

**RESEARCH PROPERTIES OF POLYMER SOLUTIONS
AND MATERIALS RECEIVED FROM THEM**

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Abstract

The presented article is devoted to research of influence of a composition and technologic factors on the processes connected with processing of polymers and their mixes through solutions and research of properties of polymeric composite materials received on their basis.

Key words: *polymer solutions, solubility parameter, intrinsic viscosity, compatibility of polymers in solution, electrospinning of fibrous materials.*

1. INTRODUCTION

Increasing industry's growth rate of dictate using more and more severe operating conditions for polymer articles. Elevated temperatures, **corrosive medium**, the high mechanical loadings, all it demands application of new materials. However, development and synthesis of new polymers is long-lasting and expensive process. The mixes of already existing polymers are one of effective ways to solve this problem. These mixes combine the balanced complex of the properties inherent in individual polymers. Hence, studying of multicomponent polymeric systems is one of the main research fields in polymer science.

Combination of various types of polymers can be realized both technologically (on the equipment) and through solutions.

Currently the extensive experimental and theoretical material permit to conclude that structural differences of solutions influence on the structure and properties of the materials generated from them. Structure formation in solutions is determined by the nature of the solvent used, and main cause of differences in the structure of obtained materials is the interaction of the polymer with the solvent. And the only scientific criterion of dissolving capability of solvent is thermodynamic affinity between the solvent and solute. A dissolvent role in ternary systems polymer 1-polymer 2- solvent- is much more difficult [1, 2].

2. EXPERIMENTAL

2.1. Materials

As objects of study were the following polymers: copolymers of vinylidene fluoride and hexafluoropropylene F-26 ($M_w = 6.0 \cdot 10^5$), SKF-26 ($M_w = 5.0 \cdot 10^5$), SKF-26/5, SKF-26/7; vinylidene fluoride and tetrafluoroethylene F-42 ($M_w = 3.0 \cdot 10^5$); vinylidene fluoride and trifluorochloroethylene F-32 ($M_w = 1.0 \cdot 10^5$), SKF-32 ($M_w = 4.0 \cdot 10^5$); vinylidene fluoride and hexafluoropropylene and tetrachloroethylene SKF-264/6, SKF-264/7, a modified vinylidene fluoride

F-2M. Copolymer of styrene and acrylonitrile (SAN) KUMHO SAN 350N ($M_w = 1.5 \cdot 10^5$), thermoplastic polyurethane (PU) Desmocoll 400 ($M_w = 2.0 \cdot 10^5$). As solvents were used following organic liquids of different chemical classes: ethyl acetate (EA), butyl acetate (BA), acetone (Ac), methyl ethyl ketone (MEK), tetrahydrofuran (THF), dimethylformamide (DMFA).

2.2. Methods

2.2.1. Preparing solutions of individual polymers. Determination of solubility parameter

The most common value used to estimate the diluting ability of solvent is the solubility parameter δ of Hildebrand. Parameter of solubility is a square root of the cohesive energy's density, representing the ratio of evaporation energy to the molar volume of substance:

$$\delta = (\Delta E / V_m)^{1/2} = ((E_d + E_p + E_h) / V_m)^{1/2} = (\delta_d^2 + \delta_p^2 + \delta_h^2)^{1/2}$$

where ΔE – molar energy of vaporization; V_m – molar volume at a given temperature; δ_d – parameter, taking into account the presence of dispersion forces; δ_p – parameter, taking into account the presence of polar (orientation) forces; δ_h – parameter, taking into account the presence of hydrogen bonds [3].

The closer to each other are the solubility parameters of polymer and solvent, the greater the probability of forming a thermodynamically stable system.

There are both computational and experimental methods for determining the solubility parameter of polymers and low molecular weight liquids.

As the computational method were used atomic constants method (MAC) and the method of Van Krevelen. The method of atomic constants is based on the representation of a repeat unit as a set of anharmonic oscillators, corresponding a pair of atoms connected by intermolecular physical and chemical bonds. The feature of this method is the use of the equations for the calculation of physical properties which were obtained on the basis of representations of solid state physics. Common to all equations is the summation of a number of atomic constants, characterizing the contributions to the energy of intermolecular interaction, energy of chemical bonds, van der Waals volume, etc. This method is calibrated by using physical characteristics of the polymer standards whose properties are well studied [4].

Calculation by method of Van Krevelen is based on the use of atomic and group contributions, mole and Van der Waals volumes [5].

2.2.2. Determination of intrinsic viscosity

The intrinsic viscosity serves as a measure of additional energy losses associated with the rotation of the macromolecules in the flow. The rotation of the macromolecules in the flow of the solvent is due to the fact that different parts of the macromolecules are in fluid layers, which move at different speed. The rotation of the macromolecules in the flow of solvent is resulting from the different parts of the macromolecules being in fluid layers which moving at different speed. The internal friction or viscosity of any fluid appears only in those cases when it is able to flow with nonzero velocity gradient.

Determination of intrinsic viscosity was carried out by us earlier [6].

2.2.3. Compatibility of polymers in solution

Estimating polymers compatibility was carried out by the method proposed by Dobry and Boyer-Kawenoki. The transparent solutions of two polymers in the same solvent are mixed together. If the

solution remains transparent the polymers are considered compatible. If the solution becomes opaque and separates into two layers, each of which contains basically one of the polymers, the polymers are incompatible. Layering of solutions can be observed not at any concentration. Thus, dilute solutions are not separated at all. In very concentrated solutions, there is practically no separation because of the high viscosity. So some middle range of concentrations of 5-10% is chosen so that the time required for the formation of two layers would not be very large [7].

2.2.4. Investigation of physical-mechanical properties of films and nonwoven fibrous materials

Measurements of mechanical properties of materials were carried out by the tensile testing machine. The measuring of mechanical properties of filtering materials complies with the following requirements:

Preparation and measurement of mechanical properties of the samples is done at the temperature of 20 ± 10 °C and the pressure of 760 ± 30 mm Hg. Humidity in the room should not exceed 90%.

Contamination or destruction of the sample with the loss of its mass is not allowed because of affecting the measurement.

Samples of fibrous material had width 4.0 ± 0.5 mm and length 25.0 ± 0.5 mm between the clamps. Samples of films had width of 3.0 ± 0.1 mm and length 10.0 ± 0.5 mm between the clamps. Deviation from the average thickness of test samples is not more than 10%.

The velocity of the lower clamp was set 25 ± 5 mm / min.

Measurements were carried out on five samples which were cut from each sample of fibrous material (film). After measuring the mechanical properties the samples of fibrous material were weighed on an analytical balance.

Physical-mechanical properties were calculated as follows:

$$L = (F \cdot l_0 / m_0) \cdot 100$$

where L - breaking length, m; F - breaking force, N; m_0 - weight of breaking sample, g; l_0 - initial length of sample, m

$$F_p = P_p / S_0$$

where F_p –tensile strength, MPa; P_p –breaking force, N; S_0 – cross- section area, m^2

2.2.5. Electrospinning of fibrous materials

The process of electrospinning of fibers from solutions and melts in the electrostatic field is known from the beginning of XX century [8]. In 1930-s electrospinning was designed; the largest number of patents that time belongs to A. Formals and C.L. Norton [9-12]. In Russia the process of obtaining ultrathin fibers developed in the Karpov Institute of Physical Chemistry by I.V. Petryanov and N.D. Rosenblum in the late 30-s of the XX century. Since the early 1990-s interest in the process of electrospinning is steadily increasing.

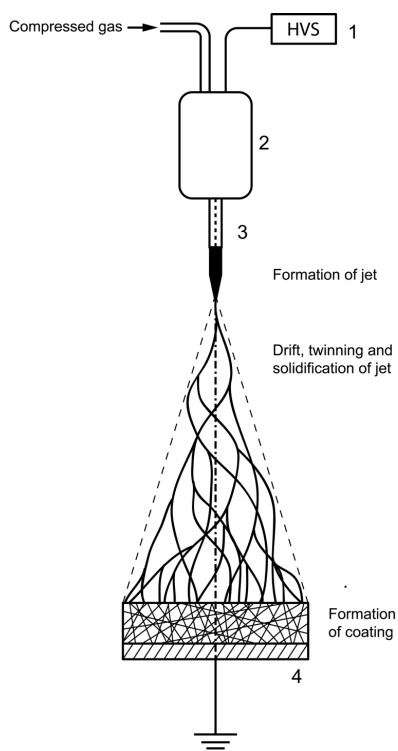


Fig. 1. Schematic diagram of a device for electrospinning of fibrous materials (explanation in the text).

Electrospinning differs from all known industrial methods of producing chemical fibers and fibrous materials on their basis in instrumental simplicity, high energy efficiency, flexibility and variety of products. Process is carried out from solutions that makes for damping of capillary waves in the charged liquid jets that form, their resistance to deforming forces and to cavitation, their ability to solidify into rather strong fibers upon evaporation of the solvent and, in the final analysis, in the formation of a fibrous layer with a microstructure and macroscopic properties that lend themselves to adjustment over a wide range.

Figure 1 shows a typical conceptual design of a device used in these processes. High electric tension is conveyed from the source 1. The polymer spinning solution is fed, by gravity or excess gas pressure, at a preset volumetric flow rate from container 2 to capillary injection nozzle 3. A metal electrode connected to regulated DC source 1, that is placed in the container, applies a high, usually negative potential difference to the free jet that is discharged from the nozzle. This causes the jet to steadily accelerate and thin out along an axis aligned with the general direction of the electric field. This is the first, relatively easy to regulate, stage of electrospinning of fibrous materials, the stability and results of which control all its subsequent stages and, in the final analysis, the desired properties of the finished fiber.

The second stage consists of several simultaneously occurring processes. In it, the fluctuations of the electric lines of force, caused by time and space variation of the bulk density of electrical charges and the inevitable concurrent deviation of these lines of force from the axis of the high-inertia accelerated jet, induce the appearance of a hydrodynamic force moment that is exerted on the jet by the viscous gas, further increasing this deviation. This causes the jet to turn transversely to the field direction and to be decelerated by the constantly increasing drag force of the gas. This produces a cloud that is

forced into the shape of a cone that expands toward its bottom by the action of same-polarity charges. This cone is delimited by a dashed line in Fig. 1 and is filled by a coiling jet. At the same time, the rate of vaporization of the solvent that started already at the first stage of the process is steeply intensified, the jet solidifies and the resulting fibrous cloud drifts in the applied electric field onto collecting electrode 4 (Fig. 1).

The following, third stage also consists of two simultaneous processes: the first consisting of random deposition of fibers into a layer with axes parallel to the plane of the collecting electrode and the second — of a gas spark discharge between the collecting electrode and the fiber layer forming on it.

To remove the solvent vapor that is released to the surroundings from the solidifying jet and to provide for operator safety, the equipment is placed in an electrically insulated, continuously ventilated enclosure, whereas process control is carried out from an insulated control platform [13].

3. RESULTS AND DISCUSSION

3.1. Obtaining solutions of individual polymers. Determination of solubility parameter

At present despite of the enormous experience in the field of polymer processing the prediction diluting ability of low molecular weight liquids of different chemical classes with respect to the polymers is not fully studied.

Table 1. Values of solubility parameters

Polymer	Experimental data	Calculated data	
		atomic constants method (MAC)	method of Van Krevelen
F-42	15.2	13.2-13.9	11.0-14.6
F-26	13.5	13.8	12.0-18.4
F-32	18.6	12.8	13.3-15.9
SKF-32	18.7	12.9-13.3	12.8-15.8
SKF-26	19.3	13.6	11.5-18.3
SKF-26/5	19.5	14.4	11.5-18.3
SKF-26/7	18.9	14.4	11.5-18.3
SKF-264/6	16.6	12.8-13.5	10.4-14.3
SKF-264/7	16.9	12.8-13.5	10.4-14.3
SAN	18.4	19.0-20.5	19.5-21.4
PU*	19.1	-	-

* There was not calculated values of solubility for PU because the company did not disclose the monomers and their ratios in the polymer.

According to the calculated data (Table 1) numerical values for the solubility parameter of fluoropolymers are in the range 12.8-13.9 (MJ/m³)^{0.5} (MAC) and 11.0-18.3 (MJ/m³)^{0.5} (Van Krevelen). However, the data are significantly different and poorly agree with the literature [14-16].

Table 2. Solubility parameter of organic solvents

Solvent	Solubility parameter (J/sm ³) ^{1/2}				Shares accounted for each type of interaction, %		
	δ	δ_d	δ_p	δ_h	f_d	f_p	f_h
Acetone	19.93	15.46	10.4	6.9	47.1	31.9	25.0
Methyl ethyl ketone	18.91	15.85	9.0	5.1	53.0	30.0	17.0
Ethyl acetate	18.56	15.18	5.3	9.2	52.1	17.5	30.4
Butyl acetate	17.30	15.65	3.7	6.3	61.0	14.4	24.6
Tetrahydrofuran	18.5	16.34	-	-	-	-	-
N, N-Dimethyl formamide	24.77	17.38	13.7	11.2	41.1	32.4	26.5

where $f_n = 100\% \cdot \delta_n / \sum \delta$, where δ_n – parameter corresponding to a defined type of interaction; δ – the sum of the parameters [3].

To verify the validity of the calculations the experimental determination of solubility parameter δ were carried out by measuring the intrinsic viscosity η of the polymer in the set of solvents (Table 2), which have different values of solubility parameter at Ostwald's viscometer. On the basis of results obtained (Table 1) and using statistical methods for processing the mathematical model describing the dependence of η of polymer solution from the solubility parameter δ of the solvent in which they were measured, have been selected. Dependence of the intrinsic viscosity of polymer solutions from the solubility parameter of solvents is often extreme in nature [2], which was taken into account when choosing a mathematical model. The maximum of this dependence determine the value of the solubility parameter of the polymer. Preference was given to models that meet the curve with a maximum, while maintaining a high adequacy (defined coefficient of determination, the Fisher criterion and the standard error).

Analyzing the data, the dependence $\eta = f(\delta)$ for the fluoropolymers can be concluded that the fluoroplastic inherent curves with a pronounced maximum in contrast to the curves for fluoroelastomer, and especially for derivatives, SKF-26, and SKF-264.

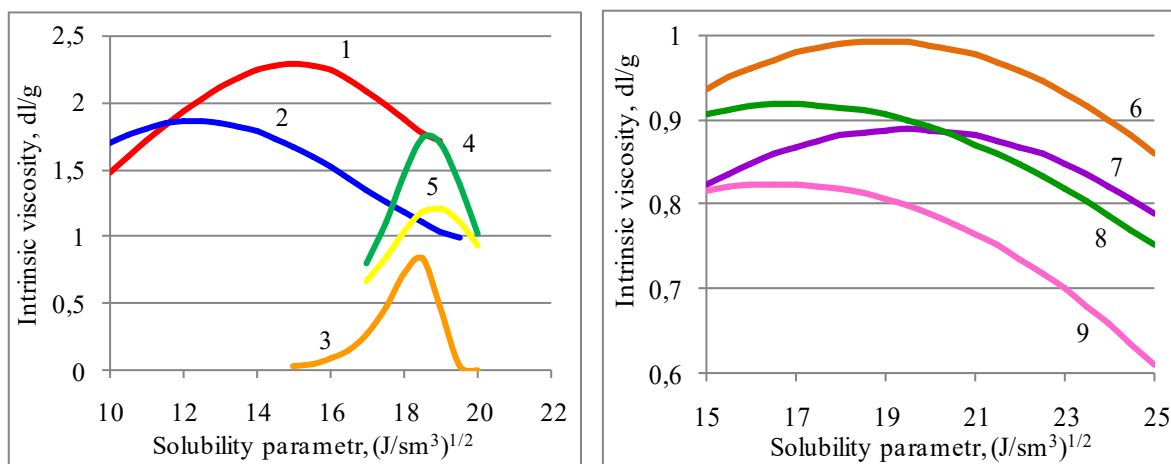


Fig. 2. The dependence of intrinsic viscosity of fluoropolymers from parameter of solubility (1 – F-42, 2 – F-26, 3 – F-32, 4 – SKF-32, 5 – SKF-26, 6 – SKF-26/5, 7 – SKF-26/7, 8 – SKF-264/6, 9 – SKF-264/7).

It should also be noted that in determining the δ polymers F-26 and SKF-26, with identical initial monomers, but with their differing ratio, there is a significant shift in the maximum values of intrinsic viscosity solutions (curves 2 and 5, Fig. 2). It is supposed that the influence of the ratio of components is retraced in this case.

The ambiguity of the results of experimental and theoretical determination of the solubility parameter fluoroplastic and fluoroelastomer, with the apply of the methods developed by Van Krevelen and others, the method of atomic constants, due to several reasons. So when estimating the solubility of the polymer carry out the procedure of comparing the values of the solubility parameters of the polymer and solvent. It is assumed that, if complied with the condition of equality, the proximity of parameters, it can be expected dissolution of the components. With such conception a view, we can except those solvents, the parameter solubility which differs significantly from one of polymer, thereby narrowing the range of verifiable solvents. Finding of organic liquid with diluting ability in relation to the fluoropolymers revealed that their number is small and the comparison of the values of solubility parameter of polymer and solubility parameter of solvent shows that the values δ have not always predictive power. So aliphatic hydrocarbon solvents (Table 2) have solubility parameter close to δ of fluoropolymers, but do not have the diluting ability in relation to these polymers. This is due to the fact that the cohesive energy density is an integral characteristic of the intermolecular interaction, and the solubility or miscibility of components depends on the availability of specific functional groups, among which appear the so-called specific and nonspecific interactions. They include hydrogen and donor-acceptor bond, leading to the formation of solvated complexes [1]. This conclusion is fully applicable to fluoropolymers. Attention is drawn to the fact that fluoropolymers readily soluble in solvents, which are capable of forming hydrogen bonds with them. Thus, the share attributable to the hydrogen bonds in the solvent for fluoropolymers ranged from 17 to 30% (Table 2), whereas the aliphatic hydrocarbon solvents, characterized by the presence of 100% of the dispersion interaction [16].

3.2. Study of compatibility of polymers in solution

Assessment of the compatibility pairs of polymers in solution was carried out by the method proposed by Dobry and Boyer-Kawenoki [7]. Based on the data obtained (Table 3), we have identified a range

of concentrations, where may be the compatibility of polymers. On this basis, were plotted diagrams of phase state for all systems.

Table 3. Systems technologically compatible polymers

Solvent	Systems
Acetone	F-42 + SKF-26, SKF-26/5, SKF-264/7, SAN + PU
Methyl ethyl ketone	F-42 + SKF-26, SKF-264/6, SKF-264/7, F-26 + SKF-26, SKF-32, SAN + PU
Ethyl acetate	F-32 + SKF-26, F-42 + SKF-26, SKF-26/5, SKF-26/7, SKF-264/6, SKF-264/7, F-26 + SKF-32, SKF-26, SKF-26/5, SKF-26/7, SKF-264/6, SKF-264/7, SAN + PU
Butyl acetate	F-26 + SKF-32, SKF-26, SKF-26/5, SKF-26/7, SKF-264/6, SKF-264/7
N, N-Dimethyl formamide	F-26 + SKF-26/5, SKF-26/7, F-2M + SKF-26/5, SKF-26/7, SAN + PU
Tetrahydrofuran	SAN + PU

Depending on the concentration in the considered temperature conditions, a mixture of polymer solution exists as single-phase and two-phase systems. The transition from one system to another with increasing concentration occurs on the curve with a maximum. Concentration corresponding to this maximum called the limit of phase separation is a measure of compatibility of polymers in solution. Visual observations showed that at concentrations above the limit of separation turbid solutions of mixtures during storage stratified into two layers, whereas the solutions, whose concentration is below the limit of separation, is a transparent, single-phase, stable in time system. Consequently, the maximum on the curve corresponds to a phase transition from homogeneous solutions, thermodynamically stable systems to two-phase delaminated over time. This maximum is called the critical concentration (C_{cr}) [2].

We built the phase diagram. As a result, all systems except the F-42 / SKF-26 in acetone ($C_{cr} = 6.5\%$), F-26 / SKF-32 in butyl acetate ($C_{cr} = 2.5\%$) and SAN / PU in various solvents (in DMFA and EA $C_{cr} = 16.5\%$, in THF and Ac $C_{cr} = 18\%$ and 20% in MEK) have $C_{cr} < 1\%$ and not exactly determined, because we consider the definition of $C_{cr} < 1\%$ is not expedient. According to available data was realized and carried out many studies to find additives that shift the C_{cr} , improving the compatibility of polymers [17].

As an example, to identify the critical concentration represented pairs of F-26 / SKF-32 in butyl acetate and SUN / PU in dimethyl formamide (Fig. 3). As the figure shows the value of the critical concentration is shifted toward the polymer with lower molecular weight. This is a known fact [18].

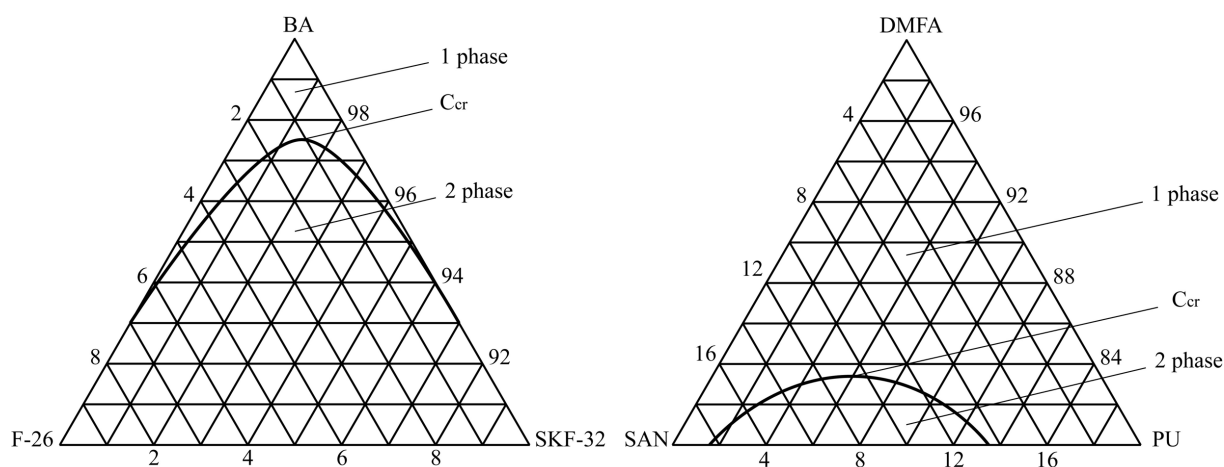


Fig.3. Phase diagram for the system a) F-26 / SKF-32 BA, b) SAN / PU DMFA.

3.3. Effect of solvent quality

There are data about the research of the influence of solvent quality on physical-mechanical properties of films casted from polymer solutions [19].

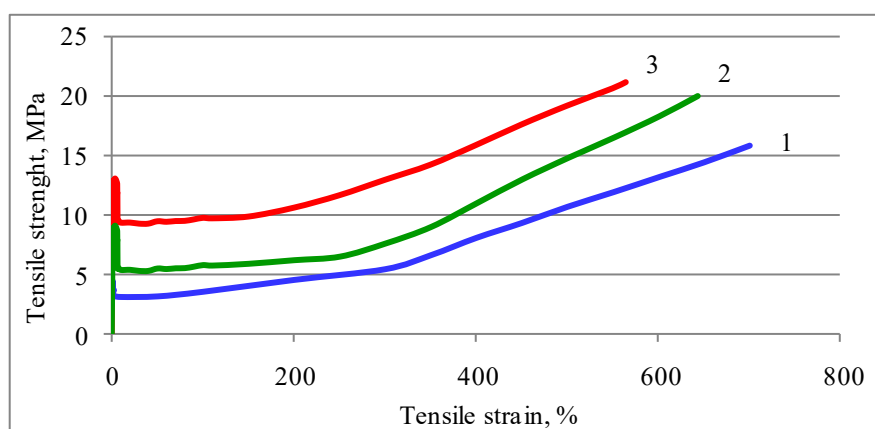


Fig.4. Diagram stress-strain for the system F-42 1 – ethyl acetate; 2 – acetone; 3 – methyl ethyl ketone.

It was found out that the solvent affects the degree of interaction of polymers not only in solution but also in the films obtained from solution. Analyzing the data obtained, confirmed by the fact that the solvent largely determines the physical-mechanical properties of polymeric materials, formed from the solution. So for the investigated films, formed from individual fluoroelastomers and fluoroplastics in the use of solvents, which can be attributed to the "good" and "bad" from a thermodynamic point of view, there is the following picture. The best physical and mechanical properties were observed for films of fluoropolymers, which used the "bad" solvent for them. For the F-42 is the MEC, F-26-EA, SKF-32-EA, SKF-26-Ac. As an example, the diagram for the F-42 (Fig. 4) was obtained. In accordance with the theoretical conceptions, in a "bad" solvent the macromolecule more tighter, what

contributes to their interaction with each other. Increases interchain interaction within the structural elements, along with it increase deformability their border areas. During the deformation of such films in the field of structural defects will be removed dangerous tension. Thus, films formed from compositions containing a polymer and a "bad" solvent have better physical-mechanical properties than the films obtained by using a "good" solvent.

In the future we will research the influence of solvent quality on physical-mechanical properties of films casted from mixtures of polymers, as well as explore the films of SAN and PU.

The data obtained by determination of the glass transition temperature for mixtures of fluoropolymers talk about the thermodynamic incompatibility of these polymers [20]. What about the system SAN / PU there are data about the partial compatibility in the range of 10-40 wt% polyurethane.

However, the lack of thermodynamic affinity says nothing about the inability to use these systems because they are technologically compatible – without layering within a certain range of concentration, at a certain temperature, for a period necessary for their processing, and thus fit for use.

To confirm this conclusion from some of the systems we have obtained non-woven fibrous material by electrospinning. Value at which we compared the quality of fibrous material was chosen breaking length.

As an example, Table 4 presents the results of physical-mechanical testing of non-woven fibrous materials obtained from the solutions of polymer blends SAN / PU in ethyl acetate and the F-26 / SKF-26 in ethyl acetate and butyl acetate.

Table 4. Physical-mechanical testing of non-woven fibrous materials

Systems	Results		
	Breaking force, N	Tensile strain, %	Breaking length, m
Ethyl acetate			
SAN	1.2	50	200
SAN + 10% PU	2.2	60	370
SAN + 20% PU	2.5	140	540
SAN + 30% PU	4.5	170	760
SAN + 50% PU	5.3	520	890
F-26	1.3	105	400
F-26 + 20% SKF-26	1.6	155	480
F-26 + 50% SKF -26	1.9	240	560
F-26 + 80% SKF -26	2.2	300	650
Butil acetate			
F-26	0.3	95	280
F-26 + 20% SKF -26	0.9	110	310
F-26 + 50% SKF -26	1.0	160	440
F-26 + 80% SKF -26	1.6	200	550

Physical-mechanical testing of materials shows that the introduction of elastomers significantly alters the properties of the final fibrous material. Based on experimental data we can see (Table 4) that the introduction fluoroelastomer SKF-26 in the fiber-forming polymer mixtures on the basis of F-26 result in increases as the breaking force and tensile strain. It is well agree with the notion of introducing a flexible chain component (fluoroelastomer). The quality of the solvent also affects the physical-mechanical properties of nonwoven fibrous material. As in the case of physical-mechanical properties of films the best results are observed for systems in "bad" solvent.

Very strong influence on the physical-mechanical properties has the introduction of PU in the mixture based on SAN (Table 4, Figure 5). Breaking force increased almost 2.5 times already by adding only 10% of elastomer, and tensile strain at break increased by 1.5 times.

It is obvious that with increasing content of PU elasticity of fibers increases. It leads to the fact that in the destructive force contribute at the same time also greater number of fibers, so the curve gets steeper form (Fig. 5).

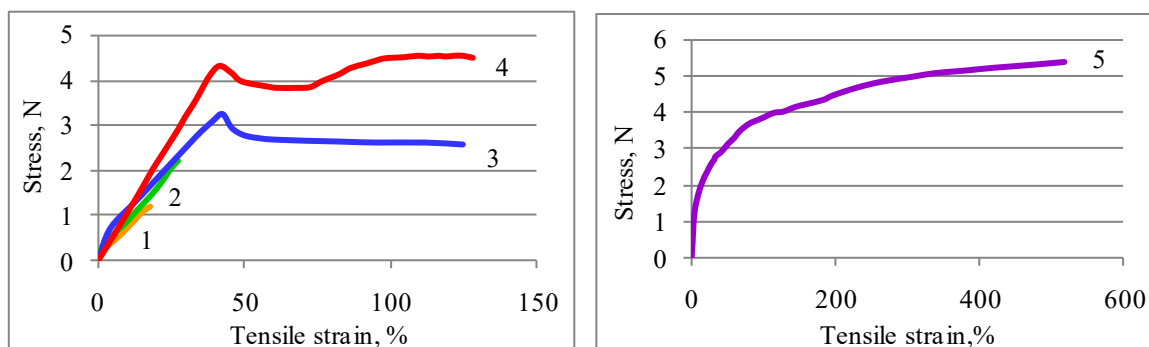


Fig.5 Diagram load-extension for the system SAN / PU EA: 1 – PU; 2 - SAN + 10wt% PU; 3 – SAN + 20wt% PU; 4 – SAN + 30wt% PU; 5 – SAN + 50wt% PU

Besides introduction elastomer causes the formation of strong splicing between the fibers at the intersections. This leads to the fact that there is a grid of gearings. First, it is accounting for all the deforming force. Straightening out and drug apart fibers without affecting increase in workload take place after the destruction of the grid. This is well illustrated by the curve of the test materials containing 20% of elastomer.

When the content of elastomer 50% fibers in interweaving spots glued together and are inseparable from each other. Grid of gearings is very stable. This sample is more elasticity in contrast to the fibrous material formed without additives, which only has plastic properties.

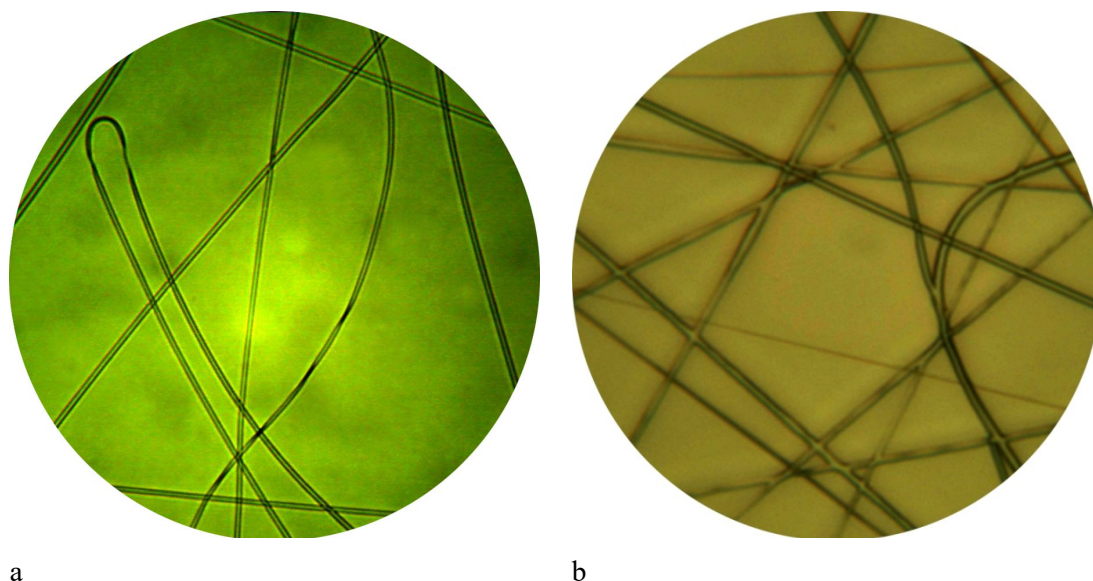


Fig. 6. Photo of non-woven fibrous material: a – SAN; b – SAN + 50wt% PU (fibers are glued together)

In general, non-woven fibrous material (Fig. 6) represents statistically packed layers of fibers. Deformation of it is actually his drug apart. At the same time during the deformation process contributed to the increase in the destructive efforts, to the extent straightening a growing number of fibers, reaching a maximum. Simultaneously there are two processes: straightening fibers and deformation of the straightened fibers.

The introduction of elastomer contributes to damping of capillary waves in the charged liquid jets of the solution, and thereby stabilizes the process of electrospinning.

Thus, the process of electrospinning depends not only on physical parameters (specific conductivity, temperature, field strength, etc.), but on the nature of the system polymer 1 - polymer 2 - solvent, which is determined by molecular characteristics of polymers and their thermodynamic affinity with the solvent.

4. CONCLUSIONS

Experience of the practical application of polymer blends has shown numerous advantages of obtained materials that can be divided into two parts:

1. Mixing of polymers with the purpose of obtaining economic benefits which were not intended to improve any properties of mixtures compared with pure components.
2. Significant improvement of properties of the mixture as compared with pure components.

Most of the practical applications belong to the second group. Improve certain properties of polymer mixtures compared with individual polymers occurs both due to the peculiarities of the two-phase structure of polymer blends and because changes in the structure of each polymer phase, occurring during mixing of polymers. In each phase of the polymer occurs a change in supramolecular structures resulting in increasing the degree of association of each polymer.

On the area of mutual compatibility of polymers in solution, which can be estimated by using the limit of separation (C_{cr}) exert influence the molecular weight of polymer, solvent quality, low-molecular additives.

The obtained results allow revealing the influence of the solvent. In the "bad" thermodynamic quality of solvents the degree of interaction of polymers is much higher than in "good". This may be due to the fact that different quality solvents create other structures of polymers in solution, remaining after removal of solvents. From the aspect of the thermodynamics of "good" and "bad" solvents differ only in their different interactions with the polymer therefore a variety of interaction themselves of macromolecules with each other in solution. In the "bad" solvent interaction is higher than in "good". Tighter macromolecules in a «bad» solvent favor an increase the number of contacts not only between homogeneous and heterogeneous macromolecules. Different interactions of polymers in solution leads to a difference in the properties of films obtained from solution so as in the films is partially preserved structure, which is present in the solution.

The same conclusion can be inferred about physical-mechanical properties of nonwoven fibrous materials: the worse the quality of the solvent the better the physical-mechanical properties.

Thus in conclusion we can say that the choice of components of polymers mixtures and solvent for processing them through solutions allows in a wide range to regulate complex physical-mechanical properties of the researched films and fibrous materials, creating the products with a complex of valuable consumer properties.

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