DIELECTRIC PROPERTIES of COPOLYMERS OF ETHYLENE WITH α - OLEFINES AFFECTED BY ELECTRIC DISCHARGE

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ABSTRACT

Dielectric permittivity and tangent of loss angle (ε, tgδ) of ethylene α - olefine copolymers affected by electric discharge are considered. It is shown, that afterwards electric ageing the studied copolymers, dielectric properties do not practically change, despite certain structural changes confirmed by the IRS analysis.

Keywords: dielectric properties, comonomers, CEP: a copolymer of ethylene-propylen, CEH: a copolymer of ethylene-hexane, PEHD: polyethylene of higher density.

I. INTRODUCTION

The aim of this article is introducing more precise definition of role of physico-chemical structure, composition and a size of lateral branching of copolymers in the process of electric ageing in macroscopic characteristics, i.e. on dielectric permittivity (ε) and a tangent of loss angle (tgδ). However, even until ageing, the molecules of researched polymers might be both polar, and unpolar. Such a state is conditioned by possibility of a symmetric arrangement of atoms and atomic groups in relation to carbon atoms in the main chain as well possibility of mutual compensation of dipole moments of polar branching. It is known, that afterwards electric ageing the polar and not polar state of molecular structure can change, as in the process of electric ageing the new polar groups are generated. Appearance of new polar groups, basically, should lead to alteration of value of dielectric permittivity (ε) and a tangent of loss angle (tgδ). But with this it is necessary to take into account such important circumstances, as first, lessening an effect caused by polar groups, with increase of a macromolecule size; secondly, a value of alteration of dielectric permittivity with other equal conditions depends not only on number of polar groups (dipoles) in a unit of substance volume, but also on a value of dipole moment of the given polar group; thirdly, the value of dielectric permittivity may be exerted by the influence of only those molecules with polar groups, the axes of which coincide with the orientations of the external field [1,2].

II. MAIN PART

Experimental results (tables 1 and 2) show that ε and tgδ afterwards electric ageing ($U_{ag.}$=10κV, $t_{ag.}$= 3h) slightly differ from the initial value. Lessening share of polar groups in whole mass of molecule with increase of molecular weight accounts for absence of expected considerable changes. An existence of polar groups noticeably influences on a value ε only in case of compounds with molecules of small size. For the molecules of greater size as in case of our samples, the effect is not substantial (fig. 1 a, b).

Table 1

The values of ε and tgδ for the initial samples and the samples afterwards electric ageing $U_{ag.}$=10κV, $t_{ag.}$ = 3h, for the different marks of polyethylene.

№	Samples of polyethylene	ε		$tg\delta \cdot 10^{-3}$	
		İnitial values	Values afterwards electric ageing	İnitial values	Values afterwards electric ageing
1	PEHD ($I_{P.}$ = 0,6)	2,30	2,40	0,96	9,95
2	PEHD ($I_{P.}$ = 3,0)	2,25	2,30	0,62	2,90
3	PEHD ($I_{P.}$ = 5,5)	2,50	2,50	0,60	3,50
4	«Marlex» - 6001	2,40	2,45	1,20	2,24
5	«Marlex» - 6006	2,20	2,30	0,60	3,00

Table 2

The values of ε and tgδ for the initial samples and the samples afterwards electric ageing $U_{ag.}$=10κV, $t_{ag.}$ = 3h, for copolymers ethylene–propylene and ethylene–hexane of different composition.

№	The samples of CEP and CEH, of different composition, mol %	ε		$tg\delta \cdot 10^{-3}$	
		İnitial values	Values afterwards electric ageing	İnitial values	Values afterwards electric ageing
1	CEP - 10 %	2,30	2,40	2,30	2,45
2	CEP - 15 %	2,30	2,35	2,00	2,40
3	CEP - 25 %	2,40	2,45	0,90	2,30
4	CEP - 40 %	2,20	2,35	1,80	2,25
5	CEH - 10 %	2,80	2,80	1,80	2,35
6	CEH - 15 %	2,70	2,95	1,70	2,48
7	CEH - 25 %	2,60	2,70	1,60	2,02
8	CEH - 40 %	2,60	2,60	1,40	2,12

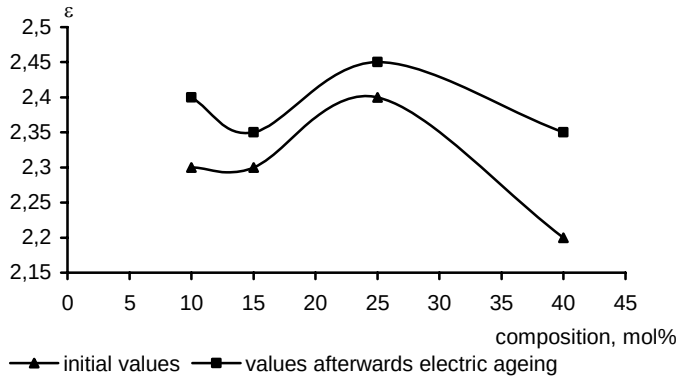

Fig. 1 (a) Dependence of dielectric permittivity before and afterwards electric ageing on composition of CEP

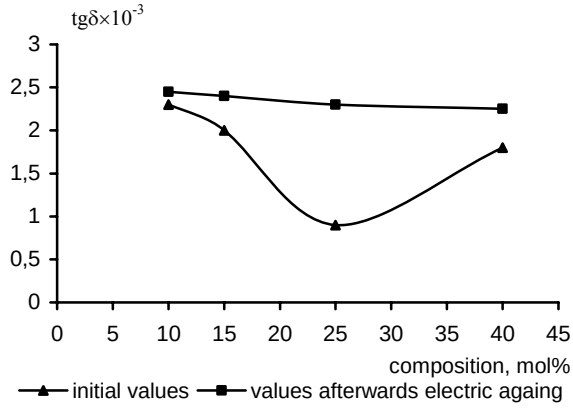

Fig. 1 (b) Dependence of dielectric loss angle before and afterwards electric ageing on composition of CEP

It is seen in table 2 that at change of the second comonomer in the composition of copolymer in the range of 10 up to 40моль %, ε does not almost change, but tgδ alternates very slightly, what by absolute values is of not practical value. Analogous results are also observed when studying dependences ε and tgδ on length of lateral branching. Therefore, despite that the changes of composition and the size of lateral branches promotes acceleration of the process of electric ageing, they are not heavily reflected in the values of dielectric properties. Obviously, the macromolecule having symmetric or asymmetrical polar groups (OH, CO, and etc.) is in saturated state and behaves as unpolar molecule, having no dipole moment [5], or there are more essential reasons which have not been established yet [4].

It is seen in IR-spectrum of ethylene–propylene copolymer afterwards electric ageing ($t_{ag.}$=3h. $U_{ag.}$=4÷10κV) (Fig.2) with molecular composition in 15 mol % of the second comonomer, that in the region of a spectrum of 1500-1700 sm^{-1} there are observed the new absorption lines corresponding to carbonyl groups. It should be noted, that valent carbonyl absorption ν(CO) is applied more often than often characteristic frequency groups used in the works on determining changes of a structure as it gives the direct information, concerning existence or absence of some functional groups. Carbonyl absorption is almost intensive and lies within the region of characteristic frequencies of groups 1820-1620$см^{-3}$.

Our copolymers may be considered as two-component system. The process of electric ageing is not volumetric process, as only surface layer of the samples are subjected to structural changes and correspondingly, the polar groups observed in IR-spectra, are accumulated on thin surface layers. However, ε and tgδ are connected with the polarization taking place in vary volume of the sample not on surface layers.

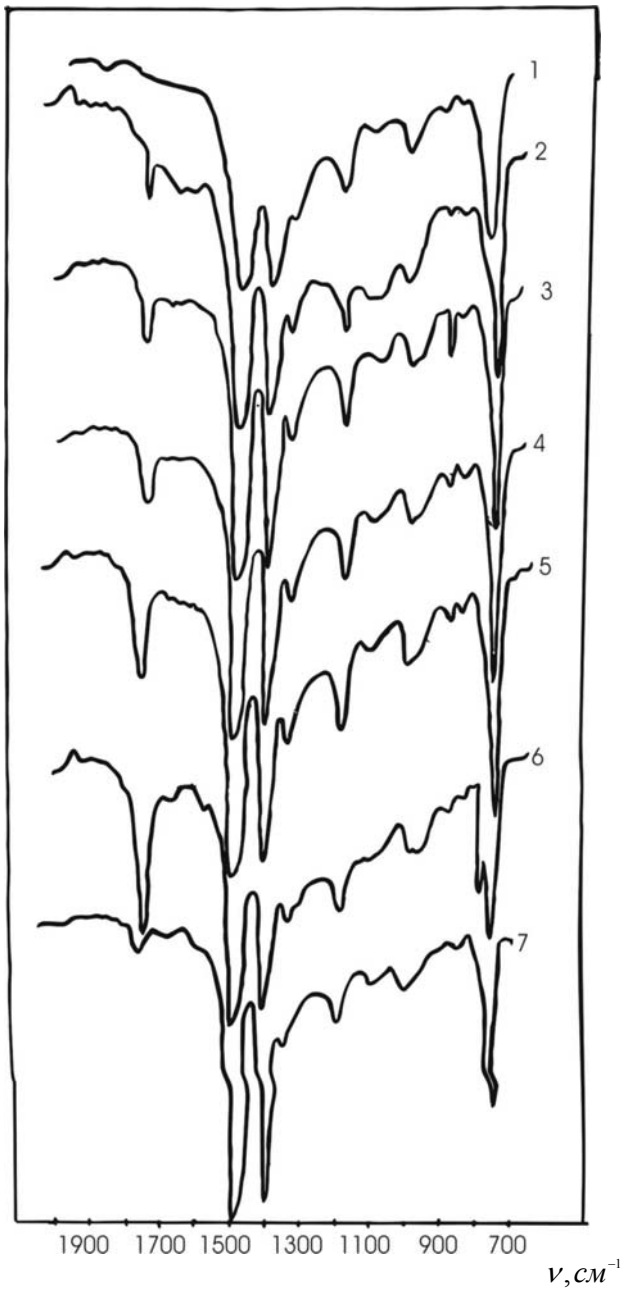

Fig.2 IR-spectrum CEP-15 % subjected to effect of electric discharge on condition that: $t_{ag.}$ = 3h and at different values of $U_{ag.}$:
1. The initial sample; 2. $U_{ag.}$=4κV; 3. $U_{ag.}$=5κV; 4. $U_{ag.}$=6κV; 5. $U_{ag.}$=7κV; 6. $U_{ag.}$=8κV; 7. $U_{ag.}$=10κV;

III. CONCLUSION

Thus, on the basis of obtained experimental data we may conclude: under effect of ionization processes emerged at gas insulations of polymer dielectric, the changes of structure occur, mainly, on surface layers of air pores of dielectric. On surface layer of polymer a new structure emerges due to the products obtained as a result of its physico-chemical regeneration. Structure changes of surface layer of the pores under electric ageing observed on IR-spectrum, mainly, influence on durability, than dielectric properties of polymer dielectric [6].

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