

Table 2: Characteristic Absorption in IR Spectra of the Sample PA/PE.

Functional group	Characteristic absorption frequency, cm ⁻¹		
	PE-layers	PA-layers	PA/PE
Stretching vibrations			
-CH ₂ -	2820-2980 (s.)		
-C=O		1623-1680 (s.) 2020 (sl.)	
-C-O-		1120 (s.)	
C-		1257-1275 (s.)	
-COO-			2340 (sl.)
-CH-			3268-3338 (s.)
Deformation vibrations			
-CH ₂ -	1480 (s.) 725-740 (s.)		718-733 (s.)
-NH-		3085 (s.)	
-CH ₃	1380-1371 (s.)		1170 (s.)

After irradiation, the characteristic absorption bands of PE- and PA- layers do not undergo radical changes in the structure of the packaging material. Explore the intensity of absorption bands of functional groups present the change of their intensity.

The intensities of the absorption bands of functional groups at absorbed doses 0 kGy and 18 kGy are in Table 3. It is possible to speak about degradation or crosslinking in samples of films. We have found that almost no change occurs in the structure of multilayered sample PA/PE.

Table 3: Intensities of Absorption Bands in Films PA/PE

Absorption band, cm ⁻¹	Functional group	Intensities of the absorption band
		PA/PE
Dose 0 kGy		
1371-1366	-CH ₃	0.11±0.01
2340	-COO-	0.76±0.01
3085	-NH-	0.19±0.02
Dose 18 kGy		
1371-1366	-CH ₃	0.10±0.01
2340	-COO-	0.76±0.00
3085	-NH-	0.18±0.01

Table 3 and Fig. 1 shows that the bands intensity of the functional groups of PA/PE samples under the influence of fast electrons from 3 to 18 kGy changes the intensity of the bands of the functional groups-CH₃ and -NH- decreases by 0.01 relative units, which can be attributed to the error limit.

The results of scanning probe microscopy showed that the surface structure of the PA/PE sample in the PE-layer

before irradiation in the area of 50x50 μm has no evenness and holes (Table 4). With a detailed increase in the holes (in the area of 5x5 μm), they can be attributed to the film production technology, since there are no through holes.

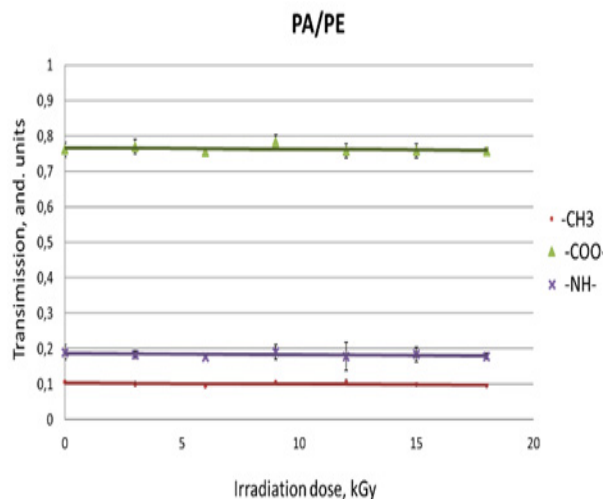


Figure 1: Dependence of fast electron irradiation doses on the intensity of absorption bands of functional groups.

After irradiation, the surface structure of the RE-layer becomes more loose and bumpy. The number of holes increases (in the area of 50 × 50 microns) after irradiation with a dose of 18 kGy more than 10 holes. In a more detailed study - the holes can be described as through. The structure of the surface in the PE-layer before irradiation has several non-through holes of 1 μm, but after irradiation the number of holes increases and the size of the holes reaches 2 μm.

Studies of the surface structure of the PA-layer in the PA/PE film before irradiation on the surface of the polymer film (50 × 50 μm) has a lumpy rough surface (Table 4). On the plot with resolution 10 × 10 μm we can be noted that deepening can be attributed to the technology of film production. After irradiation with doses of 18 kGy, the surface structure of the RA layer becomes smoother.

Thus, it is shown that the processing of PA/PE samples by fast electrons changes the number of functional groups on IR spectroscopy and is 0.01 relative units. This changes can be attributed to the error limit. However, the study of the surface structure of the samples by scanning microscopy confirms that after irradiation appear through holes mainly in the PE-layer, which proves the change in functional groups as a result of simultaneous processes of degradation and cross-linking (in the gap-hole) 0.01 relative units in the IR spectra, which refers not to the error, but to changes in the number of these groups.

Table 4: Surface Structure of PA/PE Sample before and after Irradiation.

Resolution of the microscope, μm	Dose, kGy	
	0	18
PE layer		
50×50		
25×25		
10×10		
5×5		
PA layer		
50×50		
25×25		
10×10		
5×5		

CONCLUSION

Polymer film materials with PA/PE composition as a percentage of the film 20:80 were processed by 10 MeV electrons at the accelerator UELR-10-10-40 with doses from 3 to 20 kGy. The study of the structure by IR spectroscopy showed that the irradiated PA/PE sample reduces the number of functional groups $-\text{CH}_3$ and $-\text{NH}-$ by 0.01 relative unit entails a change in the surface of the polymer material. The results of reproducing the intensity of the absorption bands of the functional groups show minimal dispersion, which indicates uniform irradiation of all samples.

By confocal laser microscopy it was demonstrated that after irradiation in the PA/PE sample with doses of 18 kGy, the film surface becomes smooth in the PA-layer. There is lumpiness, roughness and through holes appear in the PA-layer. These characteristics can lead to changes in the barrier properties of the film material, as well as affect the shelf life of food.

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