

WOOD POLYMER COMPOSITE BASED ON A STYRENE  
AND TRIETHOXY(VINYLPHENETHYL)SILANEOmar Mukbaniani<sup>1,2</sup>, Jimsher Aneli<sup>2</sup>, Tamara Tatrishvili<sup>1,2</sup> ✉, Eliza Markarashvili<sup>1,2</sup>,  
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**Abstract.** Today obtaining environmentally friendly wood composite materials is one of the main tasks. The urea-, phenol-, and melamine-formaldehyde resins used today are harmful to the human body and have a long-lasting effect. Therefore, replacing these and other resins with safe binders is one of the major problems. The aim of the work was to obtain and research ecologically safe wood polymer composites-deckings based on a new environmentally safe binder and a reinforcing agent triethoxy(vinylphenethyl)silane and styrene (*in-situ* polymerization) with a pine sawdust filler and aluminum hydroxide as an antioxidant. On the basis of triethoxy(vinylphenethyl)silane, styrene, and sawdust, the wood polymer composites – deckings have been obtained by hot pressing method at different temperatures and ratios of used components in the presence of antioxidant. For deckings surface, a morphological examination using optical microscopy, scanning electron microscopic (SEM), and energy-dispersive X-ray roentgenographic microanalysis were performed. Water absorption, softening temperature (Vicat), strength on bending, and impact viscosity were determined. Besides, using sawdust as coupling and reinforcement agents, and aluminum hydroxide as an antioxidant, wood polymer composites (WPC) were obtained by hot pressing at different temperatures. For the obtained composites, the morphological study of the surface was carried out using optical microscopy and scanning electron microscopy, energy dispersive X-ray microanalysis. Water absorption of composites, bending yield stress, impact strength, and softening temperature were determined by the Vicat method. The obtained composites were characterized by higher physicomechanical properties and water absorption.

**Keywords:** wood, polymer composite, decking, antipyrene, optical microscopy.

## 1. Introduction

A more recent development in composite technologies is wood/plastic composites (WPCs). Developed by small entrepreneurs and multi-national oil companies, these materials attempt to take advantage of the properties of both materials.<sup>1</sup> The reinforcement of thermoplastics by means of cellulosic fibers such as wood significantly improves stiffness and strength compared to the neat polymers, at the expense of ductility and impact strength.<sup>1-3</sup> Wood has been widely used to replace reinforcing fillers previously used to fill plastics, such as inorganic materials and synthetic fibers because it presents several advantages.<sup>4,5</sup>

Inorganic nanoparticles have found numerous applications in fields such as medicine, design of electronic devices, catalysis, and polymers reinforcement. Grafting polymer chains endow them with unique functional properties and allow tailoring of their surface characteristics to obtain materials with novel properties and applications. The dispersion of silica particles in aqueous media is enhanced by grafting the nanoparticles with water-soluble polymers such as poly(oxyethylene methacrylate) and ionic poly(styrene sulfonic acid).<sup>6</sup> In contrast, when silica particles are grafted with polystyrene (PS) a hydrophobic behavior is found.<sup>7,8</sup>

Surface-modified silica particles have potential applications in different technological fields, some of them are the reinforcement of polymers<sup>9</sup> and the design of heterogeneous catalysts.<sup>10</sup> Dey *et al.*<sup>11</sup> also reported the synthesis of responsive hybrid nanoparticles by the reaction of epoxy-modified silica with a stimuli-responsive poly(acrylic acid-N-isopropyl acrylamide).

The modification of inorganic materials, such as silica, requires the presence of functional groups on the surface of the particles capable of either being involved in a polymerization reaction or reacting with terminal groups of preformed polymers. Several strategies have been reported for grafting polymer chains into silica particles.

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Linking covalently vinyl moieties to the surface of the particles followed by free radical polymerization of the corresponding monomer has been widely reported.<sup>7,12-14</sup>

Comparable results are obtained when the silica surface is modified with a chain transference group.<sup>15</sup> Living polymerizations have been reported to be used for obtaining well-defined silica nanoparticles grafted with polymers. Nitroxide-mediated polymerization is reported by Chevigny *et al.* for grafting silica particles with polystyrene.<sup>16</sup> Laruelle *et al.*<sup>17</sup> grafted silica nanoparticles with polystyrene-block-polybutylacrylate using stable free radical polymerization.

The use of reversible addition-fragmentation chain transference,<sup>18</sup> atom transference radical polymerization,<sup>19-21</sup> and anionic polymerization<sup>22,23</sup> have also been reported. In the present research, the synthesis of random copolymers based on poly(styrene-co-triethoxyvinylsilane) and their application as macrosilanes for grafting silica particles with PS chains in a single-step reaction is reported.<sup>24</sup> The wood polymer composite on the basis of triethoxy(vinylphenethyl)silane and sawdust *via in-situ* polymerization has been obtained earlier.<sup>25</sup>

The aim of the work was to obtain and research new environmentally safe wood polymer composites (WPC) – based on a new environmentally safe binder and reinforcing agent triethoxy(vinylphenethyl)silane and styrene and in the presence of aluminum hydroxide as an antioxidant, to study physicomechanical, thermal properties, and water absorption.

## 2. Experimental

### 2.1. Materials

Composites based on dry sawdust on the basis of pine with triethoxy(vinylphenethyl)silane and styrene as a binder and reinforcement agent which was obtained *via* hydrosilylation reaction of divinylbenzene with triethoxyvinylsilane according to the known method<sup>26</sup> have been created.

**Processing.** The pine is one of the more extensively used types of wood used as lumber. The composites were prepared by hot pressing of highly dispersed (20–30  $\mu\text{m}$ ) dry sawdust on the basis of pine with triethoxysilylated styrene (in the presence of 1 % dicumyl peroxide) as binder and reinforcement agent. The composites have been created under pressures up to 15 MPa and in the temperature range of 413–493 K for 5 min. Two types of samples have been created: cylindrical (for investigation of water absorption) and rectangular (for mechanical testing).

**Fourier transform infrared spectra** were recorded with a Varian 660-IR FT-IR Spectrometer. The KBr

pellets were prepared by mixing 1.5–2.0 mg of the finely grounded samples with 200 mg of KBr (FTIR grade) in a vibratory ball mixer for 20 s.

**Optical microscopic examinations** of composite materials for sawdust and triethoxysilylated composites were performed on an OMAX-type polarized microscope equipped with a high-resolution digital camera A35140U3 14 MP.

**Scanning electron microscopy (SEM) and Energy dispersive spectroscopy (EDS)** observations were conducted. Measurements were performed using a microscope – Tescan Vega 3, LMU, LaB 6 cathode. The maximum accelerating voltage was 30 kV, resolution 2.0 nm. The microscope was also equipped with an energy dispersive spectrometer of X-ray-induced electron beam specimens (EDS, Oxford Systems). EDS was used to analyze the sample compositions.

**Bending testing.** Bending testing (also known as flexural testing) was performed on parallelepipeds with a length of 10 cm and a vertical square cross-section of 1  $\text{cm}^2$ . Each specimen was placed on two prisms, with a distance of 8.0 cm between the prisms. The indenter was a metal cylinder with a diameter of 10 mm applied from above to the midpoint of the specimen. Bending strength (or flexural strength) is defined as the stress needed to create a breaking point (a crack) on the outer surface of the test specimen.<sup>27</sup>

**Impact viscosity** determination, also called shock viscosity determination, is a technique applied to soft solids<sup>28</sup> and is essentially a drop impact test. The drop height ( $h$ ) is the vertical distance between the upper surface of the tested material ( $h_1$ ) and the bottom surface of the drop hammer at the end of the impact event ( $h_2$ ). With the sample mass  $m$  and the acceleration  $g$ , the work performed by the falling hammer is  $mg(h_1 - h_2)$ , normalized with respect to the horizontal cross-section of the specimen  $FF$ .<sup>28</sup>

**Vicat softening depth** is the determination of the depth of the indentation with respect to the top surface caused by a flat-ended indenter with a cross-section of 1  $\text{mm}^2$ . The load applied is 10 or 50 N and the cross-section of the indenter end is circular. The term *Vicat hardness* is also in use – really confusing since larger values correspond to lower hardness.

**Water absorption** is determined simply as the percentage weight change of the sample after submersion in water. Such measurements were performed after 3 and 24 h of exposition to water.

## 3. Results and Discussion

It is known that the wood sawdust contains cellulose, hemicellulose derivatives, and lignin structural rings with hydroxyl groups. In the triethoxy(vinylphenethyl)silane binder, there are ethoxyl groups as well as

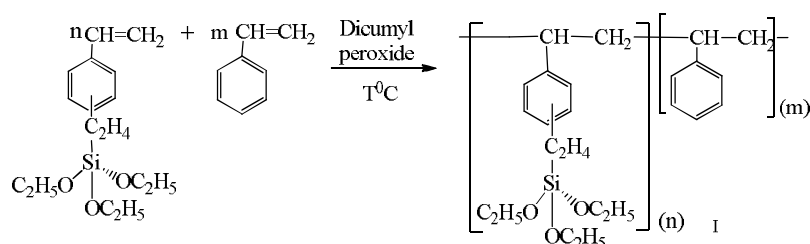
a vinyl group. Those groups were expected to participate in the etherification reaction with a binder through inter-molecular and intra-molecular reactions and the vinyl group may polymerize.<sup>29,30</sup>

Composites were prepared in the following ratio: 3 % of triethoxy(vinylphenethyl)silane, 27 % of styrene, 10 % of dicumyl peroxide, and 60 % of pine sawdust. As a filler, two types of wood sawdust have been obtained: sifted sawdust medium size particle 0.614 mm and unsifted sawdust particle size 1.615 mm. The triethoxy(vinylphenethyl)silane (TEVPES) and styrene were stirred with dicumyl peroxide (DP) (1 wt. %) and this homogeneous mixture (3–5 % (TEVPES) – 27–25 %) was added to a predefined weight ratio of pine sawdust. Then the mixture

was stirred for 5 min until it became homogeneous, then placed in a press form, and pressed at several temperatures.

During hot-pressing, the initiator existing in the mixture may initiate the polymerization reaction of vinyl groups of TEVPES and styrene. Wood sawdust impregnated with TEVPES and styrene, at the moment of hot pressing, forms chemical bonds with the hydroxyl groups of a wood surface. Active filler is likely formed, then etherification<sup>31,32</sup> and *in-situ* polymerization reactions take place.

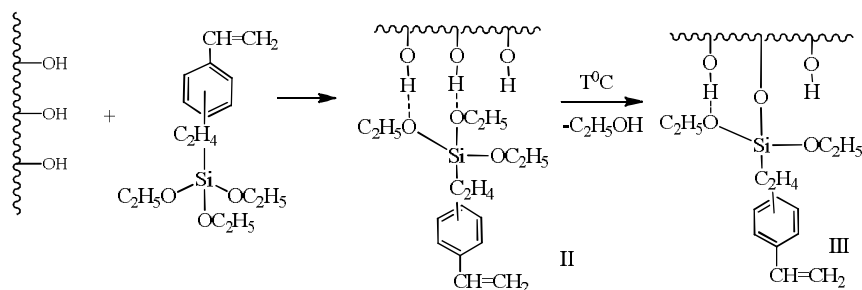
In the case of dicumyl peroxide during hot pressing, *in situ* polymerization and copolymerization by the formation of different ring polymers (Structure I) is possible according to the following scheme:



**Scheme 1.** Copolymerization of triethoxy(vinylphenethyl)silane and styrene

It is not excluded that triethoxy(vinylphenethyl)silane can form hydrogen bonds with or after the polymerization reaction with silane sawdust (Structure II) by etherification at high temperatures to form a chemical bond (Structure III) according to Scheme 2.

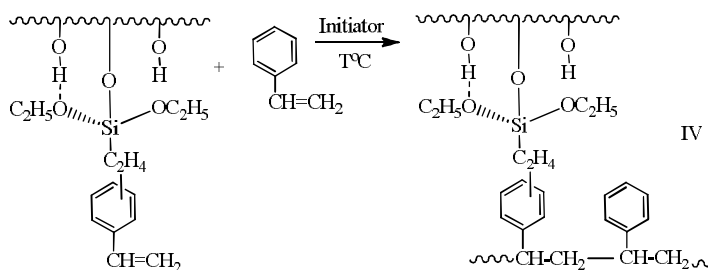
In particular, one expects the formation of hydrogen bonds before the onset of the etherification reaction with triethoxysilylated styrene and also the formation of ethyl alcohol.



**Scheme 2.** Formation of hydrogen bonds and etherification reactions of triethoxy(vinylphenethyl)silane with sawdust surface

It is possible that the product of triethoxy(vinylphenethyl)silane interaction with cellulose will undergo a

polymerization reaction with styrene (Structure IV) according to Scheme 3:



**Scheme 3.** Copolymerization reaction of TEVPES and cellulose interaction product II with styrene

### 3.1. Fourier transforms infrared spectroscopy (FTIR)

In the FTIR spectra of composite materials (Fig. 1), one can see the adsorption bands for the asymmetric valence oscillations characteristic of the  $\equiv\text{Si-O-Si}\equiv$  bond, up to the maximum of  $1026\text{ cm}^{-1}$ , corresponding to siloxane bonds. The absorption band at  $1150\text{ cm}^{-1}$  area corresponds to the asymmetric absorption bands characteristic of the Si-O-C and C-O-C bonds, where the absorption bands overlap. Absorption bands at 1262, 1370, 1419, 1507, 1600–1650, 1720, 2800–2950, and  $3346\text{ cm}^{-1}$  correspond to the methyl groups, CH bond absorption in ( $-\text{C} / \text{C}-/\text{CH}_3$ ),

$\text{CH}_2$  cellulose – lignin, C=C aromatic, C=C alkene, (C=O ester bonds), phenyl groups, and -OH groups.<sup>33</sup>

In the FTIR spectra one can see intensive absorption bands at  $557\text{ cm}^{-1}$ , characteristic of Si-O-Al bonds which may be obtained *via* etherification reaction of  $\equiv\text{Si-OC}_2\text{H}_5$  with  $\text{Al}(\text{OH})_3$ .

### 3.2. Optical microscopic examinations

The microstructure of the composite specimens obtained at different temperatures was examined optical microscope (Figs. 2, 3), and the micrographs were taken at different magnifications.

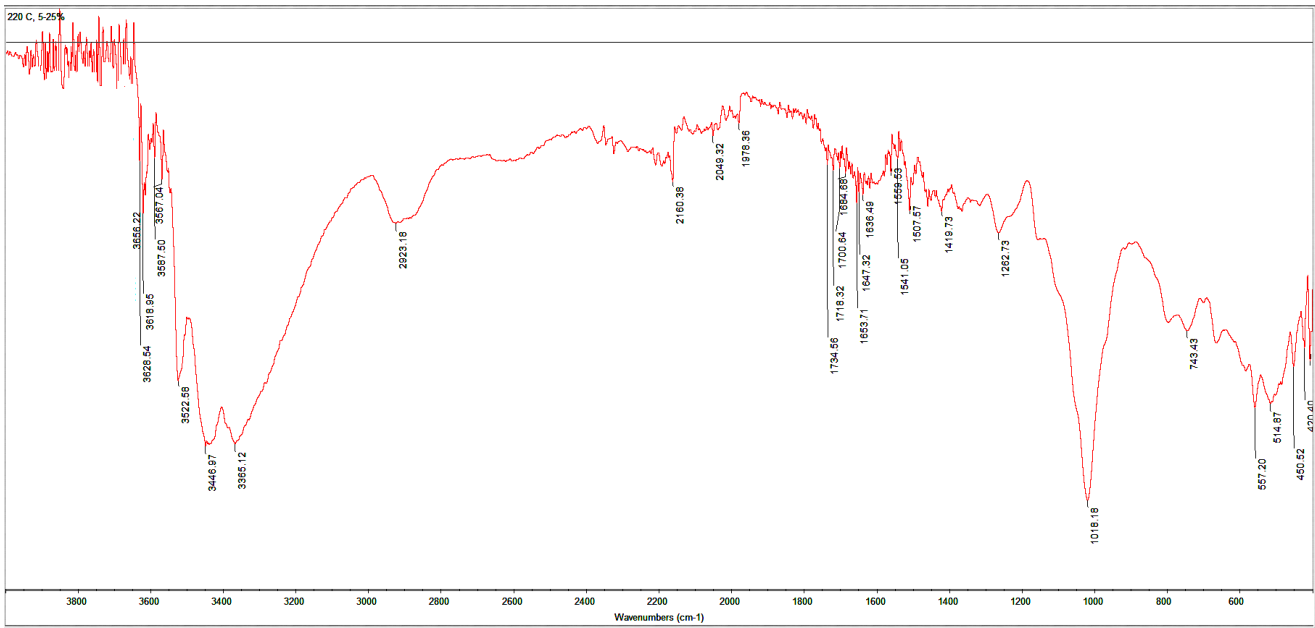


Fig. 1. FTIR spectra of composite X

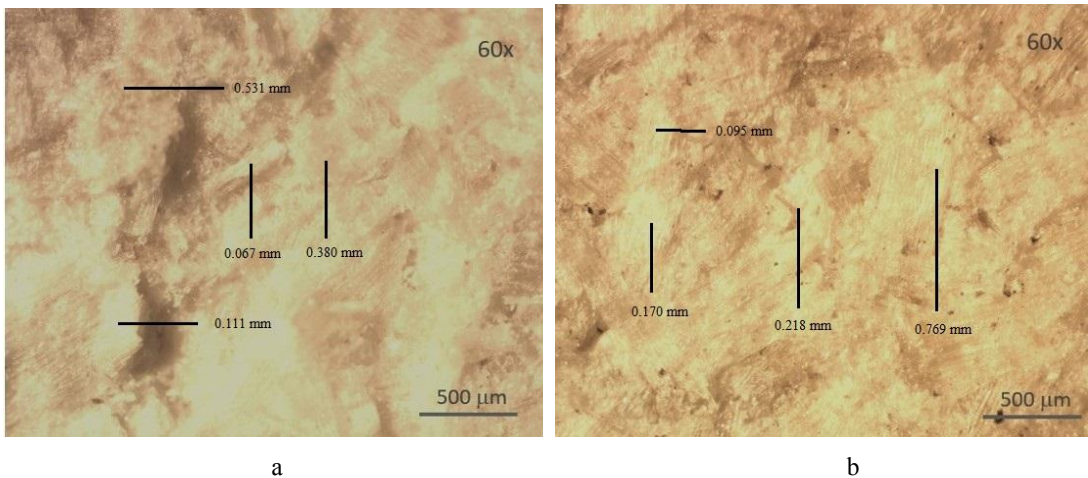
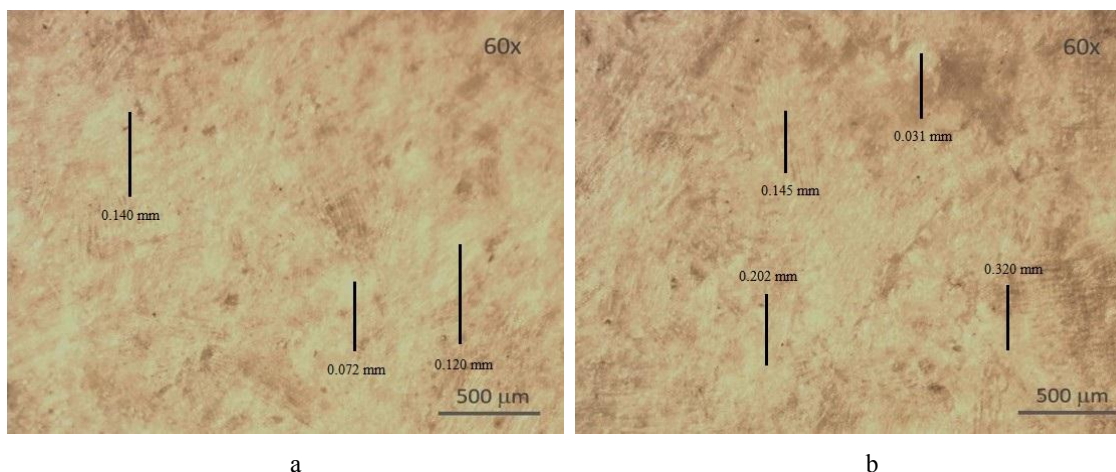


Fig. 2. Optical micrographs of composite I at 413 K (a) and V at 493 K (b)



**Fig. 3.** Optical micrographs of composite VI at 413 K (a), and X at 493 K (b)

Mostly obtained composites are anisotropic and micrographs in Figs. 2 and 3 show different sizes of particles. Cracks and dividing lines are also observed, the dimensions of which can be easily determined using the scale bar shown in the figures.

### 3.3. SEM and EDS investigations

The surface morphology of the composites was studied by scanning electron microscopy (SEM). (Fig. 4a, b) shows the composites VII and X at different magnifications, and energy dispersive X-ray micro-analysis has been performed in different areas of the sample.

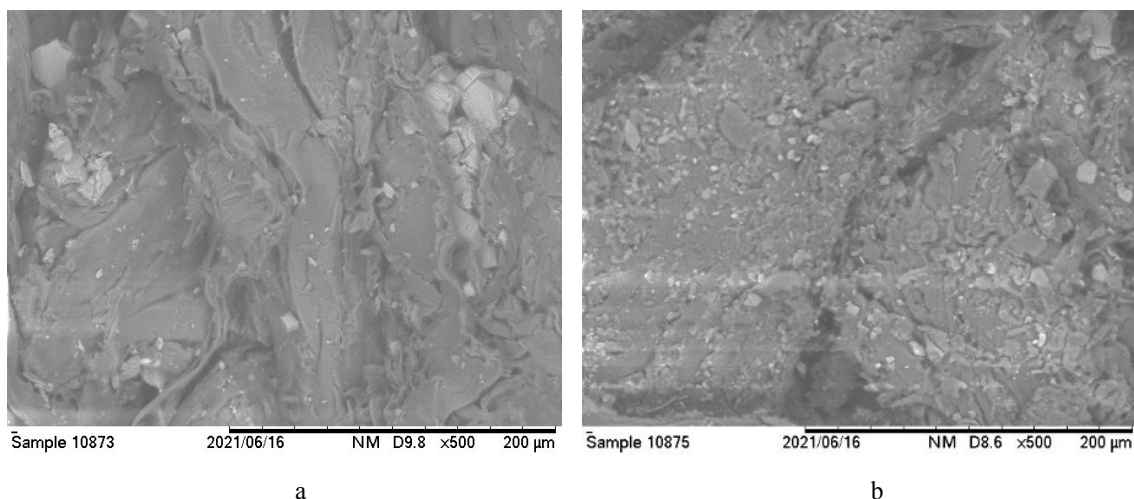
In Fig. 4, one can observe pores, indentations, and inserts with sizes in the range of 0.01–0.5 mm.

The results of energy dispersive X-ray spectral analysis of composites VII and X are depicted in Fig. 5a, b, where the content of composites is presented, which allows us to estimate the degree of homogeneity of microelements distribution in the composite.

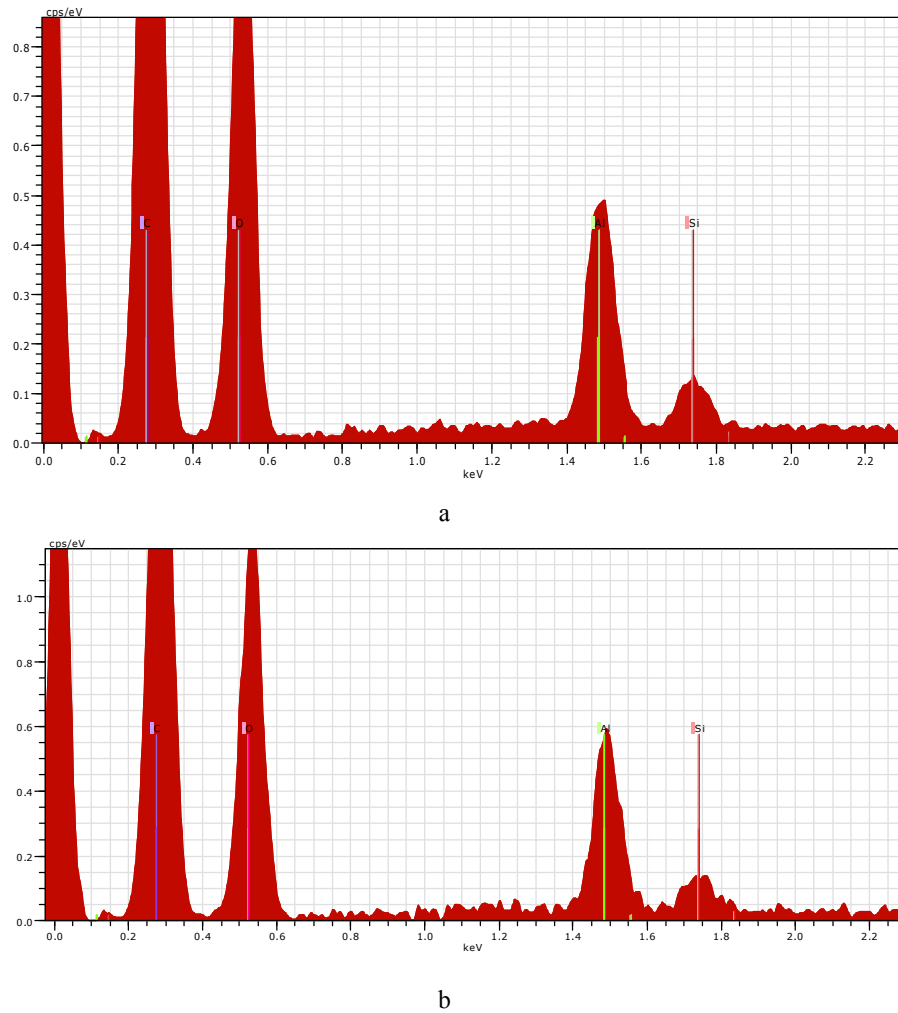
### 3.3. Mechanical testing

For composites, physic mechanical investigations have been performed. In particular, the determination of the bending strength and impact viscosity with respect to temperature and triethoxy(vinylphenethyl)silane and styrene concentrations has been studied. Table 1 shows the dependence of bending strength and the impact viscosity values of composites containing sifted sawdust on the preparation conditions (temperature, binders' concentration).

As can be seen from Table 1, with increasing temperature from 413 to 493 K, at 20-degree intervals, the values of bending strength decrease from 10.6 up to 20.9 MPa. With an increase in the TEVPES concentration the values of bending strength increase from 23.6 up to 29.6 MPa. With an increase in temperature, the impact viscosity slightly increases.



**Fig. 4.** Scanning electron microscope micrographs of composite VII – a and X – b



**Fig. 5.** Energy dispersive X-ray microanalysis of composite VII (a – spectrum 1) and X (b – spectrum 2)

**Table 1.** Dependence of bending strength and impact viscosity values of composites containing sawdust on the preparation conditions (temperature, binder's concentration)

#	Composite	T, K	Pressure, MPa	Bending strength, MPa	Impact viscosity, $\text{kJ/m}^2$
I	Sawdust (sifted)-60 % + TEVPES-3 % + St-27 % + $\text{Al}(\text{OH})_3$ -10 %	413	15	10.6	40.5
II	Sawdust (sifted)-60 %+ TEVPES-3 %+ St-27 % + $\text{Al}(\text{OH})_3$ -10 %	433	15	14.7	41.7
III	Sawdust (sifted)-60 %+ TEVPES-3 % + St-27 % + $\text{Al}(\text{OH})_3$ -10 %	453	15	14.6	38.9
IV	Sawdust (sifted)-60 %+ TEVPES-3 % + St-27 % + $\text{Al}(\text{OH})_3$ -10 %	473	15	18.8	41.7
V	Sawdust (sifted)-60 %+ TEVPES-3 % + St-27 % + $\text{Al}(\text{OH})_3$ -10 %	493	15	20.9	41.0
VI	Sawdust (sifted)-60 %, +TEVPES-5 % + St-25 % + $\text{Al}(\text{OH})_3$ -10 %	413	15	23.6	38.8
VII	Sawdust (sifted)-60 %+ TEVPES-5 % + St-25 % + $\text{Al}(\text{OH})_3$ -10 %	433	15	25.6	41.1
VIII	Sawdust (sifted) 60 %+ TEVPES-5 %+ St-25 % + $\text{Al}(\text{OH})_3$ -10 %	453	15	20.7	39.4
IX	Sawdust (sifted) 60 % + TEVPES-5 % + St-25 % + $\text{Al}(\text{OH})_3$ -10 %	473	15	22.4	44.1
X	Sawdust (sifted) 60 % + TEVPES-5 %+ St-25 % + $\text{Al}(\text{OH})_3$ -10 %	493	15	29.6	42.0



**Table 2.** Water absorption of WPC from TEVPES, styrene, Al(OH)<sub>3</sub> and sawdust prepared at various temperature

#	Composite content	T, K	Density, g/cm <sup>3</sup>	Mass after 3 h-s of exposure in water (g)	Mass after 24 h-s of exposure in water (g)	Water absorption after 3 h exposition in water in wt. %	Water absorption after 24 h exposition in water in wt. %
I	Sawdust (sifted)-60 % + TEVPES-3 % + +St-27 % + Al(OH) <sub>3</sub> -10 %	413	1.515	3.563	5.761	47.90	44.14
I'	Sawdust (unsifted)-60 %+TEVPES-3 % + +St-27 % +Al(OH) <sub>3</sub> -10 %	413	1.613	2.635	5.081	14.27	54.34
II	Sawdust (sifted)-60 %+ TEVPES-3 %+ +St-27 % + Al(OH) <sub>3</sub> -10 %	433	1.619	2.449	2.831	2.21	18.16
II'	Sawdust (unsifted)-60 %+TEVPES-3 % + +St-27 % +Al(OH) <sub>3</sub> -10 %	433	1.538	2.692	3.450	6.87	36.96
III	Sawdust (sifted)-60 %+ TEVPES-3 % + +St-27 % + Al(OH) <sub>3</sub> -10 %	453	1.603	2.240	2.437	2.47	11.48
III'	Sawdust (unsifted)-60 %+TEVPES-3 % + +St-27 % +Al(OH) <sub>3</sub> -10 %	453	1.613	2.392	2.986	2.61	28.09
IV	Sawdust (sifted)-60 %+ TEVPES-3 % + +St-27 % +Al(OH) <sub>3</sub> -10 %	473	1.524	2.360	2.401	0.77	2.51
IV'	Sawdust (unsifted)-60 %+TEVPES-3 % + +St-27 % +Al(OH) <sub>3</sub> -10 %	473	1.601	2.261	2.285	0.76	1.83
V	Sawdust (sifted)-60 %+TEVPES-3 % + +St-27 % +Al(OH) <sub>3</sub> -10 %	493	1.455	2.321	2.343	0	0.95
V'	Sawdust (unsifted)-60 %+TEVPES-3 % + +St-27 % +Al(OH) <sub>3</sub> -10 %	493	1.496	2.241	2.263	0.76	1.75
VI	Sawdust (sifted)-60 %, +TEVPES-5 %+ +St-25 % +Al(OH) <sub>3</sub> -10 %	413	1.557	1.557	3.589	5.78	45.01
VI'	Sawdust (unsifted)-60 %, +TEVPES-5 %+ +St-25 % +Al(OH) <sub>3</sub> -10 %	413	1.614	1.614	4.847	28.43	60.79
VII	Sawdust (sifted)-60 %, +TEVPES-5 %+ St-25 % +Al(OH) <sub>3</sub> -10 %	433	1.612	1.612	3.527	7.83	30.30
VII'	Sawdust (unsifted)-60 %, +TEVPES-5 %+ +St-25 % +Al(OH) <sub>3</sub> -10 %	433	1.647	1.647	2.697	2.28	15.90
VIII	Sawdust (sifted)-60 %, +TEVPES-5 %+ +St-25 % +Al(OH) <sub>3</sub> -10 %	453	1.632	1.632	2.605	2.47	10.90
VIII'	Sawdust (unsifted)-60 %, +TEVPES-5 %+ +St-25 % +Al(OH) <sub>3</sub> -10 %	453	1.580	1.580	2.679	1.59	6.31
IX	Sawdust (sifted)-60 %, +TEVPES-5 %+ St-25 % +Al(OH) <sub>3</sub> -10 %	473	1.595	1.595	2.208	0.46	1.79
IX'	Sawdust (unsifted)-60 %, +TEVPES-5 %+ +St-25 % +Al(OH) <sub>3</sub> -10 %	473	1.609	1.609	2.355	1.05	3.24
X	Sawdust (sifted)-60 %, +TEVPES-5 %+ +St-25 % +Al(OH) <sub>3</sub> -10 %	493	1.519	1.519	2.454	0.08	1.07
X'	Sawdust (unsifted)-60 %, +TEVPES-5 %+ +St-25 % +Al(OH) <sub>3</sub> -10 %	493	1.492	1.492	2.329	0.697	1.53

### 3.4. Thermal stability

The thermal properties of composites have been studied *via* the Vicat method. The Vicat softening temperature is the temperature at which a flat-ended needle penetrates the specimen to the depth of 1 mm

under a specific load. The temperature reflects the point of softening to be expected when a material is used in an elevated temperature application.

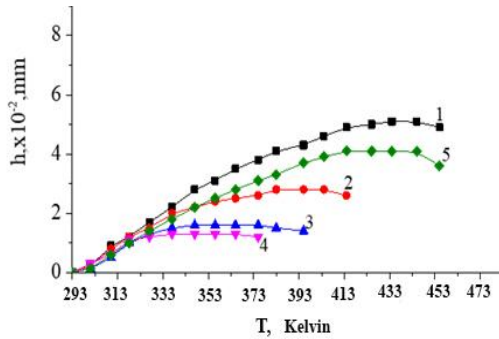
The composites based on TEVPES, styrene, and Al(OH)<sub>3</sub> with sawdust are characterized by improved thermal stability with increasing temperature. This result is

expected for two reasons. The total volume of connected empty micro spaces distributed randomly in the composite has been reduced by the pressure application.

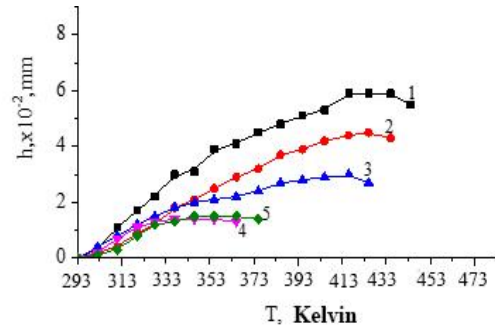
Consequently, the rigidity and thermal stability of the WPC material increase, and the density of microstructure increases again. TEVPES creates new hetero-

geneous chemical bonds in the composites *via* etherification reaction at high temperatures not only with sawdust surface but with used antioxidant  $Al(OH)_3$ .

In parallel, TEVPES reinforces composite materials by in situ copolymerization reactions with styrene. The higher this pressure, the higher is thermal stability compositions.



**Fig. 6.** Dependence of the sample softening on the temperature for composites with 3 % TEVPES + 27 % St + sawdust 60 % obtained at 15 MPa. Curve 1 corresponds to composite V, 2 – IV, 3 – III, 4 – II, and 5 – I



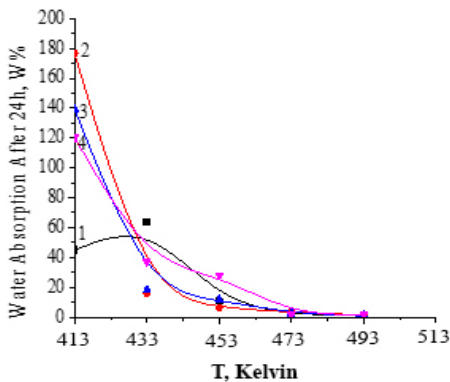
**Fig. 7.** Dependence of the sample softening on the temperature for composites with 5 % TEVPES + 25 % St + sawdust 60 % obtained at 15 MPa. Curve 1 corresponds to – X, 2 – IX, 3 – VIII, 4 – VII, and 5 – VI

### 3.5. Water absorption

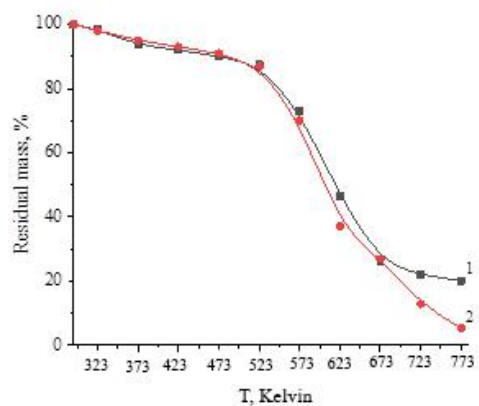
Water-absorption test is a test to determine the moisture content of the soil as a percentage of its dry weight. Water absorption is one of the significant magnitudes used to determine the amount of water absorbed under specified conditions.<sup>5</sup> In Table 2 water absorption of WPC from TEVPES, styrene,  $Al(OH)_3$ , and sawdust (sifted, unsifted) prepared at various temperatures are presented. With an increase in pressing temperature from

413 up to 493 K, the water absorption decreases from 54–60 % up to 0.95–1.07 % (Table 2). It should be noted that the WPC obtained from sifted sawdust is characterized by less water absorption. WPC prepared from unsifted sawdust is characterized by increased density compared with sifted sawdust. Both phenomena may be explained by relatively low volumes of the empty intermolecular spaces (last column of Table 2).

Fig. 8 represents the water absorption as a function of the pressing temperature, for sifted and unsifted sawdust.



**Fig. 8.** Dependence of water absorption on the pressing temperature for composites. Curve 1 corresponds to composites VI-X (sifted), 2 – VI'-X' (unsifted), 3 – I-V (sifted), 4 – I'-V' (unsifted)



**Fig. 9.** Thermogravimetric curves of composite materials. Curve 1 corresponds to composite V, 2 – composite X



The TGA results (Fig. 9) for composites showed that 5–7 % mass losses are observed at 373 K.<sup>34</sup> Obviously, this mass loss is due to moisture in the composites or the release of ethyl alcohol. The main destruction processes proceed in the temperature range of 523–623 K. Composite V is characterized by high thermal stability, compared with composite X, which can be explained by the fact, that at high temperatures the esterification reaction between sawdust hydroxyl and ethoxyl groups of binders proceeds deeper.

Differential scanning calorimetry (DSC) was also performed for composites. It does not include the curves for brevity. In some composites the so-called glass transition temperature  $T_g \approx 190$  K. As discussed by Kalogeris and Hagg Lobland,<sup>35</sup> representing a glass transition region – for instance, 303 K wide – by a single number is an uphill battle. The softening temperatures are in the range of 243–313 K.

## 4. Conclusions

Composites on the basis of sawdust and triethoxy (vinylphenethyl)silane, styrene as a new binder, and an antioxidant Al(OH)<sub>3</sub> under conditions of optimal pressure and various temperatures *via* the hot press method has been obtained. The best results were achieved at relatively low concentrations of the binder and at the high temperature of thermal treating. Structural investigations by means of FTIR, and obtaining of new bonds with surface and antioxidants were observed.

The surface of WPC has been studied *via* optical, scanning electron microscopy, and EDS. It was shown, that higher physicomechanical, thermal, and hydrophobic properties are also related to the formation of new chemical bonds because of intensive chemical reactions between active groups of composite constituents. Consequently, the composites have relatively high mechanical properties and low water absorption.

## Acknowledgments

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### ДЕРЕВИННО-ПОЛІМЕРНИЙ КОМПЗИТ НА ОСНОВІ СТИРЕНУ І ТРІЕТОКСИ(ВІНІЛФЕНЕТИЛ)СИЛАНУ

**Анотація.** Сьогодні отримання екологічно чистих деревинних композиційних матеріалів є одним із головних завдань. Карбамідо-, феноло- і меламіноформальдегідні смоли, які використовують сьогодні, шкідливі для організму людини і мають тривалу дію. Тому заміна цих та інших смол безпечними в'язучими речовинами є однією з головних проблем. Метою цієї роботи було отримання та дослідження екологічно безпечних деревинно-полімерних композитів (декінгів) на основі нової екологічно безпечної в'язучої речовини, посилюючого агента тріетокси(вінілфенетил)силану та стирену (*in-situ* полімеризація) з наповнювачем із соснової тирси та гідроксидом алюмінію як антиоксидантом. На основі тріетокси(вінілфенетил)силану, стирену та тирси методом гарячого пресування за різних температур і співвідношень використовуваних компонентів у присутності антиоксиданту отримано деревинно-полімерні композити – декінги. Виконано морфологічне дослідження поверхні декінгів за допомогою оптичної мікроскопії, сканувальної електронної мікроскопії (СЕМ) та енергодисперсійного рентгенівського мікроаналізу. Визначено водопоглинання, температуру розм'якшення за Віка, міцність на згин і ударну в'язкість. Крім того, з використанням тирси як імпрегнувального та армувального агента та гідроксиду алюмінію як антиоксиданту отримано деревинно-полімерні композити (ДПК) методом гарячого пресування за різних температур. Морфологічне дослідження поверхні отриманих композитів здійснювали методами оптичної мікроскопії та сканувальної електронної мікроскопії, енергодисперсійного рентгенівського мікроаналізу. Водопоглинання композитів, межу текучості за вигину, ударну в'язкість і температуру розм'якшення визначали за методом Віка. Отримані композити характеризуються вищими фізико-механічними властивостями та водопоглинанням.

**Ключові слова:** деревина, полімерний композит, декінг, антипірен, оптична мікроскопія.