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THERMO-STIMULATING IONIC CURRENTS IN POLYMERS IN THE ENVIRONMENT OF OZONE GAS

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Abstract- The results obtained from the study of electrically charged conditions in poly-triftorchlorethylene and recrystallized poly-vinylidene fluoride materials which are exposed to the effects of intermittent gas discharge in the environment of ozone, ozone + $5F_6$, and arachnoid gases are interpreted in the article. Experimental results on the relations between the chemical composition, structure and electro-physical properties of materials are obtained in the study.

Keywords: Spherolite, Fibril, Structure, Poly-Triftorchlorethylene, Poly-Vinylidene Fluoride, Recrystallization Electrical Charges, Emission, Ion Current.

I. INTRODUCTION

It is theoretically and practically important to study the changes occurring in wear and tear, destruction, deformation, and other physical and mechanical properties of linear polymer systems with amorphous-crystal structure in the environments having strong physical and chemical effects. So, first of all, it brings forth the necessity of the expansion of the application areas of polymer materials, as well, production and storage of acid and alkaline substances, electricity production and an increase in power field tension and powers in transmitting it to remote distances and extensive use of polymer materials in other modern technological processes [1-8].

Wear of polymer materials used as electrical insulation material in physical devices and plants that generate strong electrical fields and electric gas discharges as a result of long term operation and finally losing its insulating feature, being exposed to electrical puncture are mostly related to the occurrence of destruction process in polymer material as a result of the influence of ozone gas.

Electrically charged situations are studied as a result of the influence of intermittent gas discharge in poly-vinylidene fluoride (PVDF) in the environment of ozone (O_3) gas and elegas (SF_6) + O_3 gas mixture and poly-triftorchlorethylene materials in the environment of O_3 and argon (Ar) gas in the presented research work. Ozonizer included in the electrical system presented in Figure 1 was used in the studies to ensure the generation of ozone gas.

Electrical circuit comprises high voltage transformer, gas discharge reactor (ozonizer), kilo-voltmeter, ammeter, milli-ammeter, dischargers and other relevant elements.

A system of electrode was placed with a distance of 3 mm between two plane electrodes one of them being with high variable tension and another one being earthed that are screened with glass covering with a thickness of 1 mm within the closed system connected to the output of ozonizer. Research sample with a thickness of 1 mm is placed on the earthed electrode. Research sample was obtained by means of cooling alloy in room temperature made with a method of hot pressing of polymer powder.

Ozonizer is connected to extremely high vacuum device together with close system connected to its output and atmospheric air is given to the system up to the atmospheric pressure through compressor after $P=10^{-5}$ Pa vacuum is obtained within the system, and ozonizer is operated, thus, it becomes possible to ensure the influences of gas discharge to the polymer material in the environment of ozone gas in the system. Coordinating the closed system with mass spectrometer, opportunities of studying the influence of changes in the surface of polymer material on gas environment were achieved. Thermo-stimulated relaxation method was used to study electrically charged situations.

Scheme of intermittent electrical gas discharge used in the studies is presented in Figure 1. The surface of potential electrode is covered with glass coating with a thickness of 0.8 mm.

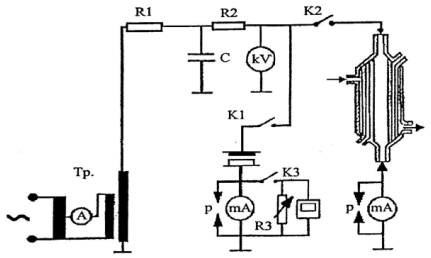

Figure 1. Electrical circuit of intermittent gas discharge

II. PROBLEM DESCRIPTION

Thermo-grams characterizing the accumulation of electrical charges in PVDF and poly-triftorchlorethylene materials in the environment of the mixture of ozone gas, Ar and SF_6 +O_3 gas are presented in Figure 2. Crystalling temperature of PVDF polymer was T_{kr}=60 °C. Crystalling temperature of poly-triftorchlorethylene was T_{kr}=185 °C.

It becomes clear from the analysis of thermos-grams that the existence of fluorine and ozone atoms as a result of intermittent gas discharges caused the accumulation of quite intensive electrical charges in PVDF and poly-triftorchlorethylene materials.

It should be noted that less amount of electrical charges accumulated in the surface when intermittent electrical discharge influences poly-triftorchlorethylene material in the environment of O_3 gas was explained by weakening of the influences of O_3 gas and F ions on the surface of material, Cl atoms forming a number of chemical compositions together with CO, ClO and ClO_2 and F atoms included in the volume as a result of emission process from the surface.

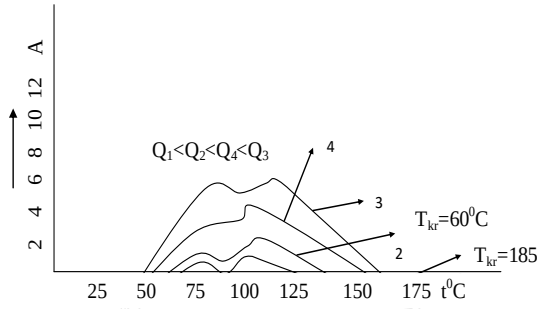

Figure 2. Thermo-grams characterizing the accumulation of electrical charges in the materials of PVDF in the environment of ozone gas and SF_6 + O_3 gas mixture and poly-triftorchlorethylene in the environment of ozone and Ar gas
1. TSR thermos-gram from poly-triftorchlorethylene sample in the environment of ozone gas.
2. TSR thermos-gram from the surface of PVDF material as a result of influences of intermittent gas discharge in the environment of ozone gas
3. TSR thermos-gram from PVDF material in the environment of SF_6 + O_3 gas mixture
4. TSR thermos-gram from poly-triftorchlorethylene material in the environment of argon gas

It should be noted that the influence of chlor atoms on the ozone gas causes the rapid decomposition of the ozone gas and in this case, realization of the following reactions is possible [10]:

$Cl_2 + O_3 = ClO + ClO_2$, $ClO + ClO = Cl_2 + O_2$

$ClO_2 + O_3 = ClO + 2O_2$, $Cl + O_3 = ClO + O_2$

$ClO + O_3 = ClO_2 + O_2$, $Cl + ClO_2 = 2ClO = Cl_2 + O_2$

Oxidizing influence of ozone gas occurs with different mechanisms:

1. Only one atom oxygen takes part from ozone molecule in the process of oxidization;
2. Three oxygen atoms of ozone molecule take part in the process of oxidization;
3. The process of oxidization is realized by the combination of the atoms of the affected material with ozone molecule.

On the other hand, it was observed that if poly-triftorchlorethylene is affected by intermittent gas discharge in the environment of Ar - inert gas, quite high electrical charges are accumulated in the material. If poly-triftorchlorethylene is crystallized in the temperature of T_{kr}=185 °C within 40 minutes, dimensions of its structural elements (long repeating period) are more than 500 A [11] and it increases non – homogenous nature of the material and respectively, the amount of defects which in its turn causes the increase in the accumulation of electrical charges.

It became clear from the results of experiments that processing (abrasion) of the surface of polymer materials through the influences of intermittent electrical gas discharge is more effective method than other types of gas discharges. In case of intermittent gas discharge, the influence covers the whole surface of material.

As a continuation of experiments, samples with a thickness of 1.2 mm and crystallizing temperature of T_{kr}=60 °C were prepared to increase the amount of defects in PVDF material and respectively, increase electrical charges accumulated in PVDF. After the prepared samples were deformed 300% in one axis direction in the room temperature, deforming samples cut under α=40, 60, 80 and 90° in relation to C axis of macro-molecules from those samples in new direction, thermos-grams reflecting electrically charged situations formed as a result of the influence of intermittent gas discharge in the environment of ozone gas were recorded (Figure 3).

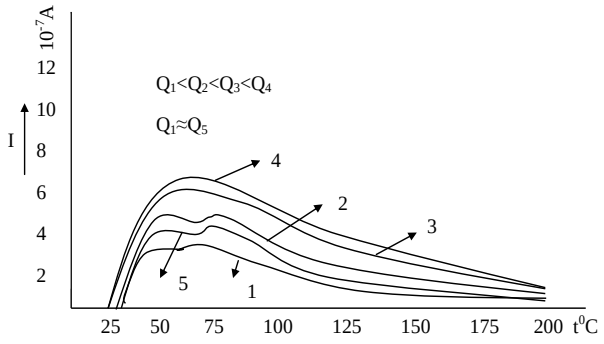

Figure 3. Thermo-grams reflecting electrically charged situations formed as a result of the influence of intermittent gas discharge in the samples cut and deformed under α=40, 60, 80 and 90° in relation to C axis of macro-molecules from PVDF material deformed as ε=300% in the environment of ozone gas
1. α=0°, ε=300% ; 2. α=40°, ε=50% ; 3. α=0°, ε=90%
4. α=80°, ε=210% ; 5. α=90°, ε=285%

It should be noted that when the samples cut under 40; 60; 80 and 90° from the initial sample deformed 300% in one axis direction are deformed in new direction, polymer material is exposed to the process of recrystallization, so, when the samples cut under 40, 60 and 80° are deformed in new directions, the initial structure is partially destroyed and the process of formation of a new structure occurs. In these cases, the possibility of the formation of numerous defects in the material between double structure existing in the polymer increases.

When the sample cut under 90° is deformed in new direction, the process of recrystallization in the material is finalized and C axis of macro – molecules is in a perpendicular state to C axis of the initial sample, in this case, older structural elements in the sample disappear and analogical structure in new direction is formed. It should be noted that it is seen from the comparisons of thermos-grams 1 and 5 that (in both cases material is characterized with fibrillary structure) the amount of electrical charges accumulated in polymer is approximately same. It becomes clear from the results of the study that as defects increases in the material, the amount of charges accumulated in the materials also increases, at the same time, it arises from the factor of memory in the material.

Electrical charges calculated from relevant telegrams are presented in Table 1 and 2.

Table 1. Electrical charges accumulated in polymers as a result of the influence of gas discharge on materials in the different gas environments

Study environment	Polymer	$Q\times10^{-7}$ KPa
O_3	Poly-triftorchlorethylene	5.4
O_3	PVDF	6.8
$SF_6 + O_3$	PVDF	9.2
Ar	Poly-triftorchlorethylene	7.8

Table 2. Electrical charges accumulated in PVDF material

Study environment	Polymer	Angle of cutting α°				
O_3	PVDF	0	40	60	80	90
		ε%				
		300	60	90	210	289
		$Q\times10^{-7}$ KPa				
		6.9	7.4	9.8	7.8	7.2

III. CONCLUSION

So, it becomes clear from the study conducted and reference information that depending on the chemical composition of polymers and the structure formed by macro – molecular set, when materials are affected in different gas environment by means of strong power fields and electrical gas discharges, the following physical and chemical processes are observed:

- The emission of atoms and molecules comprising polymers exposed to the influences of electrical gas discharges is observed.
- As rapid gas reactions are realized as a result of conversion in the volume of gas discharge, the environment of gas discharge sharply differs from the initial environment.
- There are destruction processes in the materials as a result of the influence of gas discharge on polymers.
- It was determined that the efficiency of the accumulation of electrical charges in polymers exposed to the gas discharges can be regulated through superior molecular structure formed in the material.

The results of the study is of importance in terms of being basis for forecasting the operation terms of polymer materials widely used as an insulating material in relevant industrial fields and the use of polymers as an electrical material.

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Arif Mamed Hashimov was born in Shahbuz, Nakhchivan, Azerbaijan on September 28, 1949. He is a Professor of Power Engineering (1993); Chief Editor of Scientific Journal of "Power Engineering Problems" from 2000; Director of Institute of Physics of Azerbaijan National Academy of Sciences (Baku, Azerbaijan) from 2002 up to 2009; Academician from 2007; the First Vice-President of Azerbaijan National Academy of Sciences from 2007 up to 2013; and Director of Azerbaijan Research Institute of Energetics and Energy Design from 2014 till now. He is laureate of Azerbaijan State Prize (1978); Honored Scientist of Azerbaijan (2005); Cochairman of

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