CHARGING OF POLYMER DIELECTRICS UNDER THE ELECTRICAL EXPOSURES

N.M.TABATABAEI
Tabriz Tarbiyat Moallem University
P.O.Box : 51745-406, Islamic Republic of Iran

A.M. HASHIMOV , R.N. MEHTIZADEH
Institute of Physics of Azerbaijan National Academy of Sciences
H. Javid av., 33, Baku, 370143

Results of research of the charged state formation are presented in some polymeric dielectrics under their treatment by strong electrical fields and electrical discharges. It is shown, that formation of electrical charge of high density takes place in investigated materials. This charge is revealed only at the material heating. The new composite material for the electrets making is offered which has the high charge density and stability.

INTRODUCTION

In polymeric materials subjected to various external effects such as a radiation, mechanical loads, high and low temperatures, strong electrical fields and electrical discharge etc., the essential change of their chemical and physical structure and, hence, their basic properties are observed [1]. Many investigators applying the direct research methods (electrical and optical microscopy, *X*-rays diffraction, infra-red spectroscopy, electron-paramagnetic resonance etc. [2]) have rather successfully solved a number of problems concerning with polymer dielectrics properties. However, despite of plenty spent researches in this field, the decision of many questions remains open.

The submited work is devoted to research of a charge formation in the film samples on base of Polyvinylidenfluoride (PVDF) subjected to electrical discharges effects. The basic purpose of given research is study of basic laws and physical mechanisms of a charging formation in polymers and composite systems under effects of the strong electrical fields and discharges.

EXPERIMENT

The samples of PVDF and composite material formed on PVDF as a base and porous adsorbent- KCM mark Silicagel (mainly consisting in silicon dyoxide–SiO_2) as a filler are used. The PVDF films of 180μ thickness were made by hot pressing from melting state at the temperature T= 170°C under the pressure P=10 MPa (100 athm). The size of initial powders was within the range of 63μ.

The filler-Silicagel was comminuted by special apparatus and in a powder state passed through a sieve for reception of the size no more than 63μ. The received powder was previously exposed to the heating treatment at T=200°C under the vacuum for 3 hours. Then the PVDF and Silicagel components in a powder state were mixed up in the vibrating mixer at a necessary volumetric proportion which accounted for 80 % PVDF and 20 % Silicagel.

Received homogeneous powder mixture of components was placed in special pressform, heated up to temperature T=170°C and pressed for 3-5 minutes. Received film samples have thickness 180 μ and size (50×50) mm^2.

The studies of charged state of the film samples subjected to effect of flame and corona types electrical discharges and thermal polarization in a constant electrical field are carried out. The charged state in samples was revealed by the thermal stimulated relaxation (TSR) method widely used at research of polymeric dielectrics [3]. At TSR method a material at first is charged (by means of polarization, corona discharge etc.) and then discharged on the current reading device at simultaneously heating with the constant speed of 1°C/min. According to TSR current function of time the value of storage charge into material may be determined.

Charging of samples by the flame discharge was carried out at AC voltage U=19кV and the current I=30μA at the distance between electrodes d=4cm. The typical TSR spectrum for a PVDF film, treated by flame discharge, is shown on fig.1, curve 1. The spectrum contains two peaks; the first of them is fixed at T=(95-100)°C, the second peak is observed at T=130°C. Obtained charge density is: σ_f=8.0x10^{-9} Coul/cm^2.

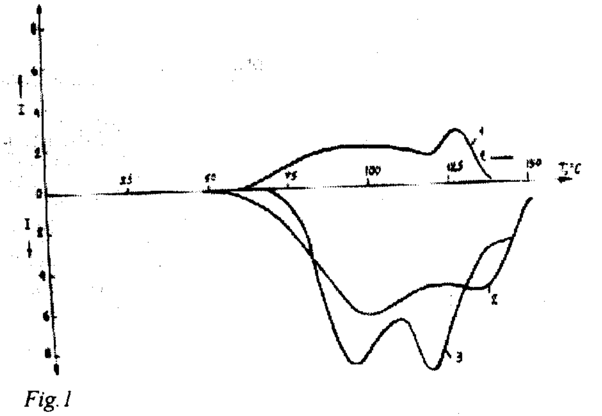

Fig.1

Charging of samples by the corona discharge at the negative polarity of coronal electrodes was carried out at U=6 кV and the current I=30μA during 30 minutes. The typical TSR spectrum for a PVDF film treated by corona discharge of the negative polarity is shown on fig. 1, curve 2. Spectrum also contains two peaks the first of them is fixed at T=(95-100)°C, the second peak is observed at T=135^{0}C. Obtained charge density is: σ_c =1.2x10^{-8}Coul/cm^2. Other kind of materials electrification used in experiments is the polarization in a constant electrical field. The investigated sample is displaced between electrodes of the heating TSR installation. There are polarization temperature T_p=130°C, polarization voltage U_p=2 кV and polarization time is 1 hour.

After the exposure during *1* hour the heating of the sample is stoped and the sample begins to cool. At achievement of a sample of the room temperature, the applied voltage is stoped and TSR spectrum is picked off. The appropriate spectrum is shown on fig. 1, curve 3. The TSR spectrum also contains two peaks, first of which is observed at T=(95-100)°C, and the second-at T=125°C. Appropriate charge density is: σ_p=2.0x10^{-7} Coul/cm^2.

Comparison of obtained results showes that all TSR spectra irrespective of a kind of an electrical effect contain two peaks and the appropriate peaks are fixed approximately in the same temperature intervals. This fact unequivocally testifies on a determining role of chemical structure and structural peculiarities of investigated materials in charge storage process.

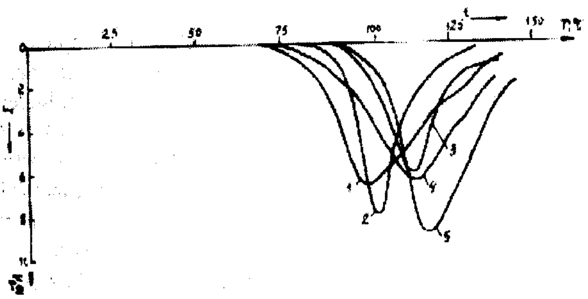

Fig.2. 1- 25°C; 2- 50°C; 3- 70°C; 4- 100°C; 5- 130°C.

Analysis of results have shown that the value of the total charge storaged in the materials treated by flame and corona discharges by an order of magnitude less than at polarization in a direct electrical field. In development of these research we spent the series of experiments on revealing of the effect of polarization temperature to the charge introduction into the material. The PVDF films were polarized in a constant electrical field at a number of temperatures (25, 50, 70, 100, 130)°C during 1 hour. The appropriate TSR spectra are shown on fig. 2.

As it is seen from fig.2, at increase of polarization temperature the TSR curves maximums shift to the higher temperatures area, however the total charge values obtained from TSR spectrum are equal in practice. The results obtained at higher electrification temperatures are apparently concerned with formation of more perfect and, hence, more stable structural units – grains.

Values of the stored charge density in PVDF and (80 % PVDF+20 % Silicagel) samples subjected to effect of the negative polarity corona discharge are equal to:

PVDF	80 % PVDF + 20 % Silicagel
σ_{PVDF}=3.9x10^{-8}Coul/cm^2 ;	$\sigma_{COMP.}$ = 1.8 x 10^{-7} Coul/cm^2 ;

These results showed that presence of Silicagel as a filler appreciable increases the stored charge in polymer composites. Research of the charged formation was carried out in the samples at various molding and crystallization temperatures of initial materials. It is obtained that at increase of initial materials molding and crystallization temperatures the maxima of peaks on TST spectra are shifted to the higher temperatures area and the values of total saved charge essentially decrease. However in case of (PVDF + Silicagel) composites these changes appear not so essential as in case of PVDF samples.

According to the linear model of amorphous-crystal polymers, we can consider that in samples subjected to electrical effect the electrical charges are trapped by both amorphous and crystal areas of a material. More less value of stored charge in moulded and crystallized samples at higher temperatures is connected with increase of a material crystalline degree, with defects reduction and formation of the more perfect crystal structural units in a material. The trapping of electrical that is charges in such materials carried by centres located in the amorphous areas which have insignificant sizes is the reason of stored charge reduction.

The stability of stored charge values in PVDF+Silicagel composites at increase of molding and crystallization temperatures is connected, obviously, with insignificancess of structural changes in a material.

The shifting of a current maximum to the higher temperatures area on TSR spectrum is caused by with a charge releasing from deeper trap levels and with more perfect structure.

CONCLUSIONS

1. Formation of electrical charge of high density takes place in dielectric film materials under the treatment by strong electrical fields and electrical discharges.
2. The value of stored charge in polymeric materials is in many respects determined by their above-molecular structures.
3. Charged state formation in materials is caused mainly by their amorphous areas.
4. The new composite material for the electrets making is offered. Material including the polymer PVDF and fine-pored Silicagel has the high charge density and stability.

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N.M.Tabatabaei, A.M. Həşimov, R.N. Mehdizadə

ELEKTRİK TƏSİRLƏRİ VASİTƏSİLƏ POLİMER DİELEKTRİKLƏRİN YÜKLƏNMƏSİ

Təqdim olunan məqalədə güclü elektrik sahələrinin və elektrik qazboşalmalarının təsirlərinə məruz qalan bəzi polimer dielektriklərdə yüklü vəziyyətlərin yaranmasının tədqiqindən alınmış nəticələr verilmişdir.

CHARGING OF POLYMER DIELECTRICS UNDER THE ELECTRICAL EXPOSURES

Müəyyən edilmişdir ki, tədqiq edilən materiallarda yüksək sıxlığa malik olan elektrik yükləri cəmlənir. Bu yüklər yalnız material qızdırıldıqda özünü büruzə verir.

Yüksək elektrik yüklərinin sıxlığına və bu yüklərin davamiyyətli zaman müddətində stabilliyinə malik olan, yeni kompozisiyalı elektret materialı təklif edilmişdir.

Н.М. Табатабаеи, А.М. Гашимов, Р.Н. Мехтизаде

ЗАРЯДКА ПОЛИМЕРНЫХ ДИЭЛЕКТРИКОВ ПРИ ЭЛЕКТРИЧЕСКИХ ВОЗДЕЙСТВИЯХ

В работе представлены результаты исследования образования заряженного состояния в некоторых полимерных диэлектриках при их обработке электрическими полями и разрядами.

Показано, что в исследуемых материалах имеет место накопление электрического заряда высокой плотности. Этот заряд выявляется только при нагревании материала.

Предложен новый композиционный материал для изготовления электретов, обладающий высокой плотностью заряда и его стабильностью.

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