DURABLE PROPERTIES AND STRUCTURE OF COMPOSITIONS OF POLYPROPYLENE-POLYETHYLENE OBTAINED BY DIFFERENT WAYS

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ABSTRACT:

The measurement of durable properties and structures of composition is carried out on the basis of polypropylene (PP) and polyethylene with low density (PELD), obtained in the mixer "Benbery" and in rotor dispergator. It is shown that regulating the regime of crystallization and content of components in system PP-PELD. It is possible to change considerably the physical structure and improve the durable characteristics of composition. It is determined that the improvement of homogeneousness of composition, reaching the rotor dispergator brings to naturally increase of mechanical and electrical durability and longevity. One of the directions of science on physics of polymers is the search of ways the increase of mechanical and electrical durability as well as the heatproofness.

Key Words: Durable properties and structures of composition of polypropylene and polyethylene, Benbery mixer, rotor dispergator.

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1. INTRODUCTION

It is known that the strengthening of polymers can - be realized by introduction in them different additions, in particular, low molecular, to number of which can be concerned the modificatory additions (fillers, structure formers, stabilizators, e.t.c.).

At the last years in creation of polymer composition materials it is begun to use two or more different polymers, i.e. It is created the polymer-polymer system. The creation of such system is also actual from the stand-point of economy of material and energetic resources owing to utilization of secondary polymer raw.

In the given work the results of investigations on creation of binary system of polypropylene - polyethylene of low density (PP-PELD) are expounded, and here it is shown that the increase of content of PELD corresponds to such decrease of content of PP. The changes of mechanical and electrical durable properties and physical structure of these compositions depending on correlation of contents of components have been studied.

It is known that the work of pounding machines, on the whole, was based on two physical principles - percussion influence, bringing to destruction (for enough solid and large materials), and cutting (for relatively soft and plastic bodies). In the process of pounding the temperature raises, which is limited with melting temperature. The polymers which in themselves are not pounded in machines, they are distracted with formation of powders in adding of other polymers. In this sense, the typical example is the PELD, being pounded in mixture with granular of PP. This process is designated by the new term "co-pounding" (The Future Sciences, Moscov, 1968). It is considered that after such procedure the composition is obtained.

2. MATERIALS AND METHODS

The mixing of components was carried out by two ways: traditionally mixing of components in melting in the mixer "Benbery" and solid elastic-deformation way in the rotor dispergator. It is known that lately worked out process of elastic-deformation processing of polymer compositions in not more high temperatures is accompanied by pounding and simultaneously careful mixing of all components of composition. In the latter case, in definite temperature-force regimes of processing of initial loaded raw in shape of pieces, granular, tape, e.t.c. comes out in shape of small powder with the size of particles within 10-500 μm.

From the prepared mixtures of PP-PELD by means of hot pressing in temperature 470 K were obtained the thin films the thickness of which is 100-200 μm, the time of pressing-15 min. Two regimes of crystallization were selected which usually are used in carrying out the structural investigation (Vunderlikn, 1976–Yakovlev, 1977): quick cooling of melting of PP-PELD with speed 2000 gr/min. by means of putting it together with aluminum foil into the mixture of ice-water and slow cooling to 293 K with average speed 2 gr/min.

The middle size of above-molecular formations (AMS) were determined by the help of metallographic microscope "MIM-7" in polarized light. It was found that quickly cooled samples of compositions of PP-PELD are optic transparent, i.e. the spherolite formations in them are very small-with sizes smaller than 3-5 μm (smallsphrolite-SS), and at slowly cooled samples are seen the well formed radial spherolites, the sizes of which, depending on composition of mixtures, consist of 5μm-150 μm.(largespherolites-LS).

3.RESULTS

In order to establish the influence of content of PELD on mechanical and electrical durable properties of composition of PP-PELD it was removed the force dependence of mechanical and electrical longevity for SS and LS samples of compositions, containing the different amount of components of PELD and PP.

In Figure 1(a) and (b) is given the dependence of logarithms of mechanical longevity (time of waiting up to break) of $\lg \tau_\sigma$ and logarithms of electrical longevity (time of waiting up to clamp) of $\lg \tau_E$ for SS and LS samples of compositions of PP-PELD with different contents of PELD and PP, obtained mixing in the mixer "Benbery", from mechanical bursting tension σ and electrical bursting tension, correspondingly, the dependence of $\lg \tau_\sigma$ from σ was removed in temperature 163 K, and $\lg \tau_E$ from E - in room temperature. From the Fig. 1(a) and (b) it is obvious that the dependence of $\lg \tau_\sigma$ from σ and $\lg \tau_E$ from E for samples of compositions with different above-molecular structures (AMS), i.e. both for SS and LS samples, is the linear, in other words, the dependence of $\lg \tau_\sigma$ from σ and $\lg \tau_E$ from E is expressed by following exponential formulas:

$$W\tau_\sigma = A. \exp (-\alpha.\sigma) \qquad (1)$$
$$\tau_E = B. \exp (-\beta.E) \qquad (2)$$

correspondingly, where A, α and B, β are they parameters determining the durable properties and depending on the nature of studied material and temperatures of experiment (S. N. Zhurkov, S. A. Abasov, 1961- Zhurkov S. N., Abasov S. A., 1961-M. A. Bagırov, Y. G. Ranimov, T. F. Abbasov, S. A. Abasov, 1975). It is also obvious from the diagram that both with change of content of PELD (as well as PP), and type and sizes of ASS the parameters A and B do not change, but change the coefficients of α and β. As it is known from the kinetic conception of destruction (S. N. Zhurkov, S. A. Abasov, 1961- Zhurkov S. N., Abasov S. A., 1961- M. A. Bagırov, Y. G. Ranimov, T. F. Abbasov, S. A. Abasov, 1975), it indicates that in obtaining the composition of PP-PELD from one side, the energetic constants do not change, and in other side, the physical structure changes, i.e. the change of durable properties is conditioned by the latter factor.

As it is obvious from Fig. 1(a) and (b), the change of mechanical and electrical durability from content of PELD and PP carries the external character. The dependence of $\lg \tau_\sigma$ from σ and $\lg \tau_E$ from E, analogical dependence, given in Fig. 1(a) and (b), were also removed for SS and LS samples of compositions of PP-PELD with different contents of PELD and PP, obtained by the second way.

In Fig. 2(a) and (b) for obviousness is shown the change of mechanical (σ) and electrical (E) durability, correspondingly, compositions of PP -PELD depending on contents of PELD and PP for LS and SS samples, obtained in the system of "Benbery" (Curve 1-3) and in rotor dispergator (Curve 2-4). It is obvious that depending on the contents of PE and PP the σ and E at first increase, pass through maximum in 20 mass.% of PELD, then reduce up to minimum in 30 mass.% PELD, but beginning from 40-50 Mass. of PE these dependence become smooth and their values correspond to the value of amount of σ and E of initial PELD, both in the case of LS and SS samples.

It is also obvious in Fig. 1 and 2 that in all cases in stable equal conditions the mechanical and electrical durability of SS samples are considerably more in comparison with durability of LS samples, which indicate the considerable influence of ASS on durable properties of polymer compositions. On the other hand, as it is obvious from the Fig. 2(a) and (b) the durable characteristics of σ and E for samples of compositions, obtained in rotor dispergator, is more in comparison with the durability of samples, obtained in the system of "Benbery".

For the purpose of elucidation the influence of additions of PELD on relaxation transit of compositions of PP-PELD in Fig. 3 is given the temperature dependence of logarithm of electrical durability of lg τ_E for SS samples in correlation of components 80+20 mass. %, in which the maximum increase of electrical durability is observed. For comparison just in this Fig. 3 it is also given the diagrams of temperature dependence of lg τ_E for SS samples from PP without the addition of PELD, as well as from the very PELD. From diagrams given in Fig. 3 it is obvious that depending on lg τ_E = f (T) for PP without the addition of PELD the two minimums in temperature about 110 K and 150 K are observed which also take place in temperature dependence of lg τ_E for PELD and optimal composition of PP-PELD. However, besides above mentioned two minimums the third minimum in the area of relatively high temperature about 200 K appears in temperature dependence of lg τ_E optimal composition of PP-PELD. It should be mentioned that the observed minimums in temperature dependence of lg τ_E optimal composition is mixed in the area of high temperatures, which correspond with raised values of its mechanical and electrical durability in comparison with durability's of PP and PELD.

So, above mentioned experimental data, both according to durable property and relaxation transit, show that the composition of PP-PELD in correlation with components 80+20 Mass. in all cases are optimal.

The observed changes of mechanical and electrical durable properties, as well as the relaxation transits of compositions of PP-PELD can be explained by the influence of processes of processing on free-radical oxidizing process, indicated temperature-force influences.

In order to elucidate the correctness of this supposition the researches on IK-spectra of absorption of initial components and compositions were carried out on their bases. The typical spectra of compositions are given in Fig. 4.

The analysis of spectra with change of content of compositions, particularly, the spectra given in Fig.4 shows that the chemical interactions of separate groups of components with each other or formation of new groups are absent. This is obvious from that this spectrum of composition clearly bears all details of spectra of components, separately-as if the separately taken away spectra artificially are laid on each other. If the joining of molecules of separate components takes place and they are become integral then the degree of branching, determining from the stripe 2960 cm^{-1} would be to grow, but as it is very strong and always scales, it is impossible to speak about it with confidence. However, the marked change in the spectrum of PELD takes place and therefore, we shall judge about the general picture by them. First of all, in rapid cooling (at that time the structure of SS is formed) both the initial PELD and optimum composition, the stripe in 720 cm^{-1}, concerning to fluctuation of CH_2-groups in amorphous zones, either appears alonely or its optical density is much stronger than for the "stripe of crystallinity" in 731 cm^{-1}. In slowly cooling (by this the LS structure is formed) they both (i.e. the stripes 720 and 731 cm^{-1}) co-exist together, being evidence that the degree of crystallinity is increased by this. The phenomenon is strongly expressed for compositions. On the other hand, for the compositions it is increased in definite relations of the contents of components (for example, it is obviously examined for the compositions of PP-PELD 80+20; 50+50; 20+80 Mass.). For the second, in samples in which the density of stripe 731 cm^{-1} is evident, the general background (dispersion on the border of large AMF) increases 2-3 times and when the optical density of stripe 720 cm^{-1} (rapidly cooling-samples Os SS) is much more or prevails, the general background decreases, but appears the resonance dispersion $\lambda=\alpha$ from border, only middle size ($\alpha=5+10$ μm)-the background in the middle zone of spectrum. These data are proved that both in different speeds of cooling and in optioning of compositions the physical structure of polymers -correlation the portions of amorphous and crystalline zones changes considerably. There exist the definite conditions in which the optimum correlation is achieved by these zones (S.A. Abasov, Sh. V. Mamedov, S. I. Mehdiyeva, I. M. Ismailov, V. Y. Yusifov, 1976) and it favours the maximum increase of mechanical and electrical durability's and longevity's (see Fig. 1-2) and at the time, the improvement of operational characters of the compositions. In this sense, it is possible to speak about the "structural composition". Such explanation enough well correlates with the changes of mechanical and electrical durability's of the compositions depending on the content of components. It should be marked that the above mentioned effect appears stronger for samples, obtained by mixing in rotor dispergator, obviously, because of more deeply and uniformly mixing the components.

The change of optical density of stripe of fluctuations of C=O groups in 1720-1740 cm^{-1} shows that in rapidly cooling for the composition with optimum correlation of amorphous and crystalline phases (as it is already marked above, the optimum correlation of amorphous and crystalline phases corresponds with the correlation of components of composition of PP-PELD in 80+20 Mass., in which its mechanical and electrical durability's increase maximum). It is much lesser, i.e. the oxidizing process becomes slower. On the other hand, in compositions appear the additional stripes in 3600-3800 cm^{-1} pertaining to different OH, NH and other groups. All these allows to conclude that, after all, in obtaining the compositions there takes place, in some degree, the interaction between the separate groups and

there chemical addition. It should be marked that the last assertion about the degree of chemical interaction between the components, judging on IR-spectrum, most of all concern to compositions made in rotor dispergator.

Subsequently, from the analysis of IR-spectrum can be made the conclusion about that the components in compositions, mainly, play the role of structural filler. This is reflected in some aspects:

1) Changes the correlation of optical density of stripes of crystalline (731 cm^{-1}) and amorphous (720 cm^{-1}) portions in PE (it is changed the optical density of corresponding stripes and in PP, but because of complication, the corresponding estimations are difficult);

2) The neutral background and depending on the length of wave of dispersion in spectra, indicating the portions of large crystallites and more smaller (from 2 μm to 25 μm) are changed correspondingly.

In Fig.5 is given the dependence optical density of the stripe 720 cm^{-1} (amorphous portion) for LS and SS samples, made by the means of "Benbery" and in rotor dispergator, from the content of PELD in the composition of PP-PELD. It is obvious that these dependence are analogous to dependence of mechanical and electrical durability's of the compositions of PP-PELD from the content of PELD for LS and SS samples, made in the system of "Benbery" and in rotor dispergator. In other words, there is the extremum, mainly, maximum in correlation of components 80+20 Mass. composition of PP-PELD, as in the case of its mechanical and electrical durability's (see Fig. 2(a) and (b)).

4. DISCUSSION

It should be marked that the stripe of crystallinity in 731 cm^{-1} is not almost settled, sometimes only the shoulder is observed. So, the next picture is observed: in content of 20 Mass. of PELD in composition of PP-PELD on the one hand, the portion of amorphous zones is maximum, on the other hand, the sizes of crystallites are maximum, though the degree of crystallinity is lesser. From here comes out the following explanation of the change of mechanical and electrical durability's of the composition of PP-PELD depending on the content of components of PE and PP. With increasing the content of PELD (simultaneously with decreasing the content of PP) in composition of PP-PELD up to 20 Mass. the correlation of amorphous and crystalline phases remove to the side of increasing the portion of amorphous phase. As, according to the idea of kinetic conception of destruction of polymer materials the out side load is initially distributed in amorphous zones, i.e. they play the prevailing role, with increasing the degree of amorphousness, partially, crytalline polymer composition its durability must increase, and it is observed in experiment (Fig. 2(a) and (b)).

Subsequently, it was determined that regulating the speed of cooling and content of components in the system of PP-PELD it is possible to change noticeably the physical structure and improve the durable characteristics of the given

composition. It should be marked that improving the homogenousness of composition, reaching in rotor dispergator brings to appropriate increase of mechanical and electrical durability's and longevity's.

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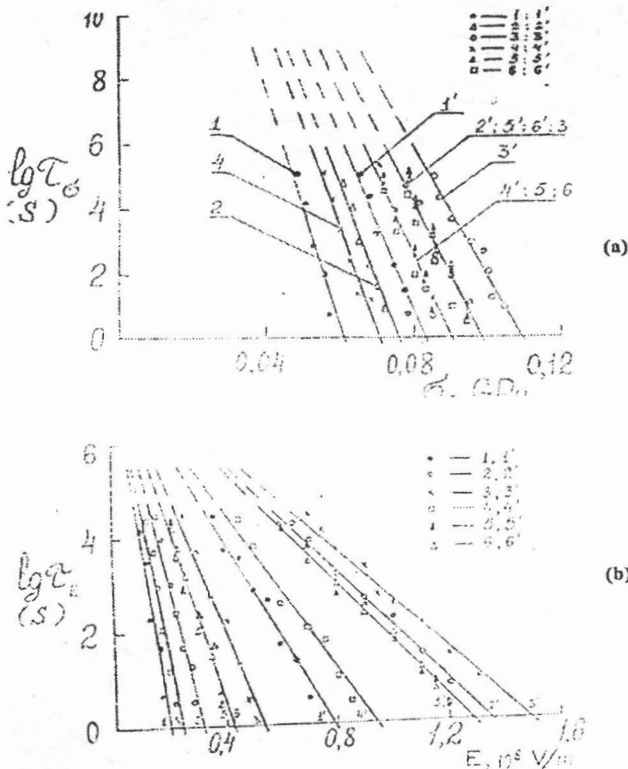
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Figure 1.(a) Dependence of logarithm of mechanical longevity and **(b)** electrical longevity LS(1,2,3,4,5,6) and SS(1', 2',3',4',5',6') samples of compositions of PP-PELD in the system "Benbery", (a) from mechanical bursting tension in T=163 K, (b) from electrical piercing tension in T=293 K.1-1' initial PP, 2-2' PP+10 Mass. %PE, 3-3' PP+20 Mass.%PE, 4-4' PP+30 Mass.%PE,5-5' PP+40 Mass. %PE, 6-6' PP+50 Mass. %PE.
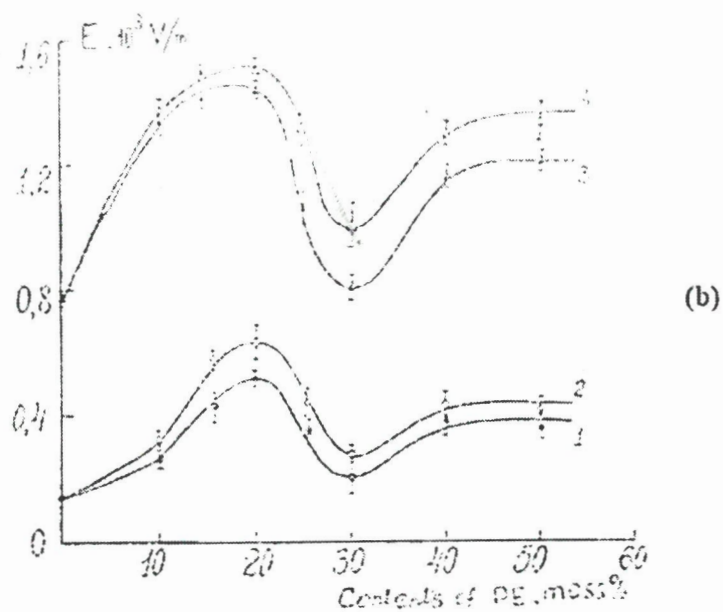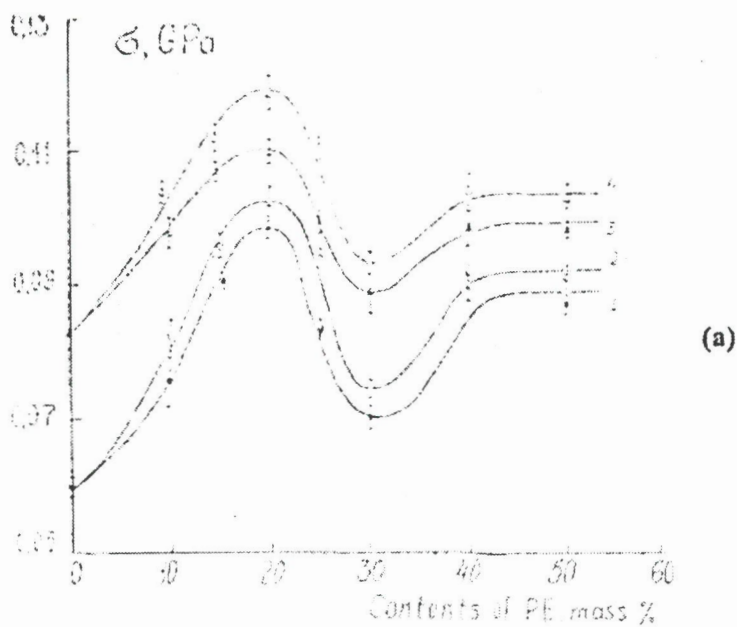
Figure 2.(a) Dependence of mechanical durability σ compositions (T=163 K) and (
b) electrical durability E compositions (T=293 K) of PP-PELD from content of PE
for LS(1-2) and SS(3-4) samples.
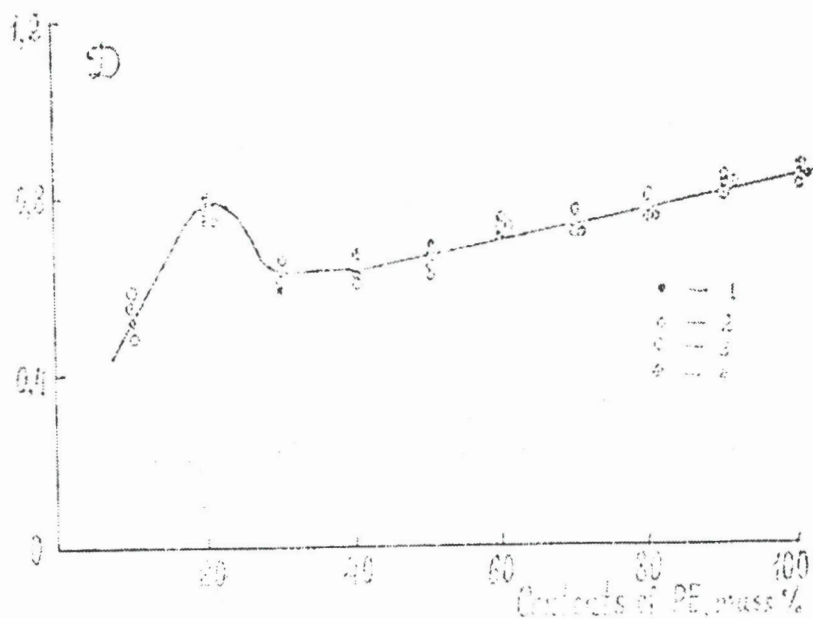1-3 samples mixed in the system "Benbery"; 2-4 samples processed in rotor
dispergator.
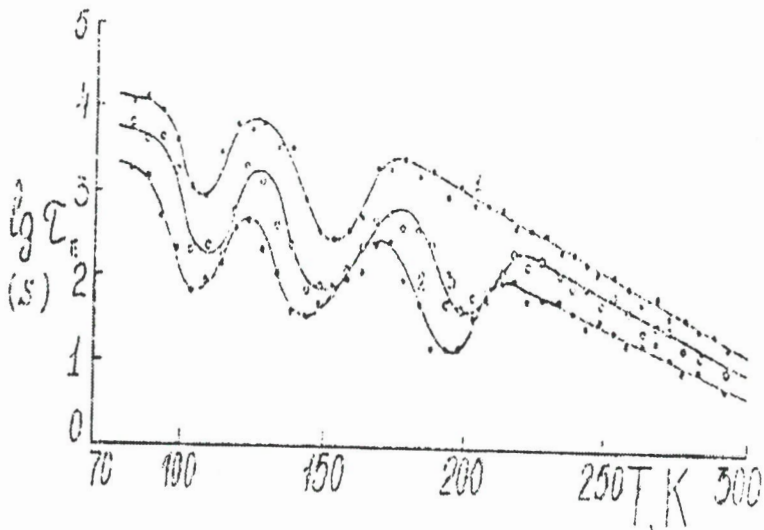
Figure 3. Temperature dependencies of electrical longevity of SS samples from i-initial PP, E=0,7.10^8 V/m;
2- optimum composition, E=1,3.10^{8}V/m; 3- initial PELD, E=1,3.10^{8}V/m.
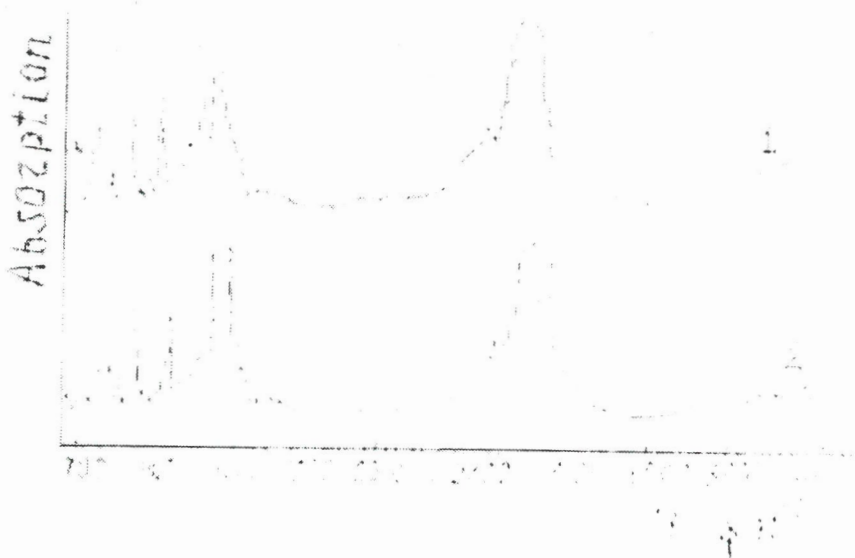
Figure 4. Typical spectra of IR-absorption of compositions of PP-PELD with content of 80+20Mass.%, obtained in rotor dispergator: 1- LS samples, 2- SS samples.

Figure 5. Dependence of optical density of IR-absorption of compositions of PP-PELD from content of PE for LS(1-2) and SS(3-4) samples: 1-3 samples, mixed in the system "Benbery"; 2-4 samples, processed in rotor dispergator.