

# Poly (Vinyl Alcohol)/Poly (Vinyl Acetate) Blend Films

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**Abstract:** Poly (vinyl alcohol) (PVA) and poly (vinyl acetate) (PVAc) blend films were prepared by mixing of water systems: PVA solution and PVAc emulsion with subsequent drying at room temperature.

Differential scanning calorimetry (DSC) and SEM investigation shows that components in mixtures form discrete phases. Blends are microheterogeneous. In blends with high PVA content where the dispersion phase is PVA, inclusions of PVAc phase with predominant dimensions 2 - 4  $\mu\text{m}$  are detectable. For systems with low PVA content PVA inclusions as discrete objects are less visible. Tensile stress  $\sigma$  - strain  $\varepsilon$  relations of blend films were determined. Some common  $\sigma$  and  $\varepsilon$  values were fixed (maximum stress  $\sigma_{\text{MAX}}$  and respective strain value  $\varepsilon_{\text{MAX}}$ , yield stress  $\sigma_Y$  and corresponding  $\varepsilon_Y$ , and characteristics at fracture  $\sigma_B$  and  $\varepsilon_B$ ), initial modulus of elasticity  $E = \lim(d\sigma/d\varepsilon)|_{\varepsilon \rightarrow 0}$ . Films with broad range of tensile strength-deformation characteristics:  $E = 0,3 - 2,2$  GPa,  $\sigma_{\text{MAX}} = 9 - 106$  MPa,  $\sigma_Y = 8 - 73$  MPa,  $\sigma_B = 11 - 42$  MPa,  $\varepsilon_B = 0,32 - 2,07$  can be obtained by variation of ratio of component content in mixture.

**Keywords:** Poly (vinyl alcohol), poly (vinyl acetate), blends, films, composition, mechanical properties

## I INTRODUCTION

Poly (vinyl alcohol) (PVA), a polyhydroxy polymer, is the largest, synthetic, water-soluble polymer produced in the world based on volume. It is produced commercially by the hydrolysis of poly (vinyl acetate) (PVAc) [1]. Polyvinyl alcohol has excellent film forming, emulsifying, and adhesive properties. It is also resistant to oil, grease and solvent. PVA is odorless and nontoxic, as well as has high oxygen and aroma barrier properties [2].

PVA has high enough tensile strength and satisfactory flexibility. To improve deformability PVA is usually plasticized by the variety of low molecular compounds mostly containing polar groups [3], which associate with hydroxyl groups of PVA chain (with or without water assistance) developing hydrogen bonds, thus reducing direct hydrogen bonding between PVA macromolecules [4].

The comparatively high biodegradability in the environment may be one of the most important and desirable characteristic of PVA, because the polyvinyl-type polymer consisting of a carbon-carbon main chain is scarcely biodegradable [5]. This property of PVA has recently been reevaluated, and much effort has been made to produce PVA-based biodegradable polymeric materials having preferred physical and chemical properties for use in industrial and medical fields.

To improve mechanical or thermal properties PVA is blended with different synthetic polymers, such as ethylene-vinyl alcohol copolymer, poly(ethylene terephthalate),

poly(vinyl chloride), polyurethanes, polyamides, polycarbonates and others [6]. Natural polymers such as starch, chitin, chitosan, lignin or cellulose are also used [7]. Blends may be processed by conventional plastics technology to form various articles, which exhibit good balance of barrier and strength properties, low moisture absorptivity, and toughness/modulus combinations adequate for packaging uses [8].

Development of PVA blends with another more deformable polymeric counter component could turn out efficient. Poly (vinyl acetate) (PVAc) was chosen as this counter component. Comparison of some strength-deformation characteristics of both polymers looks promising [3,4] (Table 1).

TABLE 1  
STRENGTH, DEFORMATION AND THERMAL CHARACTERISTICS OF PVA AND PVAc

Parameter	PVA	PVAc
Crystallinity, %	60-70	0
Glass transition temperature, °C	85	28
Tensile strength, MPa	65-120	23-35
Elongation at break, %	0 - 3	60 - 100

Seemed appropriate to use ecologically safe low concentration water systems to prepare mixtures: water solution of PVA and water emulsion of PVAc.

The main objective of the present study was to ascertain the possibility of preparation of respective PVA/PVAc mixtures and successive films and to evaluate their structural and mechanical characteristics.

## II MATERIALS AND METHODS

### A Materials

Partially crystalline water soluble PVA (GOST 10779-78) was used. Molecular weight of PVA - 133 000 Da was determined viscometrically using [Ubbelohde viscometer](#) [9]. Degree of hydrolysis was established according to ISO 15023-2 [10]. Content of acetate group in PVA - 0,98 %.

PVAc glue IMA-PVA D3 (Lithuania) was used As PVAc emulsion.

### B Preparation of films

Blends of PVA/PVAc were prepared by gentle mixing of 10 wt % aqueous systems of both components. Water systems turned out to be easy mixable. Blends were visually rather uniform.

Blends with following weight fraction of PVA  $\varphi_{PVA}$ : 1; 0,9; 0,7; 0,5; 0,3; 0,1 and 0 were prepared (respective volume fraction:  $\varphi^*_{PVA} - 1; 0,91; 0,71; 0,52; 0,31; 0,11$  and 0).

Films were made by solvent casting technique. Mixtures were poured in to plastic Petry dishes (diameter - 140 mm) to reach thickness of layer - 1,5 mm. Mixtures were dried at 17 °C temperature for 5 days till the constant residual water content (about 5 %). Final thickness of films was  $150 \pm 20 \mu\text{m}$ .

Density of films was determined using hydrostatic weighing method in ethanol according to LVS EN 1183 A (Sartorius KB BA 100).

### C Mechanical properties

The tensile tests were carried out by a Zwick/Roell universal testing machine at room temperature, according to EN ISO 527. The speed of the upper traverse - 20 mm /min.

Stress ( $\sigma$ ) - strain ( $\varepsilon$ ) relationship were determined till the breaking of specimens. All mechanical characteristics were the average of five specimens. The maximum variation of characteristics was less then 10% of the average value. All parameters are set, by use of the original program testXpert V11.0.

### D Differential scanning calorimetry (DSC)

The thermal properties of the films were determined by differential scanning calorimetry on a Mettler Toledo DSC-30 calorimeter. Specimens of weight about 10 mg were heated with heating rate of 10°C/min from 25 to 250° C in a nitrogen atmosphere. The samples are then cooled (10°C /min) till 25° C and reheated with the same heating rate (second heating cycle). All parameters are set, by using the original program METTLER GrapWare TA72PS.

PVA phase of crystallinity is set by the crystallinity melting heat effect, assuming that the melting heat of completely crystalline PVA is 138 J/g [11].

### E UV-VIS

Visible and UV light absorbance of films was measured by use of the Tidas J&M MSP 800 system.

### F Scanning electron microscopy (SEM) analysis

For microscopic examination of film structure samples were cooled in liquid nitrogen and fractured by bending. Fracture surfaces of specimens were gold covered (Emitech, K550X). The morphology of fracture surfaces of the specimens was investigated by a Tescan, Mira/LMU Schottky scanning electron microscope at the 3000x and 10 000x magnification and voltage of 25 kV.

## III RESULTS AND DISCUSSION

Components (PVA water solution and PVAc water emulsion) are easy mixable and form visually uniform mixture.

The transmittance of the obtained films differs. PVA and PVAc films are transparent and clear, transmission in visible light range is very large and practically the same (> 90%) (Fig.1). It means that both, PVA aqueous solution and the PVAc aqueous emulsion during the drying process form rather homogeneous structure.

Films, obtained from mixtures are visually opalescent, the transparency is significantly less (Fig. 1). The reason is certain heterogeneity of the mixture structures: separate structure formations scatter visible light. Films from mixtures with PVA content  $\varphi_{PVA} = 0,1 - 0,3$  have lower light transmission values.

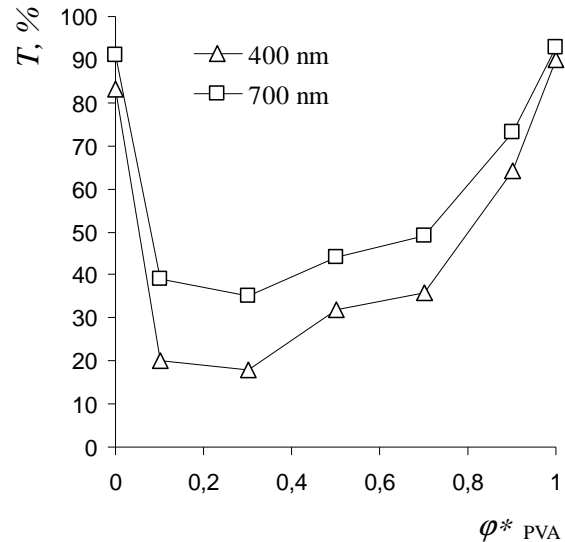


Fig.1 Transmittance T of visible light as function of PVA content  $\varphi^*_{PVA}$  in PVA/PVAc blend films

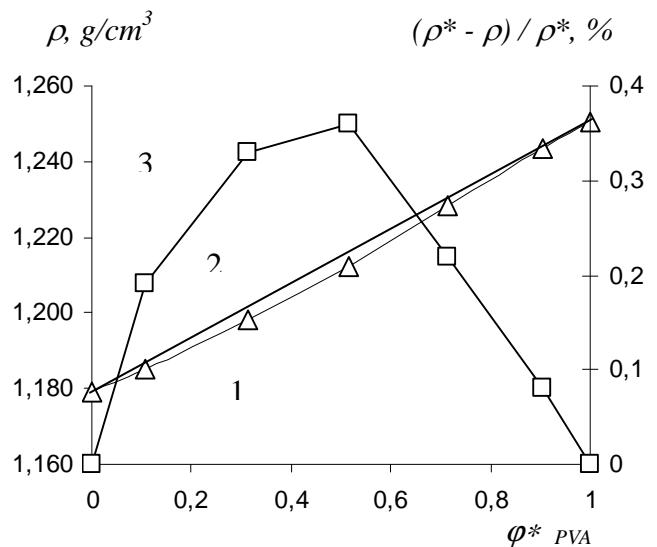


Fig.2. Experimental (1) and additive (2) density values; relative deviation of experimental density value from the additive ones (3) of PVA/PVAc blends

Experimental values of the density  $\rho$  (see Fig. 2, curve 1) are slightly lower than the corresponding density values (Fig.2, curve 2), that were calculated by use of additive relationships:  $\rho^* = \rho_{PVA} \varphi^*_{PVA} + \rho_{PVAc} \varphi^*_{PVAc}$ , where  $\rho_{PVA}$ ,  $\rho_{PVAc}$  - density of PVA and PVAc, respectively;  $\varphi^*_{PVA}$ ,  $\varphi^*_{PVAc}$  - respective volume fractions of mixture components. Mixtures with PVA content  $\varphi^*_{PVA} = 0,3 - 0,5$  shows the largest relative deviation values of experimental density values from the respective additive values  $(\rho^* - \rho) / \rho^*$  (Fig. 2, curve 3). This deviation does not exceed 0,4 %. Most likely the

reason of it is the presence of tiny, ultra microscopic inclusions of gas, those arise while mixing.

Aimed to obtain additional information about the structure of the blends the DSC test was made.

Pure PVA sample in the first heating cycle shows a strong endothermic peak in the temperature range of 191 - 234 °C, with the maximum at 224 °C (Fig. 3), that corresponds to the melting process of the PVA crystalline part. Exothermal PVA crystallization peak occurs in the subsequent cooling cycle that compared with the melting peak is shifted to the lower temperature range (158 to 195 °C, maximum at 195 °C). In the second heating cycle melting is repeated in the same temperature range as in the first. Heat effects  $\Delta H$  of these processes differs a little, and are accordingly 69, 62 and 57 J/g. Calculated crystallinity values are accordingly: 50, 45 and 41 %.

It means that in conditions of film formation by simple evaporation of water from the solution, PVA reaches crystalline structure, which practically does not differ from crystalline structure that emerges by the crystallization in the melt. The degree of crystallinity in the first case is even slightly higher, apparently due to increased mobility of macromolecular in a course of formation of the crystalline from the solution.

Distinct glass transition of polymer amorphous phase can be seeing on the PVA thermogram since the PVA crystallinity is not higher than 50%. In the first heating cycle it occurs in the temperature range: 42 - 55 °C, with flexion at 48 °C, in the second heating cycle – in the range 70 - 93 °C, with flexion at 82 °C, which is typical to the PVA [3].

We can observe also an endothermic peak in the first heating cycle in the case of PVA, which is characterizes release of remains of bounded water (temperature range 84 - 179 °C,  $\Delta H = 70$  J/g). Estimated amount of leaving water (the heat of water evaporation - 2270 J/g, [12]) is ~ 3%.

The slightly reduced PVA glass transition temperature range in the first heating cycle most probably is due to water plasticizing effect.

Thermogram of amorphous PVAc in the first heating cycle (Fig. 3) shows a glass transition, in the temperature range: 25 - 41 °C, with flexion at 32 °C.

In the subsequent cooling condition PVAc glass transition occurs in the slightly higher temperature range: 30 - 46 °C, with flexion at 39 °C, and re-heating in the temperature range: 39 - 56 °C, with flexion at 48 °C.

PVAc also contains bounded water (see the endothermic peak, Fig. 3). Since PVAc does not contain hydroxyl groups, comparing with PVA, water volatilizes at significantly lower temperature range (53 - 145 °C); the amount of water is less than ~ 1% ( $\Delta H = 23$  J/g).

Another endothermic peak appears on the PVAc thermogram in the temperature range of 168-233 °C. Most likely it is associated with the evaporation or thermal decomposition of certain emulsifying additives of PVAc.

The observed low glass transition temperature of PVAc increases at the re-heating cycle. It shows that the PVAc structure formed by evaporation of PVAc water emulsion somewhat assembles at elevated temperature, possibly as a result of water release and more complete coalescence of emulsion particles.

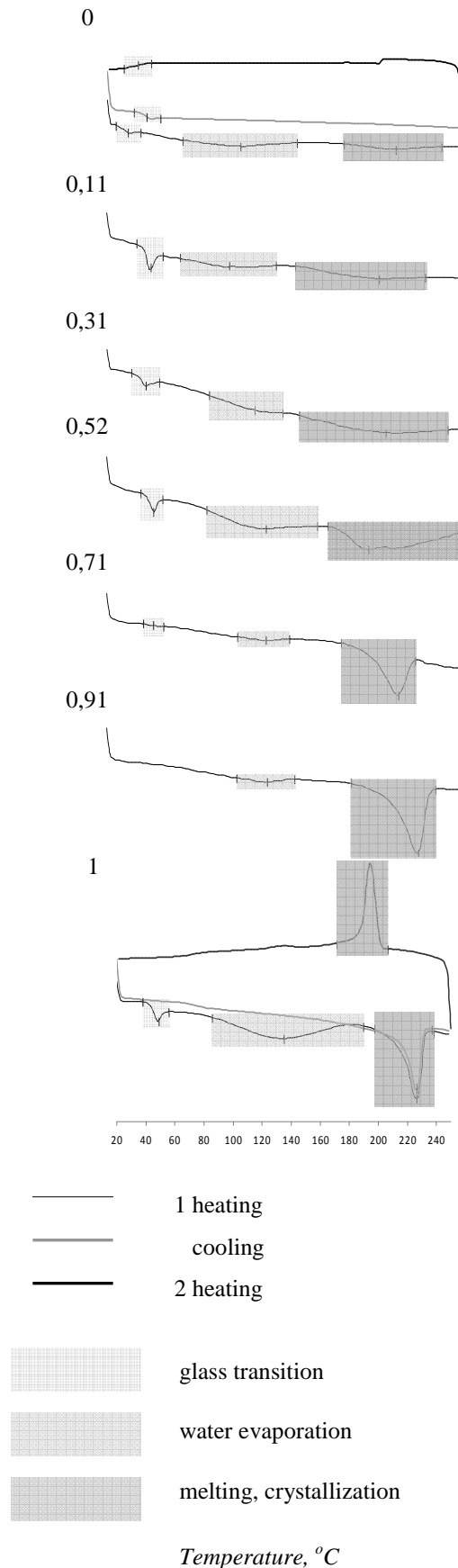


Fig.3. DSC curves of PVA/PVAc blends:  $\phi^*_{PVA}$  is depicted

Glass transition of components does not appear separately on the thermograms of PVA/PVAc mixtures. Glass transition at temperature region which corresponds to polyvinyl alcohol was observed for the mixtures with high content of PVA. In their turn the blends with higher content of PVAc shows polyvinyl acetate glass transition region.

We failed to assess melting process of PVA and to determine its degree of crystallinity in PVA/PVAc blends, because the presence of PVAc affects PVA melting process. As seen from the Figure 3 and table 2 data, with increase of PVAc content in the mixture the PVA melting initial temperature  $T_{mI}$  as well as melting maximum temperature  $T_{mmax}$  significantly decreases.

Melting heat values, calculated for PVA at low PVAc content ( $\Delta H^*$ ) almost does not change. However, at higher PVAc content values ( $\phi_{PVA} \geq 0.5$ ) it reaches illogically high values.

There is serious ground to believe that at the higher temperature ( $> 150^\circ\text{C}$ ) deliquescence of melting PVA into PVAc melt takes place. Indeed, for the system with  $\phi_{PVA} = 0.5$  in the cooling cycle crystallization of PVA part doesn't occur.

PVA melting is no longer observed in the second heating cycle.

DSC data show that the formation of a compound structure from water systems at room temperature (below the glass transition temperature of both components and, of course, below the initial melting temperature of PVA) PVAc and PVA components exist as separate phases.

SEM micrographs of brittle fracture of composite (Fig. 5) confirm it. For systems with  $\phi_{PVA} > 0.5$  (dispersion phase is PVA), inclusions of PVAc (average: 2 - 4  $\mu\text{m}$ ) are seen. For blends with  $\phi_{PVA} < 0.5$  (dispersion phase is PVAc) PVA inclusions as discrete objects is harder to observe. As seen from Figure 5, the fracture surface relief changes with content ratio of components. While fracture surface relief of pure components is relatively plane flat, with marked large smooth flat surface areas, relief of composites is rough. The reason is propagation of the fracture crack along the interface of constituent phase inclusions. Samples with equal volume parts of components ( $\phi_{PVA} = 0.5$ ) have more developed surface relief of fracture. It is likely that this region of the ratio of the component corresponds to the phase inversion.

TABLE 2  
DSC CHARACTERISTICS OF PVA MELTING IN PVA/PVAc BLENDS

$\phi^*_{PVA}$	Melting temperature of PVA, $^\circ\text{C}$			Heat of melting, J/g	
	$T_{mI}$	$T_{mmax}$	$T_{mE}$	$\Delta H$	$\Delta H^*$
1,0	191	224	234	69	69
0,91	180	222	232	64	71
0,71	172	209	220	39	56
0,52	160	187	248	60	120
0,31	144	200	244	36	120
0,11	148	195	234	16	160

$T_{mI}$ ,  $T_{mmax}$ ,  $T_{mE}$  – values of initial, maximum and end melting temperature, respectively;  
 $\Delta H$  – average heat of melting;  $\Delta H^*$  – heat of melting, calculated for PVA

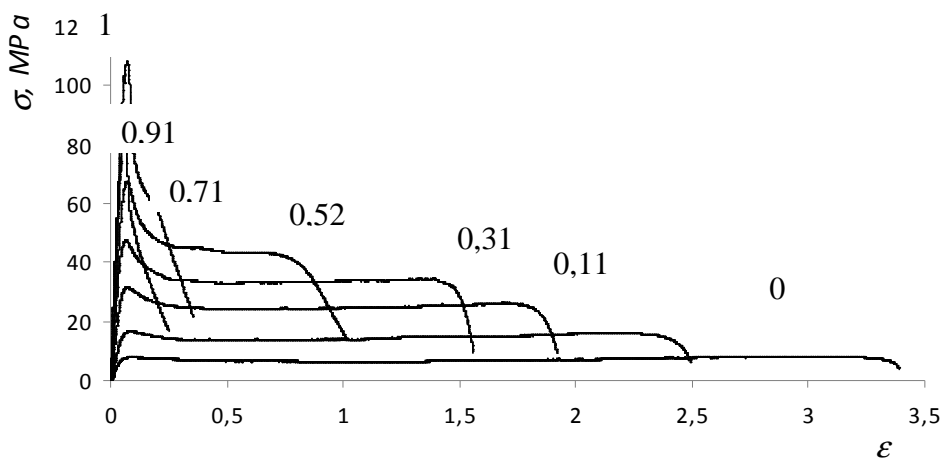
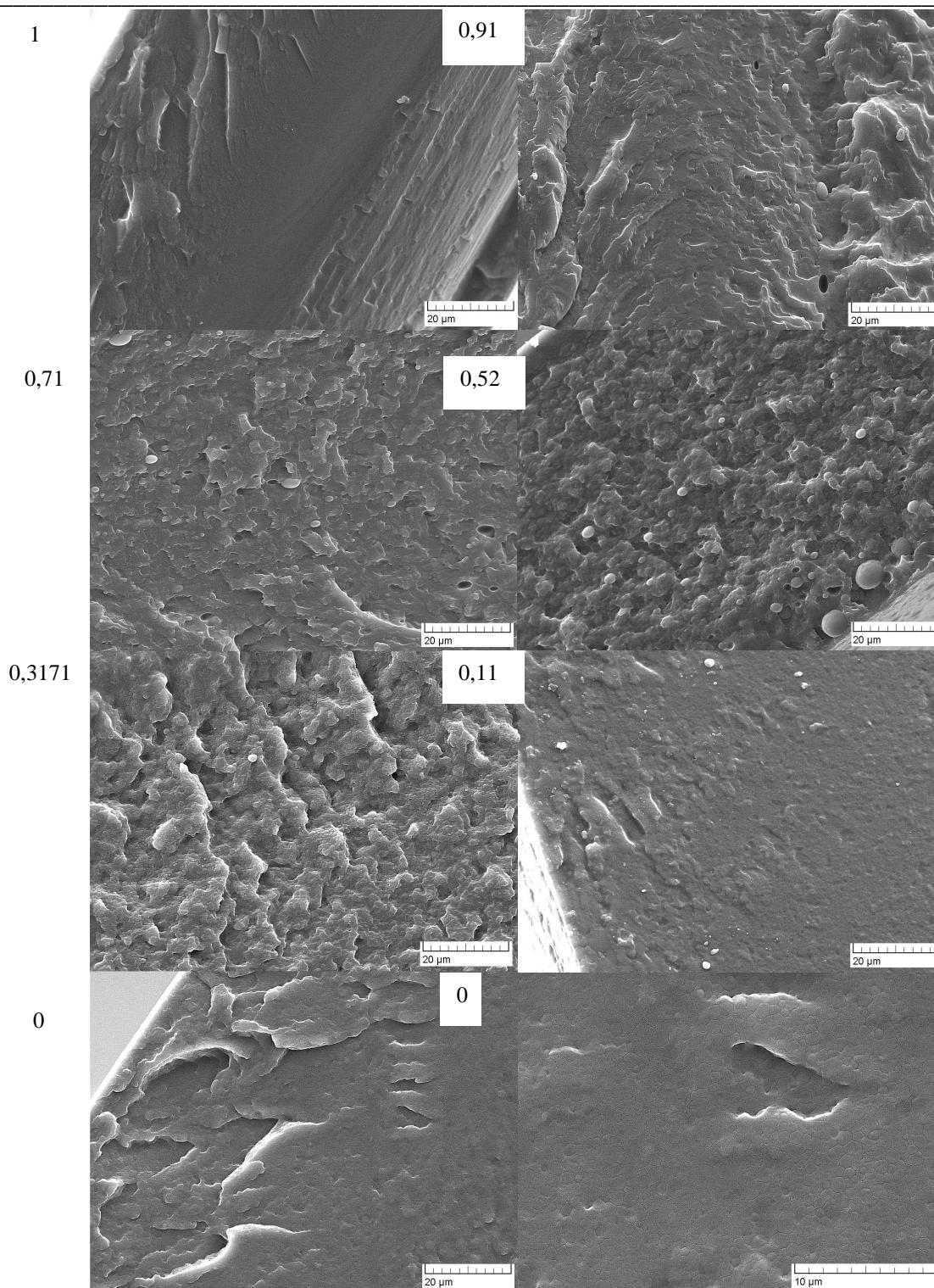


Fig. 4. Typical  $\sigma(\epsilon)$  curves of PVA/PVAc blend films ( $\phi^*_{PVA}$  are depicted)



**Fig.5.** SEM micrographs of brittle fracture surfaces of PVA/PVAc blend films ( $\varphi^*_{PVA}$  are depicted)

On the micrographs of mixtures in the areas that correspond to the PVAc phase well visible densely spaced honeycomb-like structure formations can be seen. These formations with the size about  $2 \mu\text{m}$  apparently are coalesced PVA emulsion particles (PVA emulsion particles typically are in range of  $\sim 1 - 3 \mu\text{m}$  [13]).

Tensile stress  $\sigma$  - strain  $\varepsilon$  relations of blend films were determined. Representative  $\sigma(\varepsilon)$  curves for all studied mixtures, as well as for base components are shown in Figure 4.

TABLE 3  
STRENGTH AND DEFORMATION CHARACTERISTICS OF PVA/PVAc BLENDS

$\varphi_{PVA}$	$E$ , GPa	$\sigma$ , MPa					$\varepsilon$		
		$\sigma_{MAX}$	$\sigma_Y$	$\sigma_B$	$\sigma_{MAX} - \sigma_Y$	$(\sigma_{MAX} - \sigma_Y) / \sigma_Y$	$\varepsilon_{MAX}$	$\varepsilon_Y$	$\varepsilon_B$
1,0	2,18	106 (1)*	73 (1)	42 (1)	33	0,45	0,08	0,11	0,32
0,91	2,10	93 (1,14)	65 (1,12)	44 (0,95)	28	0,43	0,07	0,10	0,23
0,71	1,58	66 (1,61)	49 (1,49)	37 (1,14)	17	0,35	0,06	0,21	0,85
0,52	1,15	46 (2,30)	36 (2,03)	37 (1,14)	10	0,28	0,07	0,23	1,65
0,31	0,83	32 (3,31)	26 (2,81)	25 (1,68)	7	0,23	0,06	0,17	1,07
0,11	0,53	17 (6,24)	15 (4,87)	16 (2,63)	2	0,13	0,07	0,25	2,07
0	0,30	9 (11,8)	8 (9,13)	11 (3,82)	1	0,12	0,07	0,41	3,48

\* in brackets: the ratio of  $\sigma$  value for PVA to the respective  $\sigma$  value for the mixture

Some distinct similarities in the resulting curves can be seen, which allows to fix some common stress  $\sigma$  and strain  $\varepsilon$  values (maximum stress  $\sigma_{MAX}$  and respective strain value  $\varepsilon_{MAX}$ , yield stress  $\sigma_Y$  and corresponding  $\varepsilon_Y$ , and characteristics at fracture  $\sigma_B$  and  $\varepsilon_B$ ), initial modulus of elasticity  $E = \lim(d\sigma/d\varepsilon)|_{\varepsilon \rightarrow 0}$ . Values of characteristics obtained from  $\sigma(\varepsilon)$  curves are summarized in Table 3.

Elastic modulus  $E$  describes the resistance of the initial structure of the material to the low deformation values, when structures transformations nearly have not yet occurred.

At temperature of the experiment (25°C) the amorphous part of PVA is almost 50 °C below its glass transition temperature. This fact, as well as reasonably high degree of crystallinity of PVA provides a relatively high level of intermolecular interactions. This is why the  $E$  value of PVA is almost 7 times higher than the modulus of elasticity of fully amorphous PVAc (the experimental temperature is very close to the PVAc glass transition range), see Table 3.

There is a reason to consider that load bearing ability of composites with  $\varphi_{PVA} > 0,5$  is determined by rigid PVA matrix, in which relatively compliant discrete PVAc inclusions are incorporated (see Fig. 5). Mixtures with  $\varphi_{PVA} < 0,5$  can be considered as composites with the compliant PVAc matrix, containing rigid inclusions of PVA, that could play a role of peculiar "filler".

For all the studied mixtures, as well as for base components the maximum  $\sigma_{MAX}$  of the  $\sigma(\varepsilon)$  curves is in the beginning, after which follows more or less rapid stress decline. After that the stress, depending on the composite content, decreases less rapidly ( $\varphi_{PVA} < 0,7$ ), remains constant ( $\varphi_{PVA} = 0,3 - 0,5$ ), or even slightly increases ( $\varphi_{PVA} < 0,3$ ). At this stage the stress falls rapidly, the sample loses integrity and collapses.

PVA deforms as a crystalline polymer, sufficiently large amorphous part of which is in glassy state - in the temperature range between glass transition temperature and the brittleness temperature [3].

Deformation value of  $\varepsilon_{MAX}$  respective to  $\sigma_{MAX}$  value is small (<0.08) and for various mixtures is practically the same. Just as the modulus of elasticity,  $\sigma_{MAX}$  is characterized by composite structure resistance to deformation.

The individual characteristics of two components manifest as  $\sigma(\varepsilon)$  characteristics in further deformation process as well.

The values that characterize the end of rapid stress drop ( $\sigma_Y$  and  $\varepsilon_Y$ ) are completely dependent on the content of the composition. The stress fall certainly is associated with stress initiated release of "frozen" conformations of PVA macromolecules.

The more rigid is composite structure (higher PVA content), the greater is stress fall (the difference  $\sigma_{MAX} - \sigma_Y$ ) and its relative value (the difference  $(\sigma_{MAX} - \sigma_Y) / \sigma_Y$ ) (Table 3) and the lower is the strain value  $\varepsilon_Y$  (Table 3).

Surpassing the  $\sigma_Y$  and  $\varepsilon_Y$  values, systems with a high content of PVA ( $\varphi_{PVA} < 0,7$ ) are characterized by a significant reduction in stress ( $\sigma_Y > \sigma_B$ ) up to the collapse of the sample. This clearly shows that the composite structure degrades in the deformation process.

For composites with lower content of PVA ( $\varphi_{PVA} = 0,3 - 0,5$ ) the stress is practically constant ( $\sigma_Y \approx \sigma_B$ ).

If the PVA content is very low ( $\varphi_{PVA} = 0 - 0,1$ ) the stress slightly increases ( $\sigma_Y < \sigma_B$ ). This increase is attributed to the effect of orientation strengthening increase [14]: straightening of macromolecules and mutually parallel orientation of the tensile direction.

#### IV CONCLUSIONS

Development of PVA/PVAc blend films from water systems (PVA solution and PVAc emulsion) by simple mixing and subsequent drying at room temperature (below the glass transition temperature of both polymers) leads to formation of mixtures in which components exist as separate phases.

Blends are microheterogeneous. In blends with PVA volume fraction  $> 0,5$  where the dispersion phase is PVA, inclusions of PVAc phase with predominant dimensions 2 - 4  $\mu\text{m}$  are detectable. For systems with PVA volume fraction  $< 0,5$  (dispersion phase is PVAc) PVA inclusions as discrete objects are less visible.

Films with broad range of tensile strength-deformation characteristics: elastic modulus: 0,3 - 2,2 GPa, maximum stress: 9 - 106 MPa, yield stress: 8 - 73 MPa, ultimate stress: 11 - 42 MPa, elongation at break: 0,32 - 2,07 can be obtained by variation of component ratio in mixture.

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**Natalja Jelinska, Mārtiņš Kalniņš, Velta Tupureina, Anda Dzene. Polivinilspirta/polivinilacetāta maisījumu plēves.**

Polivinilspirta (PVS) un polivinilacetāta (PVA) maisījumi tika iegūti sajaucot ūdens sistēmas: PVS šķīdumu un PVA emulsiju. Komponentes viegli sajaucas un veido vizuāli viennērīgu maisījumu. Plēves tika iegūtas lejot ar sekojošu žāvēšanu istabas temperatūrā. PVS un PVA plēves ir caurspīdīgas un bezkrāsainas. Maisījumu plēves ir opaliscējošas, to caurlaidība redzamās gaismas diapazonā ir zemāka, kas liecina par noteiktu struktūras heterogenitāti. Diferenciāli skenējošās kalorimetrijas (DSK) un skenējošās elektronu mikroskopijas (SEM) pētījumi liecina, ka komponenti maisījumā veido atsevišķas fāzes. Maisījumi ir izteikti mikroheterogēni. Maisījumos ar lielu PVS saturu, kad dispersijas fāze ir polivinilspirts, saskatāmi polivinilacetāta ieslēgumi ar dominējošiem izmēriem 2-4 μm. Savukārt sistēmās ar zemu PVS saturu, kad dispersijas fāze ir PVA, PVS ieslēgumi kā diskreti objekti ir grūtāk saskatāmi. Iegūtām plēvēm tika noteiktas sprieguma σ – deformācijas ε sakarības stiepes režīmā. Eksperimentāli noteikti atsevišķi visām sistēmām kopīgie sprieguma un relatīvās deformācijas raksturlielumi stieperē (maksimālais spriegums σ<sub>MAX</sub> un tam atbilstošā deformācijas vērtība ε<sub>MAX</sub>, tecēšanas spriegums σ<sub>γ</sub> un atbilstošais ε<sub>γ</sub>, stiepes robežspriegums σ<sub>B</sub> un trūkšanas pagarinājums ε<sub>B</sub>), kā arī sākotnējais elastības modulis  $E = \lim(d\sigma/d\varepsilon)|_{\varepsilon \rightarrow 0}$ . Kompozītu slodzes nestspēju pie PVS tilpuma daļas kompozītā > 0,5 nosaka stingā PVS matrica, kurā izkliedētas relatīvi padevīgā PVA ieslēgumi. Maisījumi ar PVS tilpuma daļu kompozītā < 0,5 var tikt uzskatīti kā kompozīti ar padevīgu PVA matricu, kurā ietvertas stingi PVS ieslēgumi, kuriem ir savdabīgas „pildvielas” loma. Variējot komponentu saturu kompozītā, iespējams iegūt plēves ar plašu stiprības-deformācijas rādītāju diapazonu: E = 0,3 – 2,2 GPa, σ<sub>MAX</sub> = 9 – 106 MPa, σ<sub>γ</sub> = 8 – 73 MPa, σ<sub>B</sub> = 11 – 42 MPa, ε<sub>B</sub> = 0,32 – 2,0.

**Наталья Елинска, Мартиныш Калниньш, Велта Тупуреина, Anda Дзене. Пленочные материалы на основе смесей поливинилового спирта и поливинилацетата.**

Смеси поливинилового спирта (ПВС) и поливинилацетата (ПВА) были получены путем смешения водных систем: раствора ПВС и эмульсии ПВА. Компоненты легко смешиваются образуя равномерную смесь. Пленки получали методом литья с последующей сушкой при комнатной температуре. Пленки ПВС и ПВА прозрачны и безцветны. Пленки смесей опалисцируют, их светопропускание в области видимого света ниже, что свидетельствует о некоторой гетерогенности структуры. Исследования методами сканирующей дифференциальной калориметрии (ДСК) и сканирующей электронной микроскопии (СЭМ) свидетельствуют о том, что компоненты в смеси формируют отдельные фазы. Смесей выражено микрогетерогенны. В смесях с высоким содержанием ПВС, где дисперсионной фазой является ПВС, обнаруживаются включения поливинилацетата с преобладающими размерами 2 – 4 мкм. В системах с низким содержанием ПВС, когда дисперсионной фазой является ПВА, дискретные включения ПВС обнаруживаются менее отчетливо. Для полученных пленок определены зависимости напряжение σ - деформация ε. Экспериментально определены отдельные общие характеристики напряжения и деформации (максимальное напряжение σ<sub>MAX</sub> и соответствующее ему значение деформации ε<sub>MAX</sub>, напряжение текучести σ<sub>γ</sub> и соответствующее ε<sub>γ</sub>, предел прочности при растяжении σ<sub>B</sub> и относительная деформация при разрыве и ε<sub>B</sub>), а также начальный модуль эластичности  $E = \lim(d\sigma/d\varepsilon)|_{\varepsilon \rightarrow 0}$ . Несущую способность композитных пленок при объемной доле ПВС и композите > 0,5 определяет жесткая матрица ПВС, в которой распределены включения относительно податливого ПВА. Смесей с объемной долей ПВС < 0,5 могут рассматриваться как композиты с податливой матрицей ПВА и жесткими включениями ПВС, выполняющими роль своеобразного «наполнителя». Варьированием соотношения содержания компонентов могут быть получены пленки с широким диапазоном значений деформационно-прочностных показателей: E = 0,3 – 2,2 ГПа, σ<sub>MAX</sub> = 9 – 106 МПа, σ<sub>γ</sub> = 8 – 73 МПа, σ<sub>B</sub> = 11 – 42 МПа, ε<sub>B</sub> 0,32 – 2,0.