frequency at room temperature is shown in figure (4) . The conductivity σ_{Ac} is the increases with increasing frequency . This behavior can be explained in terms of polarization effect and hopping ,i.e. a polarization effect since the LiF concentration is insufficient to form an infinite network, i.e. the polarization effect between these finite network(cluster) as well as hopping of the electron between adjacent states , randomly distributed within these finite network[Vishnuvardhan et al, 2006, Jovic et. al, 2007, Karmakar et al,2008].

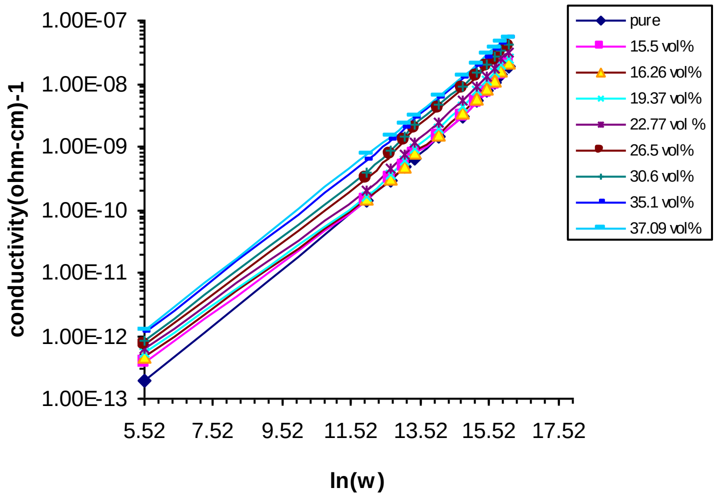

Figure (4) variation of A.C electrical conductivity Frequency for (HDPE-LiF) composite

The variation of electrical conductivity as a function of the volumetric filler content at room temperature and at 100kHz is shown in figure (5) . The figure shows that when LiF vol. % content increases the value of the bulk increases.This result can be

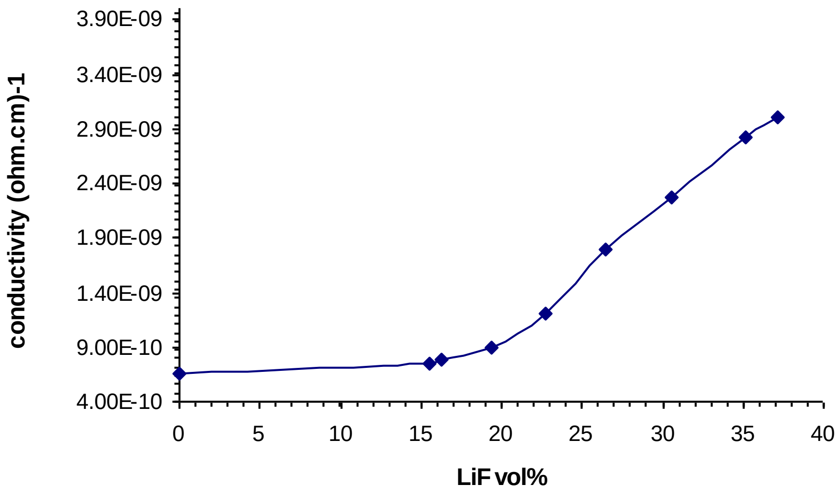

Figure (5) variation of A.C electrical conductivity with LiF vol% concentration for(HDPE-LiF) composite

Attributed to the increase in conductivity as a result of the increase charge carrier density in polymer matrix [G. Shui et al,2004, M. P. Alvarez et al,2008] .

Conclusions

1. The dielectric constant decreasing with increases the frequency and increases with LiF vol.% content .
2. The dielectric loss is oscillatory in the whole frequency region and increase with increasing LiF vol.% content .
3. The AC electrical conductivity of HDPE-LiF composites is increases with increasing frequency of applied electrical field and LiF vol.% content .

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