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IR SPECTROSCOPIC ANALYSIS OF BIAXIALLY DIRECTED POLYPROPYLENE AND POLYETHYLENE POLYMER FILMS

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Abstract: In this article, calculation of IR spectra of experimental polymer materials after corona discharge, chain length, intensity of IR spectroscopic absorption fields of oriented polymers, polarization and effect of chain length on normal frequencies were researched. A significant increase in surface energy is observed when treating the surface of biaxially oriented polypropylene and polyethylene polymer films with a corona charge. As a result of the chemical interaction of the polymer material with the solution, active groups are formed in the surface layer, which react with the surrounding nitrogen, hydrogen, argon and oxygen.

Keywords: Biaxially oriented polypropylene, polyethylene, polymer film, crown charge, roughness

In the last decade of the 22nd century, the packaging industry became an important part of the world economy. The increase in attention to packaging in our country corresponds to the next 20-30 years. Modern packaging not only protects the product from external influences, but also ensures its transportation, competition among alternative products with its appearance. This situation can be clearly observed in rapidly developing enterprises that produce packaging products. Packaging is a complex of factors such as product storage, protection from external influences, protection of the environment from pollution, product delivery, distribution, information, sale and consumption [1-8].

The most commonly used polymer films in the packaging industry are polyethylene and polypropylene films. Table 1 lists the polymer materials selected for this scientific work and their abbreviations. In the printing process, it is important to know the roughness value of the surface of the printed material in order to ensure the high quality of the quality indicators of the printed product, which is of practical importance.

Table -1

Research object

№	Naming	Purpose
1	Polyethylene (PE) transparent polymer film	For food and chemical industry
2	Double Oriented Biaxial Transparent Polypropylene Film (BOPP)	For food and chemical industry

During the printing process, the roughness of the surface of the printed material is controlled by various methods, each method has its own characteristics and range. The porosity of the surface of the printed material with standard values of the parameter Ra is evaluated by quantitative methods. The main indicators describing the microrelief of the surface of printed materials include the following (Fig. 1): Rp - the height of the largest roundness of the profile, Rmax - the maximum height of the roughness. It is calculated as the difference between the maximum and minimum heights of the profile points (profile interval), the average step of Sm-profile irregularities. [9-12].

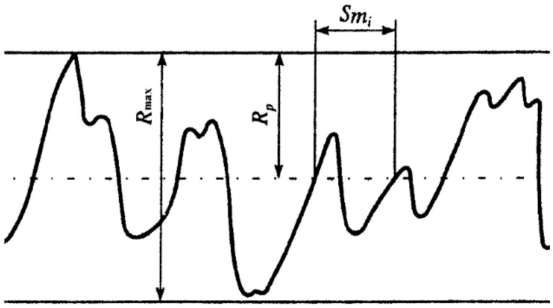

Fig. 1. Parameters of height

It is used in researching the surface morphology of polymer films, evaluating surface parameters (surface roughness and the presence of macroparticles), and determining film thickness. The roughness refers to the microgeometry of the printed material, which determines its important operational properties. First of all, it gives information about friction resistance, strength, bond density (hermeticity), chemical stability, appearance. The shape of micro bumps is determined by the height of the surface and the size of the pits, as well as their frequency [13-15]. These parameters describe the width of elevations or depressions, i.e., a measure of surface profile accuracy, describing the length of the profile distribution.

Table 2

Roughness indicators on the surface of polymer films

т/р	Surface description	Polymer			
		BOPP Before the coronation	BOPP After the coronation	PE Before the coronation	PE After the coronation
1	R_a, mkm	0,312	1,828	0,249	1,568
2	**R_m, mkm**	**1,063**	**10,21**	**0,528**	**7,058**
3	R_q, mkm	0,614	1,940	0,300	1,486
4	R_t, mkm	0,464	1, 962	1,600	1,058
5	R_z, mkm	0,470	6,680	0,360	5,350
6	**R_p, mkm**	**0,718**	**2,524**	**0,542**	**1,912**
7	S_k, mkm	0,655	5,268	0,129	4,847
8	S, mkm	0,205	3,259	0,114	2,348
9	**S_m, mkm**	**0,999**	**5,357**	**0,363**	**4,482**

The experimental data of the results of calculation of roughness indices performed according to the developed model are combined in Table 2, and the relative changes of the calculated values of roughness parameters from the average experimental values for each sample are shown.

According to the experimental data of the BOPP sample, it was found that the change in the average arithmetic expression of the profile roughness Ra after corona discharge changed from 0.312 μm to 1.828 μm, while in PE, this indicator changed from 0.249 to 1.568 profile points. Estimating the maximum height Rm of the profile, which is the sum of the average absolute values of the depth of the five largest bulges and the five largest depressions at the border of the base line, we can see that in these samples it varies from 1.063 μm to 10.21 μm, and in PE, these values change from 0.528 μm to 7.058 μm possible

Comparing the obtained results with GOST 2789-73, it was found that they correspond with the specified value indicators (Table 3).

Table-3

Comparative results

Indicators	GOST 9378-93	BOPP	PE
R_a, мкм	0,025-10,0	1,828	1,568
$S_м$,мкм	0,02-12,5	5,357	4,482
R_z, мкм	0,10-40,0	6,680	5,350

The average relative deviation of Ra, Sm ,R z showed 0.312: 0.999: 0.470 in BOPP film and 0.249: 0.363: 0.360 in PE before corona treatment, and 1.828: 5.357: 1.568 in PE after corona treatment; 4,482; It was 5,350. Thus, the experimental results revealed that there is roughness on the surfaces of the polymer films, and this is the main factor affecting the adhesion properties of the polymer films.

Also, the height of the largest roundness of the profile Rp, the depth of the largest hollows of the profile Rv, the full height of the profile Rm, the average pitch of profile unevenness Sm, the average pitch of local roundness in the profile S are also determined, and their average relative deviation before and after corona discharge, respectively, are shown in the table given.

The obtained results show that, as a result of the indicators in all cases, it was possible to achieve a high level of adhesion after corona discharge. At the same time, it should not be forgotten that it is very important to pay attention to the composition of the polymer films when processing the surface of the polymer film, because it also affects the adhesion strength. As can be seen from this experiment, it was found that polypropylene films have a higher degree of turbidity than polyethylene films. Crown charge treatment for BOPP is more efficient than for polyethylene.

The obtained results showed that the formation of bumps on the surface of the polymer films was confirmed after corona charge treatment. After the corona charge, the formation of a strong adhesive layer on the surface of the polymer film, the high surface energy of the printed material ensures good adhesion of the dyes and helps to create conditions for reacting with polymer molecules and their uniform distribution.

IR-spectroscopy is one of the main methods of studying the physical structure of the material, the orientation of polymer chains, as well as changes in the physical structure of polymers under the influence of external factors. The study of IR-spectra of polymers is to assign absorption areas to certain groups of atoms, to determine the logical connection between the spectrum of the polymer and the observed changes in its structure. Various variants of the theory of vibrations for polymers have been proposed and algorithms for calculating the

frequencies of normal vibrations have been created on a computer [16-17].

The purpose of the study is to calculate the IR spectra of experimental polymer materials after corona discharge, to study the influence of chain length, intensity of IR spectroscopic absorption fields of oriented polymers, polarization and chain length on normal frequencies. IR spectroscopic analysis of the samples was carried out with a Perkin Elmer Spectrum two spectrophotometer in the range of 4200–600 sm-1. It was determined that 1-3 μm thick sample films were obtained based on the technology of production of oriented polypropylene polymer films, and they were analyzed. The absorption area of functional groups was also studied in the analysis. The obtained results are presented in Figures 3-4.

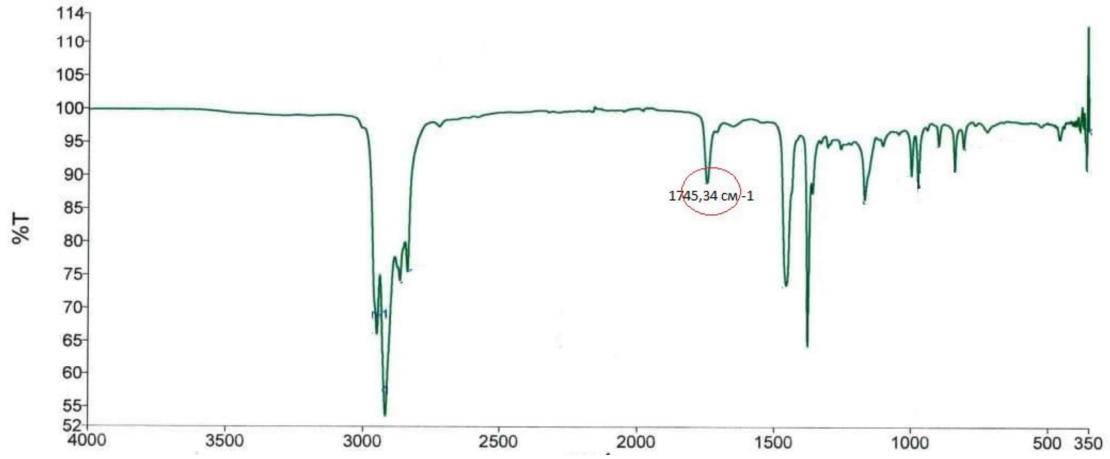

Figure 3. IR spectroscopic analysis of experimental BOPP films

It was determined that the sample films with a thickness of 20 μm were obtained based on the technology of preparation of biaxially oriented polypropylene polymer film and polyethylene, and the IR-spectrum was analyzed with the library base program. The spectrum of polypropylene produced clear 1370 sm and 1330-770 sm field lines of intensity after coronal charge to 1163, 1000, 970 and 840 sm.

In this case, the absorption lines of vinyl groups at 1645 sm^{-1} and carboxyl groups at 1715 sm-1 - 1790 sm-1 can be easily determined in polypropylene and polyethylene materials.

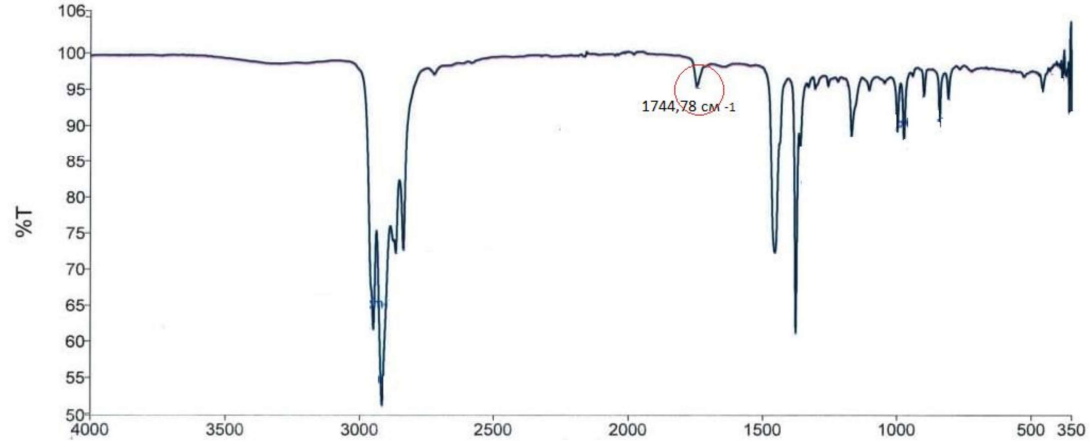

Figure 4. IR spectrum analysis of experimental PE polymer

Usually, the structure of the polymer IR spectroscopy gives information about the functional groups (C–H, C=O), while the latter is sensitive to the polarizable groups in the macromolecular chains (C–C, C=C).

In IR spectroscopy, absorption spectra appear to be typical of polypropylene. Absorption areas of symmetric valence vibrations characteristic of saturated (C-H) bonds in polypropylene in the region 2949-2918 sm-1; In the 2867-2838 sm-1 region, absorption regions of asymmetric valence vibrations characteristic of saturated (C-H) bond in polypropylene are represented.

IR-spectroscopic analyzes show that a new peak around 1700-1750 sm-1 is formed on the surfaces of materials treated with corona discharge, indicating that carbon-oxygen double bonds are characteristic. Absorption minima characteristic of unsaturated carbon-oxygen (C=O) bond in polyethylene were observed at 1745.34 sm-1 in polypropylene and at 1744.78 sm-1 in polyethylene. In the 1456-1375 sm-1 region, the absorption regions of the valence vibrations characteristic of the saturated carbon-carbon bond (C-C) in polypropylene are shown.

1167 sm-1, 997 sm-1, 972 sm-1, 840 sm-1 are the absorption minima of deformation vibrations characteristic of saturated (C-H), carbon-carbon bond (C-C) in polypropylene. Vibrations of a certain wavelength are characteristic for each functional group.

The obtained results revealed the presence of S=O (carbonyl and carboxyl) bonds on polymer surfaces in the peaks at 1745.34 sm-1 and 1744.78 sm-1. S=O (carbonyl and carboxyl) bonds provide adhesion properties [18]. That is, these bonds explain the presence of undulations on the polymer surfaces after the corona discharge and respond to the absorption properties of the paint.

When treating the surface of polymer films with a corona charge, a significant increase in surface energy is observed. As a result of the chemical interaction of the polymer material with the solution, active groups are formed in the surface layer, which react with the surrounding nitrogen, hydrogen, argon and oxygen. As a result of reactions with the environment, new functional groups such as hydroxyl (-ON), carboxyl (-COON), hydroperoxide (-OON) are formed, which leads to an increase in adhesion and surface energy. Due to such groups, it was observed that the adhesion properties with strong chemical affinity with dyes were activated.

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A NEW ADHESIVE COMPOSITION FOR THE MANUFACTURE OF CORRUGATED CARDBOARD

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Abstract: The article is devoted to the complete coverage of information about the composition of a new glue with bactericidal properties used in the manufacture of corrugated cardboard products.

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