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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

PHYSICAL MECHANISMS OF DIFFERENTIATION OF ELECTROPHYSICAL PROPERTIES CORRESPONDING TO STRUCTURAL CHANGES IN POLYMER DIELECTRICS

Speciality: 3303.01 – Chemical Technology and Engineering

Field of science: Technical

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Baku - 2022

The work was performed at the Institute of Physics of the National Academy of Sciences of Azerbaijan at the laboratory "Physics and Technique of High Voltages"

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GENERAL CHARACTERISTICS OF WORK

The actuality of the subject. Due to the wide range industrial application of hydrocarbon materials that are considered as strategic materials, their use in technology industry, daily life and in general in solving a number of problems, in some cases non-competitive use, the study of these materials in different aspects is in the focus of advanced scientific research centers in developed countries.

Extensive classification, multi-fractionation, found and synthesis of materials of different hydrocarbon in different states of matter, activity in chemical reactions, composition and structural complexity, wide range of physicochemical, mechanical, etc. Properties, requires a complex approach in the study of these materials, applying various modern research methods.

The study of hydrocarbon materials in the form of gases, liquids and solids, which have different areas of application, is usually carried out on the basis of states of matter, such as physics, chemistry, mechanics, physicochemistry, biophysics and biochemistry, etc. was included in the list of research areas.

The main points of research in the study of hydrocarbon materials are finding methods for obtaining superior quality in materials, the study of the relationship between the important properties of materials and their chemical composition and physical structure, the development of new cost-effecive and environmentally friendly technologies, development of new effective methods of cleaning materials from impurities, their modification by various methods in order to add new qualities in materials, development of theoretical bases of technological processing and application of materials, etc.

It should be noted that the analysis of the results of numerous studies published in the relevant literature has shown that the numerical values of the properties of polimeric materials demonstrated in experiments, such as mechanical and electrical strength are at least one order lower than their theoretically possible values. This fact and the high technological capability of application of polymeric materials, the presence of a number of superior electrophysical, mechanical, etc. properties of these materials have increased the interest of researchers and industrialists in these materials.

Specify of structural concepts of polymer-dielectrics widely used in the electric power industry, mainly as electrical insulation material, clarification of the mechanisms of change of physical, electrophysical, mechanical, etc. properties under various influences, especially on the surface and volume of polymer dielectric materials exposed to strong electric fields and gas discharges determining the mechanizms of chemical processes can lead to the full realization of their technical capabilities and serving to expand the application of these materials in industry.

Taking into account that stated above, the relevance of the topic of the dissertation and its relevance to the requirements of the day is confirmed.

Object and subject of research. In the presented dissertation a large experimental work on the study of interrelationships "upper macromolecular structure-property" in polymeric systems with linear chemical structure was carried out. Applying different parameters of the technology of processing of polymeric materials (pressure, temperature, time, etc.), experimental samples were obtained with different supramolecular structure with corresponding properties. Samples of polymeric materials made of high-density polyethylene, polyamide-6, polyvinylidene fluoride, polyethylene terephthalate, and polytryptochloroethylene were used as the object of study.

The dissertation considers linear polymer systems as an object of research, the subject of research is the study of the relationship "structure-property" in materials.

Goals and objectives of the study. This is the study of “structure-property” relationships of linear polymer and composition systems that exposed to deformation and gas discharges, having various structure and chemical composition.

- Study of mechanical deformation processes of polyethylene material prepared under different technological conditions and accordingly with different supramolecular structure;
- Investigation of emission processes from the surface of

polyethylene and polypropylene with spheroidal structure which exposed to influence of gas discharges;
- Investigation of emission processes from the surface of polyethylene and polypropylene materials with fibrillar structure and exposed to gas discharge;
- Investigation of destructive emission processes from the surface of a material composed of polytrifluorochloroethylene and polyvinylidenefluoride exposed to the effects of gas release in the ozone gas environment;
- Investigation of the emission of atoms and molecules from the surface of polyvinylidenefluoride and polycaproamide materials exposed to the effects of flare-type gas discharge;
- Investigation of the results obtained from research in terms of "structure-property" relationships at the level of electron-ion mechanisms.

Research methods. In the dissertation, samples of high-density polyethylene, polyvinylidene fluoride polyamide-6, polypropylene and polyvinylidene fluoride polytrifluorochloroethylene composite materials were used as objects of research in the study of processes occuring in linear polymer systems as a result of the effects of gas discharges. The effects of gas discharge on materials were carried out in atmospheric air, SF_6 and ozone gases.

In these investigations the effects of high-voltage partitions and torches gas discharges were used in the research.

In order to study the processes in polymer systems during exposed to gas discharges, MSX-4 brand mass spectrometer, which distinguishes and records ions of different masses according to their drift distances, ultra-high vacuum device, high-voltage electrical circuits, various types of gas-discharge reactors, various auxiliary technical equipments and a number of technical means were used.

The main provisions of the defence:
- Explanation of character of deformation processes of linear polymer systems through structural concepts;
- Different results of dependance of uniaxial deformation processes of amorphous-crystalline polymer systems from the parameters of technology of research samples production;

- Regularities of experimentally recorded emission processes from surface and volume of linear polymer systems exposed to the effects of gas discharges;
- Defined explanations of emission processes in terms of “structure-property” relationships;
- As a means of influence, gas discharges has advantages over mechanical and chenical methods, in the process of modification of polymeric materials;

Scientific innovation of research:

- The investigating of the deformation process of samples made of polyethylene material with a thickness of 0.6, 1.2, and 1.6 mm under different technological conditions showed that as the thickness of the samples increases, the process of mechanical breaking of samples as a result of the deformation process is observed at low relative deformation values. This experimental result was explained by the heterogeneity of the samples with high thickness and the large number of defects in it. Investigating of the dependance of deformation process from crystallization temperature of material, crystallization rate, deformation rate, to define the dependance of deformation process from supramolecular structure of polymer and to state structure concepts of explanation of noted results;
- Confirmation of the dependence of individual atoms and molecules emission from the macromolecules of the polymer on the supramolecular structure of the material as a result of the effect of gas discharges on polymeric materials;
- Possibility to determine the chemical elements that make up polymer through the analysis of ions recorded with mass spectograms and to determine the additives contained in materials;
- Weakening of the emission process with increasing degree of crystallization of the polymer material (mainly in the fibrillar structure), caracterization of “structure-property” relations of the materials;
- It has been found that, the emission process is stronger in elements that made of a few atoms in the materials;

- Experimentally confirmation of possibility of the effects of gas discharges resulting in a number of physical-chemical processes on surface and volume of polymer materials and using this method (different than and superior to mechanical and chemical methods) for modification processes of polymer materials.

Theoretical and practical significance of the research. High requirements are applied to the physical, chemical and mechanical properties of polymeric materials, which are widely used in the manufacture of insulating materials and parts of technical equipment in the energy, electrical, light industry, household, electrical appliances and other fields of the national economy. So that, durability and long service life of polymeric materials are of great practical importance while being exploited in various industries, chemical, acidic and alkaline environments, at high and low temperatures, under the influence of solar radiation, gas discharges, mechanical and other external factors.

The main results of the dissertation work are related to the determination of the relationship between supermolecular structure and physical and mechanical properties of the material, which characterizes the linear polymer systems. The idea of the study is to develop the scientific and practical basis of technological processes for the production of polymeric materials with superior physical and mechanical properties or the required properties and management of their properties through the structures realized in polymeric materials.

The results of dissertation are important in terms of expanding the field of application of polymer materials.

Approbation and application. Based on the results of research on the dissertation, 12 articles and 6 conference materials were published.

The main results of the work were presented and discussed at the following conferences: “The 13th international conference on Technical and Physical Problems of Electrical Engineering” (Van, Turkey-September 21-23, 2017); International Scientific Conference “Actual Issues of Applied Physics and Energy” dedicated to the 100th anniversary of the Azerbaijan Democratic Republic (Sumgayit, May 24-25, 2018); The 14th International Conference on "Technical and Physical Problems of Electrical Engineering" (Nakhchivan, October 15-17, 2018); 15 international Conference on "Technical and Physical Problems of Electrical Engineering" (Istanbul, Turkey, October 14-15, 2019) "Innovative Trends in Ensuring Regional Development: Realities and Modern Challenges", (Mingachevir, December 11-12, 2020) the 17 international Conference on "Technical and Physical Problems of Electrical Engineering" (Istanbul, Turkey, October 18-19, 2021).

It is recommended that the results of the study be used to determine the optimal choice of parameters for the technology of preparation of electrically insulating polymeric materials, to predict the service life of polymeric materials in operation under mechanical load and electrical influences.

The name of the organization in which the dissertation work is performed: The dissertation work is performed at the Institute of Physics of the National Academy of Sciences of Azerbaijan in the laboratory "Physics and Technology of High Voltages"

Plaintiff's personal presence. The main purpose of the research and the issues required to achieve the goal, the direction of the research, the systematization and implementation of experimental research and the design of the dissertation were carried out by the applicant personally. The scientific results of the research and the articles and conference materials based on them were discussed with the scientific supervisor and co-authors of the dissertation.

The structure and capacity of the work.

The dissertation consists of content 2 pages (1798), introduction 14 pages (28,000) and four chapters, chapter I 20 pages. (36000), Chapter II 14 pp. (28000), Chapter III 27 pp. (54000), Chapter IV 34 pp. (68000), result 3 pages (6000), compiled on 138 pages, including the total volume of the mark (221798), 57 figures, 9 graphs, 15 tables, 18 titles, 114 references, including author's works.

Content of the work:

At the entrance substantiated the actuality of the topic, the purpose of the research, scientific innovation, the main provisions of the defense, the practical significance of the work, reaearch methods and objects, and brief summary of each chapters of the dissertation were explained.

The first chapters presents the results of research on the structure of linear polymer systems of hydrocarbon, solids and the structure of materials under the influence of external mechanical and electrophysical influences on structural changes and related changes in their properties. Explanations on the structure of linear polymer systems in the literature show that in isotropic and deformed anisotropic materials, in addition to small periods characterizing the interatomic distances, there is also a large repetition period of 50-1000Å formed by a set of polymer macromolecules. It is noted that linear polymer systems have the ability to crystallize and form amorphous-crystalline structures, so that in the isotropic state they are mainly spherulite, and in the anisotropic state they are caracterized by fibrillar and lamellar structural elements. It has been found that the large repetition period which characterizes the structure formed by a set of macromolecules can vary in size and structure depending on the technology of preparation of the material.

The second chapter justifies the choice of methods for solving objectives of research. The deformation process of polymer materials that carried out in technical devices in the laboratory is noted. The types of gas discharges of gas used as a means of influencing materials, operating modes, design of reactors, working principle, technical capabilities and specific features of electrical, technological and other devices are explained. In order to investigate the physical-chemical processes in contact with "gas-discharge-polymer" materials with high accuracy, the technical capabilities of a vacuum device with high and extremely high vacuum capacity, which allows to conduct complex research and its use rules were explained. In the course of investigations in closed systems, a mass spectrometer "MSX-4" connected to a vacuum system, has a wide mass range, high sensitivity and resolution, works in inertia, and differentiates ions of different masses according to flight times over the drift distance was used to monitor changes in the chemical composition of the gas medium. The chapter describes the working principle and technical capabilities of the applied mass spectrometer.

The third chapter describes the results of an experimental study of the dependence of the deformation process on the parameters of technological processing of the material in a polyethylene linear polymer system with an amorphous-crystalline structure.

It should be noted that, as a rule, thin-layer (150–200 μm) polymer materials were used in the study of the processes of deformation of polymeric materials. The limitations of studies on samples of polymeric materials with a certain block thickness (1-2 mm) and the difference in the results obtained led to disputes and disagreements in the literature. The important scientific and practical significance of deformation processes in amorphous-crystalline polymer systems stimulates further research in this area.

The chapter presents the results characterizing the process of deformation of polyethylene material processed in various technological modes.

The fourth chapter describes the results of studying the processes of emission of charged particles from the surface and volume of materials, their dependence on the structure of materials when exposed to linear polymer systems with crystallization properties of an amorphous-crystalline structure, through gas discharges.

Samples of high-pressure polyethylene (PE), polyvinylidene fluoride (PVDF), polypropylene (PP), polycaproamide (PK) polymeric materials, prepared in different technological modes and having different structures accordingly, were used in the research. . Research samples with a thickness of 0.5 mm were prepared from granular materials at different temperatures and pressures.

In studies, a mass-spectrogram of destructive emission processes was obtained from the surface of a composite polymer composed of polytrifluorochloroethylene and polyvinylidene fluoride in an ozone gas environment.

THE SUMMERY OF THE RESEARCH

The first chapters presents the results of research on the structure of linear polymer systems of hydrocarbon, solids and the structure of materials under the influence of external mechanical and electrophysical influences on structural changes and related changes in their properties. Explanations on the structure of linear polymer systems in the literature show that in isotropic and deformed anisotropic materials, in addition to small periods characterizing the interatomic distances, there is also a large repetition period of 50-1000Å formed by a set of polymer macromolecules. It is noted that linear polymer systems have the ability to crystallize and form amorphous-crystalline structures, so that in the isotropic state they are mainly spherulite, and in the anisotropic state they are caracterized by fibrillar and lamellar structural elements. It has been found that the large repetition period which characterizes the structure formed by a set of macromolecules can vary in size and structure depending on the technology of preparation of the material.

In the chapter, the brief results of the work carried out on the study of the processes taking place in polymer materials exposed to the effects of elastic deformation processes of linear polymer systems and gas discharges are described.

The second chapter justifies the choice of methods for solving objectives of research. The deformation process of polymer materials that carried out in technical devices in the laboratory is noted. The types of gas discharges of gas used as a means of influencing materials, operating modes, design of reactors, working principle, technical capabilities and specific features of electrical, technological and other devices are explained. In order to investigate the physical-chemical processes in contact with "gas-discharge-polymer" materials with high accuracy, the technical capabilities of a vacuum device with high and extremely high vacuum capacity, which allows to conduct complex research and its use rules were explained. In the course of investigations in closed systems, a mass spectrometer "MSX-4" connected to a vacuum system, has a wide mass range, high sensitivity and resolution, works in inertia, and differentiates ions of different masses according to flight times over the drift distance was used to monitor changes in the chemical composition of the gas medium. The chapter describes the working principle and technical capabilities of the applied mass spectrometer.

In the research, while investigating the effects of gas discharges on the gas environment and gas-solid contact, natural atmospheric air, its rasidual gases, ozone and SF_6 gas were used as the gaseous environment.

The third chapter describes the results of the experimental study of dependance of the deformation process on the parameters of technological processing of the material in a polyethylene linear polymer systems with amorphous-crystalline structure.

It is known that the properties of solid materials, including polymers, depend on their chemical composition and physical structure. Taking into account that the structure of linear polymer systems is sensitive to external influences, by changing the parameters of the processing technology of the material, the control of one or another property can be obtained by changing its structure.

Linear polymer systems consist of amorphous and crystalline parts. Thus, amorphous parts are characterized by the chaotic arrangement of the beginning and end parts of macromolecules, while crystalline parts are characterized by several folding of macromolecules, a number of defects and the formation of a regular structure.

It should be noted that, taking into account that the density of the material in the crystalline parts is higher than the amorphous parts and differ in the regular-irregular structure, elastic and inelastic deformation processes in polymer materials, depending on the processing technology, different mechanisms of transition from isotropic to anisotropic.

Polyethylene samples with thickness of 0.6, 1.2 and 1.6mm were studied in the dissertation. The choice of the research sample is primarily due to the fact that the polyethylene material, as a typical representative of the linear polymer class, crystallizes with an amorp-hous-crystalline structure to form polycrystalline structures and isot-ropically composed of spherulite structural elements. Due to the fact that polyethylene material is widely studied in a number of aspects, it is possible to provide single-valued or multivalued explanations of the results of the study of problems raised, using the information in the literature.

By means of the method mentioned above, research samples of different thicknesses (0.6, 1.2, 1.6mm) were obtained in experiments by applying a pressure of 40-150atm. The crystallization temperature of the samples was 20ºC. It is known from the literature that in the temperature-pressure regimes mentioned above, polyethylene material is composed of small spherical structural elements. Because the crystallization temperature is close to room temperature, the crystallization process in the material proceeds fairly rapidly, and the development of the spherulite structural elements is limited, and the spherulites are small in size. Spherulites are characterized by smaller dimensions, given that the relatively thin layers act more rapidly at 20ºC on the thickness of the material. At the same time, the number of defects is high in small values of P pressure and in thick materials.

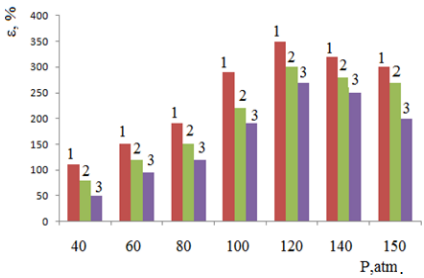
The results are obtained from the experiments are shown in Table1 and the corresponding diagram (Figure1.). It was found that as the thickness of the material increases, the phenomenon of

Table 1

The results obtained from the experiments of deformation of high-pressure polyethylene layers of different thicknesses d at a temperature T_m = 200ºC, crystallization temperature T_{cr} = 22ºC at different P pressures and in the direction of one axis.

№	P, atm	d=0.6mm	d=1.2mm	d=1.6mm
		ε, %	ε, %	ε, %
1	40	110	80	50
2	60	150	120	95
3	80	190	150	120
4	100	290	220	190
5	120	350	300	270
6	140	320	280	250
7	150	300	270	200

mechanical breaking of polymer samples as a result of the deformation process is observed at low values of deformation. Initial results from the deformation process of materials are explained by the fact that in samples with small thickness, the crystallization process ends more rapidly at room temperature. Thus, because of the



Picture 1. Deformation process of polyethylene layers diagram on the results: 1-d = 0.6mm, 2-d = 1.2mm, 3-d = 1.6mm

small size of the spherulite structures, the distances between the spherulites are also small and making the material more homogeneous. In high-density samples, due to the uneven distribution of room temperature in the direction of the thickness of the material, the degree of release of macromolecules in the volume of the material is higher, and therefore allows the development of spherulite structures and their size. In this case, due to the large distances between the low-density spherulites, the degree of heterogeneity of the material is high, which reduces the mechanical deformation of the material. On the other hand, the higher the number of defects in thicker samples, the lower the mechanical deformation of the material.

It should be noted that mechanical deformation of samples prepared at 140-150atm pressure was less observed than samples prepared at 120atm pressure. This result is explained by the fact that at a pressure of 140-150atm, the formation and development of structural elements in the material becomes more difficult, the degree of crystallization of the material decreases and the material has more defects.

It should be noted that when polyethylene material with an amorphous-crystalline structure is deformed in the direction of one axis, there are structural changes in the amorphous and crystalline parts of the material. Thus, the nature of structural changes depends mainly on the parameters of the material preparation technology. In other words, the nature of structural changes depends on the temperature of the environment in which the deformation process takes place, the internal structure of the spherulite structural elements, the circular or radial arrangement of the spherulite elements in the material, whether the spherulites are more defective or less defective, the nature of the radial distribution of macromolecules from the center of the spherulite, the chemical structure of the material and other parameters that characterize the material. Taking into account that stated above, it can be concluded that the explanation of the mechanical strength of polymers and the mechanisms of deformation processes is determined not only by the size of the structural elements (spherulites) and depends on a number of factors. Therefore, the results obtained in the initial experiments characterize the "structure-property" relationships of high-pressure polyethylene processed under the specified temperature and pressure conditions.

In order to determine the dependence of the deformation processes on the size of the spherulite, if it is possible to exclude the influence of other factors and the same internal structured spherulites on the sample, in this case it is possible to make a unambiguous opinion on the nature of the dependence of the property of the material on the dimensions of the structural element.

The reasons stated above make it difficult to give a general theory that covers the deformation processes of polymeric materials in all cases. In this regard, the collection of statistics from the experimental study of the deformation process in individual cases may help to overcome the limitations of the theory of the deformation process.

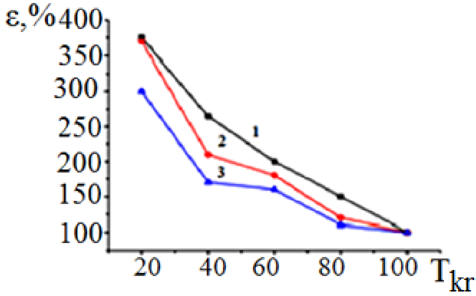
In the chapter the dependence of the deformation process on the crystallization temperature of high-density polyethylene material made at different crystallization temperatures has been studied. For this purpose, polyethylene samples with a thickness of 0.6mm,

1.2mm and 1.6mm were processed at a pressure of P = 120atm, crystallized at a crystallization temperature of T_{cr} ~ 20-100°C, and deformed in the direction of one axis at a temperature of T = 20°C.
The results from the experiments are given in Table2, and in the graph (Figure1). The chapter describes the results that characterizing the deformation process of PE material processed at different crystallization temperatures. It was determined from the presented results that the deformation process is characterized by small values as the crystallization temperature increases in the polymer samples prepared under the technological conditions which stated above. It is known that as the crystallization temperature and crystallization time increase, larger spherulites are observed in polymeric materials.

The large size of spherulites in block polymers leads to the fragility of the material, which in turn results in a decrease in the strength and deformation properties of the material. The process of destruction of the fragile polymer material can occur at the boundary of the spherulites or in numerous internal defects of large spherulites.

Table 2.
Results from uniaxial deformation experiments of high-pressure polyethylene layers made at different crystallization temperatures (T_{cr}), melting temperature (T_m = 200°C), pressure P = 120atm and deformation temperature (T_d = 20°C):

№	T_{cr}, °C	d=0.6mm	d=1.2mm	d=1.6mm
		ε, %	ε, %	ε, %
1	20	375	370	300
2	40	265	210	170
3	60	200	180	160
4	80	150	120	110
5	100	100	100	100



Graphics 1. Diagram of the results of deformation process of polyethylene layers: 1-d = 0.6mm, 2-d = 1.2mm, 3-d = 1.6mm

In the presented work, the dependence of the deformation process of the high-density polyethylene material in the direction of one axis on the deformation temperature is shown. For this purpose, polyethylene samples with a thickness of d = 1.6 mm were processed at a pressure of P=100atm, crystallized at a crystallization temperature of T_{cr} = 20ºC, and deformed in one axis at a temperature of T_d = 10-95ºC.

The temperature dependence of the deformation process of polyethylene material in the direction of one axis is presented.

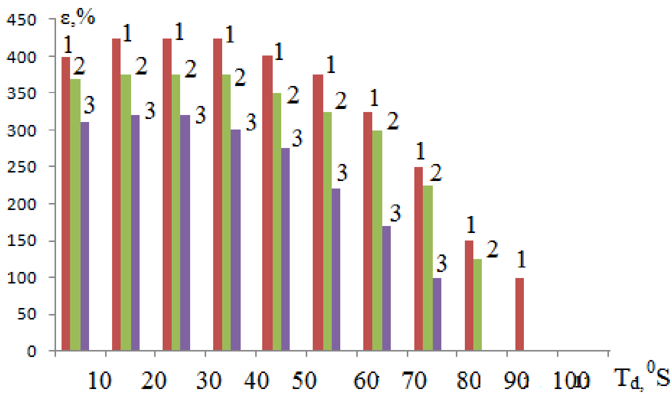
An appropriate diagram of the experimental results is given in Table 3 (Figure 2).

The results of the study show that as the deformation temperature increases, the deformation process passes the maximum, and the temperature of the deformation environment weakens significantly as the material approaches the melting temperature. The observed result is explained. The process of low-temperature deformation occurs mainly due to the attraction of the set of macromolecules in the amorphous parts of the sample in the direction of the applied force. In this case, the spherulites do not change and move away from each other. At the same time, at low temperatures, the development of gaps, cracks, gas bubbles and other micro-defects in the sample is weak. The temperature corresponding

Table 3.

Results obtained from the study of the deformation process of polyethylene with melting temperature T_m=200°C, pressing pressure P = 100atm, crystallization temperature T_{cr} = 20°C, at different v-velocities and T_{def}-deformation temperatures.

v, mm/dəq №	T_d, °C	v_1=10 mm/min	v_1=20 mm/min	v_1=30 mm/min
		ε_1,%	ε_2,%	ε_3,%
1	10	398	370	310
2	20	425	375	320
3	30	425	375	320
4	40	425	375	300
5	50	400	350	275
6	60	375	325	220
7	70	325	298	170
8	80	250	225	100
9	90	150	125	X
10	95	100	X	X



Picture 2. Diagram of dependence of the deformation process on the deformation temperature: 1-v_1 = 10 mm/min, 2-v_2 = 20 mm/min, v_3 = 30 mm/min.

to the maximum of the deformation curve can be considered the optimal temperature of the process. Structural changes intensify in the process of high-temperature deformation. In the process of deformation, along with the amorphous parts, the crystalline parts are also deformed, collapsed, new additional defects appear in the material and the expansion of the defects in the direction of the impact force results in the weakening of the deformation process.

In the presented work, the dependence of the deformation process on the thickness of the samples and the cooling rate of the polymer alloy in the polyethylene material was investigated.

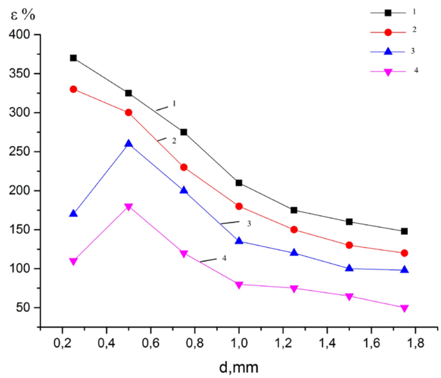
Samples of high-pressure polyethylene material with a thickness of 0.25-1.75mm were prepared as the object of research. Samples of different thicknesses were prepared by pressing at T = 200°C, and after crystallization at room temperature, the material was subjected to an axial tensile deformation process. The deformation process of the samples was carried out at room temperature.

Table 4 and graphics 2 present the results obtained from the deformation process. It is clear from the presented results that the deformation process of high-pressure polyethylene samples prepared under the technological conditions stated above, has a maximum on the curve depending on the thickness of the material, and the deformation process decreases with increasing sample thickness.

Table 4

Results from the study of the dependence of the deformation process of polyethylene material on the thickness of the samples and the cooling rate of the alloy. The melting of the material was carried out at T_m = 200°C:

№	d,mm	ε_1%	ε_2%	ε_3%	ε_4%	P, atm	T_d,°C
1	0.25	370	330	170	110	80	20
2	0.5	325	300	260	180	“-“	“-“
3	0.75	275	230	200	120	“-“	“-“
4	1.0	210	180	135	80	“-“	“-“
5	1.25	175	150	120	75	“-“	“-“
6	1.50	160	130	100	65	“-“	“-“
7	1.75	148	120	98	50	“-“	“-“



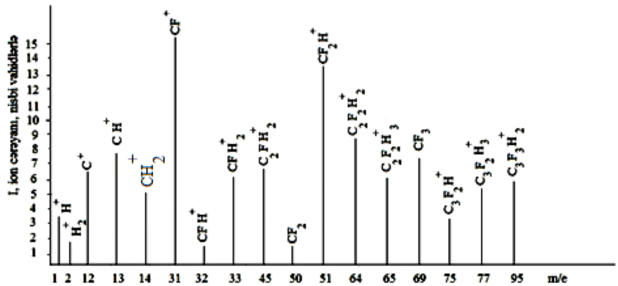
Graphics 2. Dependence of the deformation process of high-density polyethylene layers on the cooling rate v of the alloyand the thickness d of the material: 1-v= 400c/min, 2-v=270c/min, 3-v=10.50c/min, 4-v=1.00c/min. The deformation process was carried out at a temperature of T_d = 20 ºC.

It should be noted that in polymeric materials with polyethylene, polypropylene, caproic, polyvinylidene fluoride and other linear structures, as the thickness increases, the order in the spherulite structure is disturbed to some extent and spherulite-like crystalline structural elements are formed in the materials. The large number of voids, cracks in thick samples, the size of the spherical-like structural elements increase the degree of heterogeneity of the material, affecting the deformation process of the material and reducing the deformation. On the other hand, the cooling of the polymer alloy at low speeds and 200ºC is the cause of the weakening of the deformation process.

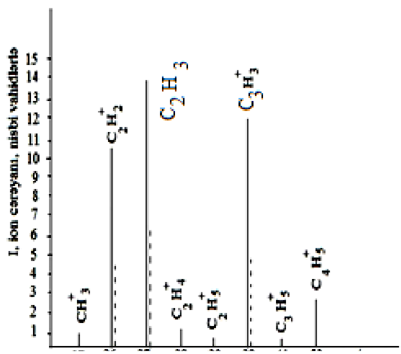
In this case, the size of the structural elements of the spherolite is larger, which again leads to a high degree of heterogeneity of the material.

The fourth chapter describes the results of the study of the emission processes of charged particles from the surface and volume of materials, the dependence of the structure of the material on the linear polymer amorphous-crystalline-structured systems with crystallizing properties when exposed to gas discharges.

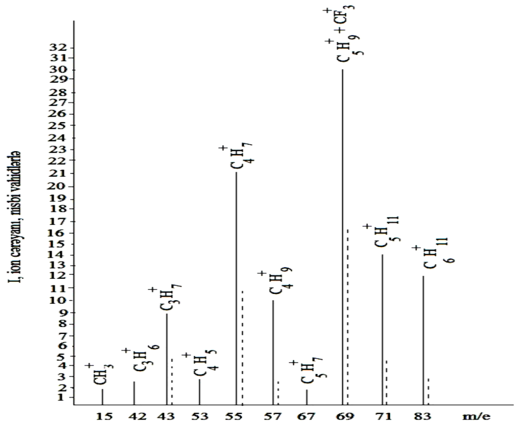
Samples of high-pressure polyethylene (PE) polyvinylidene fluoride (PVDF), polypropylene (PP), polycaroamide (PK) polymeric materials prepared in different technological regimes and having different structures, respectively, were used in the research. Research samples with a thickness of 0.5 mm were prepared from granular materials at different temperatures and pressures.



Picture 3. The second type of ion emission from PVDF material mass spectrogram.



Picture 4. The second type of emission from polyethylene Material mass spectrogram. Indicated by dotted lines spectrum from the surface of PE having a fibrillar structure which characterizes the emission process.



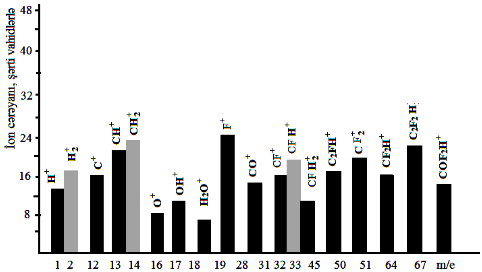
Picture 5. Polypropylene with spherolite and fibrillar Structure the mass of the second type of ion emission from the surface of the material spectogram. Spectrum indicated by dotted lines emission from the surface of PP with fibrillar structure characterizes the process

Elegas (SF_6) was used as the gas medium in the experiments. The effects of flare-shaped gas discharges were used as an electrical effects on the materials. Mass spectrogram of the new medium formed in the form of ions from polyvinylidene fluoride materials exposed to flare gas discharge in SF_6 medium for 10 minutes in the reactor with a vacuum (10^{-4} Pa) has been obtained in the analyzer of mass spectrometer.

It has been found that during the interaction of gas ions with PVDF material, ions of carbon, fluorine and hydrogen atoms emit ions into the vacuum from the surface of the material, causing rapid gas reactions, resulting in hydrocarbon and hydrofluorocarbon compounds.

The chapter presents mass spectrograms showing the emission processes of the second type of ions observed on the surfaces of spherulite-structured PVDF, PE, PP and PK materials. At the same time, in the case of PE and PP, the results of the second type of emission processes from the surface of the samples which exposed to deformation in the direction of one axis were recorded.

The results of the research show that each polymer is characterized by its own mass spectrum. The results also show that despite the same elemental composition, the mass spectra of PE and PP are quite different.

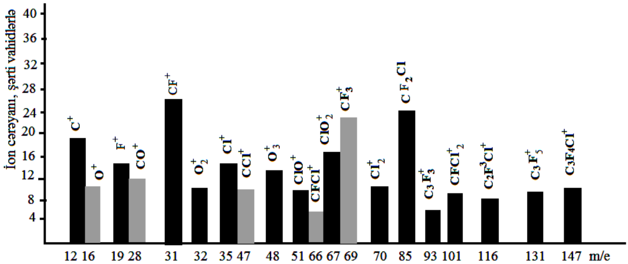


Picture 6. PVDF material in ozone gas environment observed mass spectrogram

Partial weakening of the emission process from polymers exposed to deformation in the direction of one axis was observed. The result obtained in the experiment was explained by the high degree of crystallization of the fibrillar structural material.

In studies, a mass spectrogram of destructive emission processes was obtained from the surface of a composite polymer composed of polytrifluorochloroethylene and polyvinylidene fluoride in an ozone gas environment.

The analysis of the spectrogram shows that the emission of F^+ atoms from the surface of the material occurs intensively as a result of the release of gases in the ozone gas environment. In the gaseous environment of the system, along with ozone gas, F^+ atoms are actively involved in surface bombardment and rapid gas reactions. It should be noted that the oxidizing property of ozone gas is high, the reaction efficiency of ozone gas is significantly lower than the reaction activity of only F^+ atoms, fluorine oxides and fluorine free radicals. The chemical properties of ozone gas are characterized by its instability and oxidizing properties. The decomposition of ozone gas into constituent atoms is accelerated in H_2, Cl_2, Br_2 environments and at high temperatures (100, 250ºC).



Picture 7. PVDF + Politrifluorochloroethylene in ozone gas environment observed mass from the material spectogram.

The mass spectrogram shows that ozone gas partially decomposes to form CO and CO_2 gases with the carbon atom emitted. The reaction activity of fluorine atoms is mainly characterized by the formation of various compounds by reacting with the emitted C and Cl atoms. The main reason for the formation of these compounds is the presence of F atoms in both materials that make up the composition and the high reactivity of F atoms.

MAIN RESULTS

1. The deformation process of polyethylene samples with thickness of 0.6, 1.2 and 1.6 mm was studied in this work. It was found that as the thickness of the material increases, the breaking of polymer samples is observed at small values of relative deformation. At the same time, the weakening of the deformation process at low (40 atm) and high (150 atm) pressures was explained by the number of defects, the size of the structural elements, the degree of crystallization of the material and the unequal distribution of crystallization temperature along the thickness of the material (1).
2. It was found that in polymer samples, the relative deformation process is characterized by small values as the crystallization temperature increases. It is known that as the crystallization temperature

and crystallization time increase, larger spherulites are observed in polymeric materials. The large size of spherulites in block polymers leads to the fragility of the material, which in turn results in a decrease in the deformation properties of the material (2).

3. It is shown that the process of high-temperature deformation intensifies structural changes, along with amorphous parts in the deformation process, the crystalline parts are deformed, collapsed, new additional defects appear in the material and the expansion of defects in the direction of the impact force weakens the deformation process. At the same time, increasing the speed of the deformation process also weakened the deformation process (3).
4. In this study, the dependence of the samples of high-pressure polyethylene material with a thickness of 0.25-1.75mm on the thickness and the cooling rate of the alloy was studied. It was found that as the thickness increases, the number of voids, microcracks in the samples, the size of the spheriolite-like structural elements affect the deformation process of the material and reduce the relative deformation. On the other hand, as a reason of the weakening of deformation process the cooling of the polymer alloy at speeds below 200ºC can be seen. In this case, the larger size of the spherulite structural elements leads to a higher degree of heterogeneity of the material. When crystallized polymeric materials are exposed to deformation in the direction of one axis, a recrystallization process actually occurs in the material (4).
5. When T_{cr}=60ºC, the electrical and mechanical strength of polyethylene material with a spherulitic structure, and when T_{cr} =100C and P=100atm of hot pressing, polypropylene and polyvinylidene fluoride materials have higher electrical and mechanical strengths than in other cases. The temperature-pressure values that stated above can be considered as the optimal processing parameters of polyethylene PP and PVDF materials with spherical structure in terms of electrical and mechanical strength.
6. Mass spectrogram of the emission process from the surface of polytrifluorochloroethylene (60%) and polyvinylidene fluoride (40%) composite material exposed to the effects of gas discharge in the ozone gas environment was analyzed. It was found that the

release of F^+ atoms from the surface of the material occurs intensively as a result of the release of gases in the ozone gas environment. This means that in the gaseous environment of the system, along with ozone gas, F^+ atoms are also actively involved in surface bombardment and rapid gas reactions. The results of the study show that as a result of the effect of electric gases in ozone gas on polymeric materials, rapid gas reactions occur between atoms and molecules emitted in gaseous materials, residual gases in the closed system (hydrogen, oxygen) and other system gases. and the gaseous medium formed in the closed system differs sharply from the original gaseous medium

7. Emission processes of polyethylene terephthalate material in SF_6 gas environment under the influence of gas discharge were studied and it was determined that the emission process from the surface was significantly weaker in polycrystalline material than in amorphous material. Due to the long processing time of the material and the fact that the crystallization temperature is close to the melting temperature of the material, the intensity of the emission process decreased sharply. It should be noted that the results obtained in the research are of scientific importance for the study of "structural-property" relationships in polymeric materials. In addition, the use of polymeric materials as an insulating material in strong electric fields and in industries where the effects of electric gases are present is also of practical importance in terms of predicting the service life (6, 7, 8).
8. The research results showed that the process of emission of atoms and molecules occurs on the surface of linear polymer systems exposed to electric torch discharges, and the intensity of the emission process increases with increasing temperature of the material. The results are explained using structural concepts. Based on the results of subsequent studies, it was concluded that the synthesis of high purity H_2O_2 without the introduction of hydrogen and oxygen into the system, the impact of an electric discharge on the PET material can be applied to a new method for the synthesis of H_2O_2 [16, 17, 18].

The results of the dissertation were printed in the following scientific publications:

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Azərbaycan Respublikasının Təsil Nazirliyi Sumqayıt Dövlət Universiteti, Tətbiqi fizika və energetikanın aktual məsələləri Beynəlxalq Elmi Konfransın materialları, -Sumqayıt:- 2-25 may, -2018, -s.192-195.

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The defense will be held on 31 May 2022, at 10^{00} at the meeting of the Dissertation Council ED 1.17 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at Institute of Petrochemical Processes named after Academician Y.H. Mammadaliyev, of Azerbaijan National Academy of Sciences.

Address: AZ 1025, Baku, Khojaly avenue 30.

Dissertation is accessible at the Azerbaijan National Academy of Sciences, at the library of Institute of Petrochemical Processes

Electronic version of the dissertation and abstract are available on the official website of the Institute of Petrochemical Processes of the National Academy of Sciences of Azerbaijan (www.nkpi.az)

Abstract was sent to the required addresses on 29 April 2022.

Signed for print: 26.04.2022

Paper format: A5

Volume: 36801

Number of hard copies: 20