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STUDY OF CURRENT DENSITY OF ELECTRO-ACTIVE LOW DENSITY POLYETHYLENE POLYMER

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Abstract

In this paper, the theoretical study of current density of low-density polyethylene polymer has reported at constant temperature 308 K and 363 K. The theoretical values found reasonable agreement with experimental data. The pressure dependent constant α and β has introduced in the theoretical calculation of space charge limited current (SCLC) density which are almost matched with experimental values.

Keywords: Current Density, Electro-Active Polymer, Piezoelectric Effect, Pressure.

Introduction

Polymer based materials have attracted a great deal of attention and have many applications for electrochemical devices to perform energy conversion between the electric and mechanical forms. Polymers are attractive because they are light weight, flexible and can be conformed to complicated shape [1-5].

On the other hand, compared with inorganic materials, the electrochemical response of polymer-based materials is quite low. Especially, one of the unique features of the polymers that is, most polymers can with stand very high strain (>5%) without fatigue which is not possible in inorganic materials [6]. Electroactive polymers with high electrochemical performance are needed in order to meet the demands in the applications, such as artificial, smart skins for drag reduction, actuators for active noise and vibration controls.

Earlier, research work from several groups have demonstrated that in several electroactive polymers, strain level from the traditional piezoelectric materials can be achieved [, polymer thick film technology refers to pastes based on polymers, and sometimes organic semiconductors, which are cured at temperature (250 ^{o}C) [7-10].

The development has shown of new polymer thick film materials, in particular piezoelectric polymer thick materials, for sensor application [11-12]. In this paper, we have, therefore, extended the application of theory to explain the pressure induced electrical properties of poly-based polymer [13], including strain and stress generation capability of an actuator material.

Theory

The current density can be thought of as being made up three components made up of three components [14],

$J(t) = \sigma E + a E^2 + b E^2 + \ldots\ldots\ldots.$ (1)

With, $a = 9\, \varepsilon_0 \varepsilon_r\, \mu / 8L$............. (2)

Where ε_0 is the permittivity of free space, ε_r the dielectric permittivity, μ the mobility, b a constant and n a temperature dependent exponent equation (1) represents an approximation for the case when there is no information about the trap distribution [9].

The effect of induced pressure on current density of piezoelectric materials has been discussed in reference [13], after taking volume effects [11, 12]. The current density J at a pressure P is thus, given by

$J = [\, C(P_C/P)^{\alpha}\, \alpha \exp(-\beta P/P_c\,)]\, E + a E^2 + b E^n$ .... (3)

With, $\sigma = [\, C(P_C/P)^{\alpha}\, \alpha \exp(-\beta P/P_c]$................ (4)

Where α and β are dimensionless constant and P_c is the pressure at which the conductivity is maximum. The constant α is related to intermolecular spacing and β depends on the mean free path.

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Calculation and Discussion

The electrical conduction of low-density polyethylene has been experimentally studied intensively [15]. Here, the theoretical calculation for electrical conduction of low-density polyethylene has been studied by analytical approach by equation (3) and compared with experimental data [15].

The two contributions to the measured current, namely space charge limited current (SCLC) and power law term in the right-hand side of equation (3) are presented in figure (1) and figure (2) by dotted line and dash-dotted line respectively. In this paper, the theoretical values calculated and compared with experimental values for SCLC contribution only.

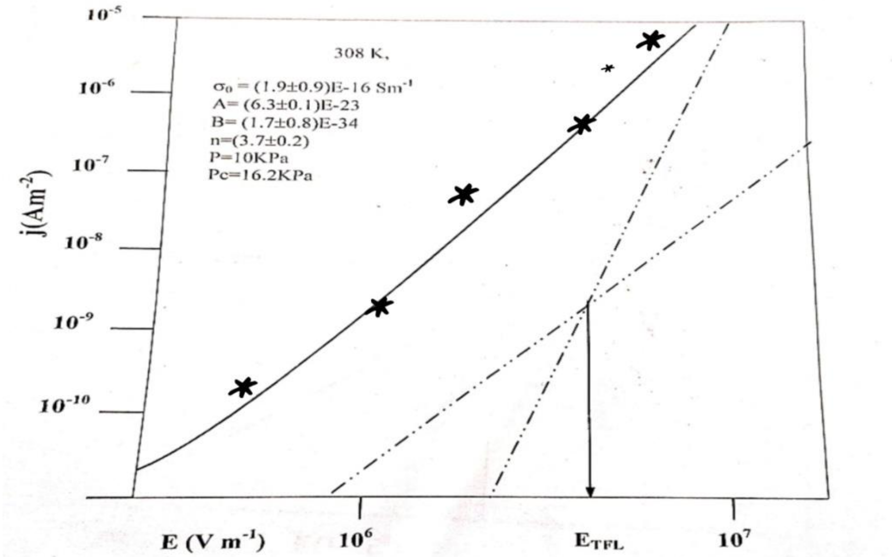

Figure 1. Current density versus applied field

In figure, the current density has studied at 308 K temperature with parameter a= (6.3 ± 0.1) E-23, b= (1.7 ± 0.8)E-34 and n= (3.7 ± 0.2) in reference [rk]. In the present calculation the constant α, β and C are calculated by using algebraic equation with pressure P=10KPa and P_c = 16.2 KPa. The value of constant α is calculated 0.3016, the value of constant β is calculated -0.1320 and constant C is -12.31. Stars are denoting theoretical values of first part of equation (3) at 308K which have reasonable agreement with experimental values.

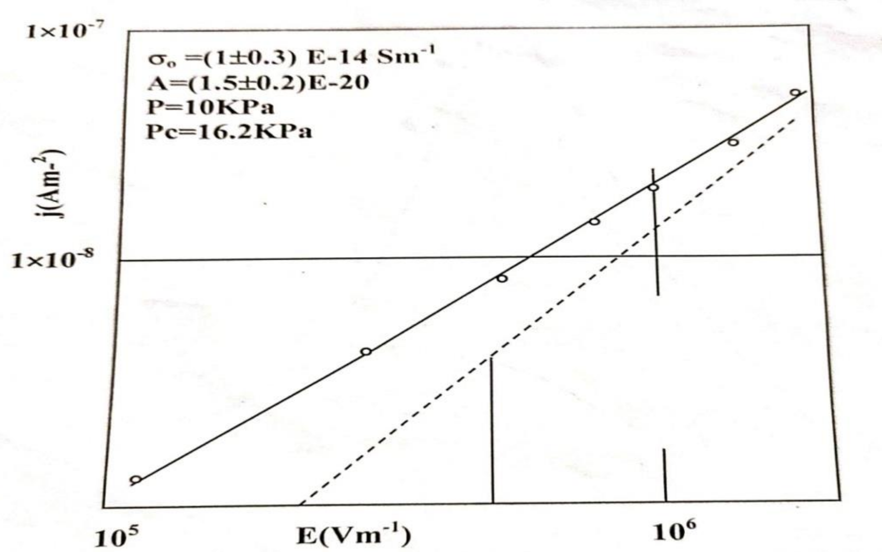

Figure 2. Current density versus field at 363 K.


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In figure (2), the current density J has studied at 363 K temperature with a= (1.5 ± 0.2) E-20 and b=0 in reference [rk]. In the present calculation constant α= 0.4583, constant β= -0.1987 and C= -10.87. Circles are denoting theoretical values of first part of equation (3) at 363 K which have reasonably good agreement with experimental values.

Table 1: Theoretically calculated parameter

Constant Temperature	α	β	C	α/ β
308 K	0.3016	-0.1320	-12.31	-2.285
363 K	0.4583	-0.1987	-10.87	-2.306

Conclusion

Space charge limited current density theoretical calculation has good agreement with experimental values accounting with induced pressure and taking volume effects. The ratio of α/ β is almost constant.

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