THE ELECTRIC AGEING OF THE POLYETHYLENE AND POLYPROPYLENE POLYMER MIXTURES IN THE REGION OF LOW ADMIXTURES OF ONE OF THE COMPONENTS

A.A. ALIYEV

The Institute of Radiation problems, Azerbaijan NAS,
370143, Baku, H. Javid ave. 31"a"

The influence (1-10 weight %) of polypropylene (PP) concentrations in polyethylene (PE) upon the durability to the electric ageing was studied. It is shown, that the injection of the low (1-2 weight %) PP concentrations into PE increase the PE durability to the erosion and oxidation, caused by the electric discharge effect and leads to the growth of the PE electric solidity.

INTRODUCTION

One of the reasons of the high-voltage insulation break is the development of the electric discharge in the place of the gas inclusion inside the insulation [1]. The second main reason of the insulation break under the long influence of the electric field is the appearance and development of the partial break channels in the parts with the sharp heterogeneity field, i.e. dendrites or triings, leading to the gradual loss of the material mass (erosion) and the local reduction of its thickness and at last to its full break.

In order to increase the high-voltage polymer insulation lifetime it is necessary to create the material, having the monolith structure (with the minimal number of the gas inclusion and heterogeneities), and having the resistance to the electric discharge effect.

Recently the polymer mixtures have attracted the researcher attention. The obtained materials have the complex of the new properties, which are absent at the initial polymers [2].

There are a number of works, devoted to the research of the PP-PE mixtures with the purpose of the PP shock strength increase, fragility temperature drop, but there is no information on the research of the PP-PE mixtures with the purpose of the application as a polymer insulation.

The properties of the polymer mixtures, components of which do not come into the chemical interaction with each other, essentially depend on its structure, which, in its turn, is determined by the concentration relationship between the components, with the increase of the component content in the matrix of another the mixture structure passes by the sequence the row of stages: the solution, the region of the interphase dissolution, the dispersed microheterogenous structure, the coagulation net, the inversion structure [3].

It might be supposed, that the mechanism of the polymer mixture damage under the influence of the external factors will also essentially depend on the concentration relationship between components.

THE EXPERIMENTAL PART

The work purpose is to investigate the electric ageing of the polypropylene (PP) and polyethylene (PE) mixtures films in the region of the low (up to 5-10) weight % of one of the components. The mixtures PP with PE were prepared from non-inhibited isotactic powders PP (the average weight mass $\overline{M}_\omega = 2.86 \cdot 10^5$, the average numerical molecular mass $\overline{M}_n = 6.23 \cdot 10^4$, $\overline{M}_\omega / \overline{M}_n = 4.6$, the crystallization degree $\chi = 64$) and PE $/\overline{M}_\omega = 4.15 \cdot 10^4$, $\overline{M}_n = 2.71 \cdot 10^4$, $\overline{M}_\omega / \overline{M}_n = 1.53$ $\chi = 49$) on the ball mill during 60 minutes with the following passing through the microextruder with the three regulated temperature bands-140, 160, 190°. The isotropic films were obtained by the extrudate pressing during 30 minutes at 200° and the pressure 200 atm. on the substrate from the polyimide film. The film thickness makes 100-120 mcm. The film were tempered in water at 30°C right after the pressing.

The influence of the electric discharge is realized in the asymmetric test cell, composed of the flat metal electrode, on which the tested sample of the polymer film was placed, with the air gap of the value 1.5 mm and the glass plate of the same thickness: the high electric voltage U=9 kV of the industrial frequency was applied to the metallized cover on the interface of the glass plate.

The sample weighing before and after the influence was made on the balance VLP-200 to a precision up to 0.05 mg. The oxidation is followed by the band of the carbonyl (C=0) groups at 1720 cm^{-1} by means of the UK-spectrophotometer. The electric strength E_{str} is determined on the current of the industrial frequency as the arithmetical average from the results of 10 independent relations measurements. U_{br} /h, where U_{br} is the break voltage, increasing with the velocity 2kV/s, h is the average thickness round the break place. The tangent of the corner of the dielectric losses $tg\delta$ and the dielectric constant ε of the films were measured by means of the bridge P-589.

RESULTS AND THEIR DISCISSION

The results of the polymer compositions PE-PP test are presented in the table 1. It is seen from the table 1, that the admixture of PP (0-5%) in PE causes the negligible changes of the electric characteristics of the following compositions.

The polyethylene and polypropylene are incompatible polymers. PE crystallizes in more stable orthorhombic lattice, while PP in the monoclinic shape. However, both components have the mutual influence on the crystallization process and the low-molecular structure formation [3-7].

The injection of the low (1-2 weight %) concentration PP in PE increases the PE resistance to the erosion and oxidation, caused by the electric discharge effect (fig.1 and 2).

Table 1.

The polymer compositions PE-PP characteristics

Sample	PE	PE+0.5%PP	PE+1%PP	PE+2 %PP	PE+5 %PP
Characteristics					
E_{str} кV/mm	118	116	120	118	116
$tg\delta \cdot 10^{-4}$	7	6	5	4	6
ε	2.2	2.4	2.8	2.9	2.7
Lg (ρ_v, ohm*m)	14.5	13.8	14.6	14.3	14.2

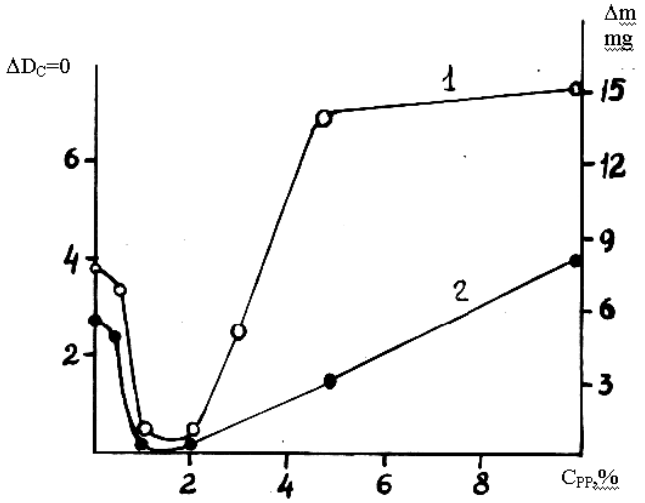

Fig. 1. The dependence of the mass losses Δm (1) and the oxidation degree (2) of the PE sample versus the PP content U_{agi}= *9 kV*, t_{agi}=20 hours.

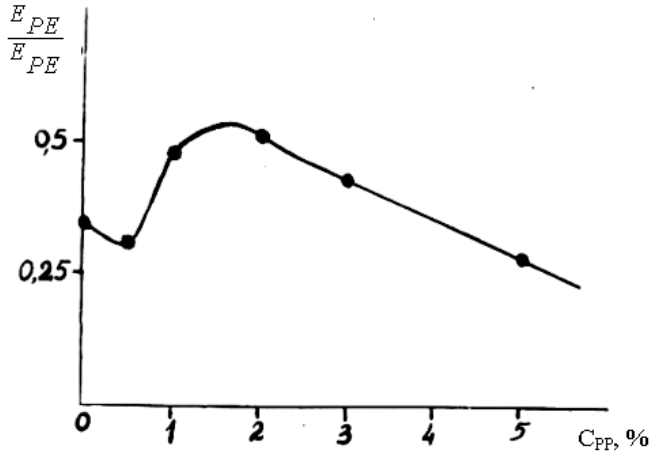

Fig. 2. The dependence of the electric strength E_{str} of the PE samples with the various PP content: U_{agi}= 9 kV, t_{agi}=10 hours.

It is known, that PP is less stable to the electric discharge influence, than PE, what is explained by the presence of the tertiary atoms of the carbons in the macromolecules. Actually, for 20 hours of the electric ageing in our conditions the mass decrease at the individual PP has made about 20 mg; but at the individual PE it is only 8mg.

It is seemed, that the injection of PE in PP should increase its resistance to the electric discharge influence and vice verse, however, it is not observed in the region of the low admixtures. The external nature of the mass and oxidation loss in the region 0.5-1 weight % PE in PP and in the region 1-2 % PP in PE may be explained by means of the interphase layer presentations.

According to [8,9] the external nature of the changes of the polymer mixtures properties in the region of the very low admixtures of one of the components (modifier) is explained by the spilling of the polymer solution at the determined modifier content, its emission in the dispersed phase and the formation of the interphase layer with the specific properties. The modifier may form the reinforced cage or fill the structural defects of the polymer matrix, i.e provide more small and one-phase structure or vice verse, expand the matrix structure and increase its defects.

Therefore, the reduction of the free volume occurs at the injection of the low admixture of PP in PE, the interphase layer becomes more dense, and the resistance to the electric ageing becomes maximal (table 2)

Table 2

The polymer compositions characteristics after the electric ageing

Sample-characteristics	PE	PE+0.5%PP	PE+1%PP	PE+2%PP	PE+5%PP
E_{str} кV/mm	43.0	38.0	60.0	64.0	32.0
$tg\delta \cdot 10^{-4}$	95.0	80.0	26.0	32.0	78.0
ε	3.2	3.8	4.7	4.8	4.2
lg, ρ_v, ohm*m	9.32	9.47	11.6	10.6	9.4
Δm, mH	7.5	6.6	0.87	0.93	14.8
ΔD_c=0	3.75	3.56	0.03	0.02	1.48

At the moment of the interphase spilling a number of the modifier particles of the small sizes are formed and the value of the interphase layer is maximal. The particles sizes increase with the further growth of the modifier content and their concentration falls [10] and the interphase layer reduces.

Actually, in our case the sharp oxidation reduction and the mass loss under the influence of the partial discharges, and also the electric strength growth are observed after the concentration of PP 1 weight % in PE.

[1] *A.N. Tzikin, S.N. Katkov*. Elektricheskoye stareniye polimernoy izolyatzii. L: Ximiya, 1968.
[2] *A.A. Popov, A.V. Russak, M.P. Gladilin, G.E. Zaykov.* Visokomolekulyarniye soyedineniya: A, 1986, v.28, №5, pp.1083-1087.
[3] *O.F. Noel, I.F. Carley*. Polymer Eagng Sci. 1975, v.15, p.117.
[4] *R.B. Robertson, D.R. Raul*. .J. Appl. Polymer Sci., 1973, v. 17., № 8., p. 2579.
[5] *J.W. Ten.* J., Appl. Polymer Sci., 1983, v. 28, №28, №2,. p. 605.
[6] *G. Ragosta, R. Greco, E. Martuscelli*. Polymer, 1982, v.23, №3, p. 466.
[7] *A.J. Lovinger, M.L. Williams.* J. Applied Polymer Sci., 1980, v. 25, №8, p. 1703.
[8] *Y.S. Lipatov, Y.V. Lebedev.* Phis.-khim. Mekhanika i liophilnost dispersnikh system. Resp. Mejved. Sb., Kiev, Naukova dumka, 1982, №14, p.3-13.
[9] *V.N. Kuznetzov, V.D.Klinov, L.V.Kandirin, L.V. Vergilin*. Phis-khim. mekanika i liophilnost disperstnikh sistem/ Resp. Mejved. Sb., Kiev, Naukova dumka, 1982, №14, p.14-20.
[10] *M.A. Novikov*. Visokomolekulyarniye soyedineniya, 1978, 20B, №3, p.224-226.
[11] *M.A. Bagirov, V.P. Malin, S.A. Abassov.* Vozdeystviye elektricheskikh razryadov na polimerniye dielektriki, Baku "ELM", 1975, p.167.
[12] *A.A. Aliyev, M.A. Bagirov, N.D. Huseynov, V.P. Malin, A.A. Popov.* Avtorskoye svidetelstvo №1515203, A1, 1989.
[13] *M.A. Bagirov, V.P. Malin, A.A. Aliyev, A.M. Gorbunov, N.D. Huseynova.* Elektroizolyatzionniye smesi polietile-polipropilen s malim soderjaniyem odnogo iz komponentov. Sb. trudov Az PI im. Ch. Ildirima, Baku, 1989, p.3-8.

A.Ə. Əliyev

POLİETİLEN VƏ POLİPROPİLEN POLİMER QARIŞIQLARIN KOMPONENTLƏRİNDƏN BİRİNİN KİÇİK AŞQARLAR SAHƏSİNDƏ ELEKTRİK «QOCALMASI»

Polietilenə polipropilenin müxtəlif konsentrasiyaları daxil edilməklə (1-10 çəki%) elektrik «qocalmasına» qarşı dayanıqlığı öyrənilmişdir. Həmçinin, polietilenə kiçik konsentrasiyalı (1-2% çəki ilə) polipropilenin əlavə edilməsi ilə polietilendə elektrik boşalmalar nəticəsində yaranan eroziya və oksidləşməyə qarşı dayanıqlığın və elektrik möhkəmliyin artması göstərilmişdir.

А.А. Алиев

ЭЛЕКТРИЧЕСКОЕ «СТАРЕНИЕ» ПОЛИМЕРНЫХ СМЕСЕЙ ПОЛИЭТИЛЕНА И ПОЛИПРОПИЛЕНА В ОБЛАСТИ МАЛЫХ ДОБАВОК ОДНОГО ИЗ КОМПОНЕНТОВ

Изучено влияние (1-10 вес %) концентраций ПП в ПЭ на стойкость к электрическому старению. Показано, что введение малых (1-2 вес %) концентраций ПП в ПЭ повышает стойкость ПЭ к эрозии и окислению, вызванному действием электрических разрядов и приводит к возрастанию электрической прочности ПЭ.

Received: 24.02.03