The Impact of Vinylotrimethoxysilane-modified Linseed Oil on Selected Properties of Impregnated Wood

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Abstract: This study aimed to examine the effect of organosilicon compounds-modified linseed oil parameters on wood utility properties. Linseed oil silylation with an organosilicon compound containing a vinyl group (vinyltrimethoxysilane) has made it possible to synthesize products characterized by high stability in storage. The impregnation of wood with these resulting products contributed to increased resistance of the protected wood to water exposure when compared to unprotected wood or wood protected by polymerized oil that was not subject to the silylation reaction. The protected wood was characterized by a lower water absorption rate in liquid as well as vapor forms contained in the humid air. This property immediately translated into an increase in the resistance of the wood exposed to Basidiomycota. The loss of mass of Pinus sylvestris L. (pine wood) exposed to the Coniophora puteana was approximately 3%. This parameter did not improve when the wood was subjected to the washing process (mass loss approx. 3.6%). Thus, the resulting products are those demonstrating the highest potential for use in the preparation of wood protection means.

Keywords: biobased materials; linseed oil; silane; VTMOS; wood

1. Introduction

Despite a broad range of existing wood protection products, the search for solutions that would meet growing market expectations, such as water resistance and microbial attack, UV radiation, or low toxicity relative to the natural environment, still continues. Due to the limitations of synthetic materials, it is also important to remember that the natural origin of raw materials is often defined by their so-called biogenic carbon content. Oils of natural origin, in particular, attract increasing attention [1–5]. It is generally known that the impregnation of wood with natural oils, including linseed oil or tung oil, contributes to the reduction of water absorption and results in the wood demonstrating higher resistance to wood decay fungi (white and brown rot) [6–9]. Despite the aforementioned advantages in terms of the use of natural oils in wood protection methods, these products have numerous disadvantages. The major imperfections are coating hardening, high viscosity, relatively low mechanical parameters of the coating (hardness, flexibility, abrasion), a relatively high water washout, low resistance to UV radiation, and they tend to change color (most often, they are prone to yellowing). Thus, increasing attention is paid to wood modification with oils used for its protection. Due to the unsaturated transtype bonds in its content, linseed oil is characterized by higher reactivity than other commonly used oils, e.g., tung oil [10]. Veigel et al. [11] observed that adding the modified nanocellulose to linseed oil improves its mechanical parameters (resistance to abrasion) and resistance to weather conditions. Several authors described linseed oil modification methods through uretining reactions in the acetone process in which the product formed coatings fit for wood protection [4,8,12–14]. These tests were developed by implementing modified oils.
with metal-containing microbiocides, i.e., silver, zinc, manganese, lead, or calcium. The authors stated that the most efficient products were achieved by implementing silver compounds. Other tested parameters, i.e., hardness, impact strength, binding strength, adhesion, and resistance to light, have not changed compared to the coatings that do not contain microbiocides. Linseed and soy oil have also been subject to in situ epoxidation and copolymerization with vinyl acetate. Positive effects of the modification have been observed only for the linseed oil-based product. Pinewood impregnated with the above product has a higher resistance to decay fungi (Trametes versicolor, Postia placenta, and Coniophora puteana) compared to commercially accessible polymerized linseed oil [15].

The application of silanes to modify natural oils by means of the reaction of substitution of nucleophilic 3-chloropropyltrimetoxy silicone to sodium salts of fatty acids in the presence of potassium iodide as a catalyst appears to be very promising. Rape oil modified with organosilicon compounds obtained in this way was then used to protect pine wood. Due to the formation of chemical bonds between hydroxyl groups located on the surface of wood and the silane (wood–O–Si), a highly durable coating was formed. While the wood was immersed in water, no coating deterioration was observed on pine wood treated with the obtained product. The synthesis of silane derivatives of rape oil determined new prospects for the use of natural products in obtaining silanized natural polymers and their application for manufacturing protective coatings permanently bonded with the wood surface. Such products may provide an alternative for the silanes containing fluorine groups that are more broadly applied as strongly hydrophobic [16–18].

Stable products of the reaction were obtained in soybean oil silylating reaction by means of vinylotrimethoxysilane (VTMOS) in the presence of 5-Bis(tert-butylperoxy)-2.5-dimethylhexane as a catalyst. Srinivasan et al. [19] indicated that the most likely course was the “ene” reaction being a part of the Diels–Alder reaction mechanism. Tambe et al. [20] conducted the silylating reaction for soybean, rape, and abyssinian oils. The researchers concluded that the reactivity of vinylsilane with olefin subjected to the “ene” reaction mechanism did not depend on the double bond position in olefin, and non-terminal unsaturated bonds of fatty acids are also affected by the reaction. The previous tests were supplemented with a detailed description of the VTMOS-modified linseed oil. The products of silylating reactions are characterized by relatively low viscosity and a tendency to form gel without any necessity of introducing catalysts promoting polymer structure netting [21,22].

The course of the linseed oil silylating reaction with VTMOS results in a new product with a high potential to provide resistance to water and, thus, increase the durability of treated wood in response to external impacts. This study aimed to determine the impact of linseed oil parameters on wood utility properties when modified with organosilicon compounds. The following physical properties described the reaction products: non-volatile content/solid content, vapor absorption from humid air, water absorbability, contact angle, testing the change of color in view of aging factors, and exposure to fungi-causing mold growth, both in laboratory and field conditions.

2. Materials and Methods

2.1. Materials

Linseed oil was purchased from Alberdingk boley gmbh (DE). The vinyltrimethoxy silane (VTMOS) [CAS 2768-02-7] with a purity of 99% was purchased from Dow Corning. The catalyst 2.5-Bis(tert-butylperoxy)-2.5-dimethylhexane, (Luperox 101 [CAS 78-63-7]) was purchased from Arkema.

The sapwood of pine (Pinus sylvestris L.) and spruce (Picea abies), with sizes consistent with specific test requirements, were used for tests.

2.2. Linseed Oil Modification

The catalytic course of the linseed oil silylation reaction with VTMOS was conducted in a high-pressure reactor (PARR Instrument Company, USA, ST Moline, IL). Prior to
silylation, the heating reactor was purged with nitrogen. The reaction components were put into the reactor and after 5 min of stirring the mixture at room temperature, the heating started. Depending on the substrates, the proper reaction temperature was achieved after 90–120 min. The reaction was run at the temperature of 280 °C with a rotation speed of 220 rpm ± 2 rpm throughout the entire process. The composition of the amount of the components mixed in a reactor is summarized in Table 1.

Table 1. The chemical composition of the reaction mixture based on linseed oil.

| Reaction ID | Luperox 101 [mol] 1 mol of Linseed Oil | VTMOS [mol] 1 mol of Linseed Oil | Time of VTMOS Addition | Reaction Time in 280 °C [h] |
|-------------|----------------------------------------|-----------------------------------|-------------------------|-----------------------------|
| 1           | 0                                      | 0                                 | No addition             | 12                          |
| 2           | 0.008                                  | 0.6                               | At the beginning of reaction | 3                          |
| 3           | 0.04                                   | 0.6                               | 3rd h of reaction        | 6                           |
| 4           | 0.04                                   | 0.6                               | 3rd h of reaction        | 9                           |

2.3. Methods

The method and materials used in the paper methodology are graphically presented in Scheme 1.

Scheme 1. Graphical picture of the methodology used in the work.

2.3.1. Non-Volatile Content/Solid Content

The solid content of products (2 g) was measured using moisture analyzer equipment (Moisture analyzer MA 40, Satorius Company, Göttingen, Germany) at 105 °C and 125 °C based on the modified PN-EN ISO 3251:2008P method.

2.3.2. Determining the Viscosity of the Obtained Reaction Products

Determining viscosity was performed using the Hoppler apparatus by measuring the times of flow of an adequately selected ball. Then, viscosity was calculated using the following formula:

\[ \eta = K \times (q_1 - q_2) \times t \]

where:

- \( \eta \) — viscosity
- \( K \) — apparatus calibration constant
- \( q_1 \) — density of the ball [g/cubic cm]
- \( q_2 \) — density of tested liquid [g/cubic cm]
- \( t \) — time of falling of the ball between two marks [s]
2.3.3. Water Absorption from Humid Air

Wood samples of the following sizes, $18 \times 30 \times 30$ mm (thickness, width, and length), the latter dimension represents the size along the fibers), were treated by immersion in oil for 10 min (5 samples per product). The average value of the applied preparation was $200 \pm 20$ g/m$^2$. The treated samples were dried in the laboratory dryer for 72 h at a temperature of $80^\circ$C. Oversaturated solution of diammmonium phosphate was prepared in an airtight glass container (desiccator). The samples were weighed and placed in the desiccator above the solution when dry. The container was tightly closed. Later, the samples were weighed after 1, 2, 4, 24, 48, 72, 96, 120, and 168 h. After each measurement, the samples were put back into the desiccator. Untreated pine wood was used in the reference samples. Water absorption was determined using the following formula:

$$W_a = \frac{100\% (m_n - m_p)}{m_p}$$

where:
- $W_a$—water absorption
- $m_n$—humid wood weight
- $m_p$—dry wood weight

2.3.4. Absorbability

The test was performed on the samples of treated pine wood and spruce wood of the following parameters: $20 \times 75 \times 150$ mm (thickness, width, and length, the latter dimension represents the size along the fibers). In order to obtain constant weight, wood samples were conditioned at the temperature of $20 \pm 2^\circ$C and a humidity of $65 \pm 5\%$. Then, 200 g ($\pm$20 g)/m$^2$ of the preparations (non-modified and modified oil by silane) were applied to the surface of the wood prepared in this experiment. After conditioning the wood, the side edges and untreated side of samples were blocked with epoxy paint and silicone. The weighed samples prepared in this way were put for 24 h in deionized water by immersing the entire tested surface in water, and then it was conditioning for 3 h at the temperature of $20 \pm 2^\circ$C and relative air humidity of $65 \pm 5\%$, and 3 h at the temperature of $50^\circ \pm 2^\circ$C, then 18 h at the temperature of $20 \pm 2^\circ$C and relative air humidity of $65 \pm 5\%$. Then, the samples were restored at the temperature of $20 \pm 2^\circ$C and relative air humidity of $65 \pm 5\%$ until a constant weight was achieved. The absorbability test was performed by immersing the treated surface of samples in water so as to ensure that the entire tested surface was wet. After 72 h, the samples were taken out of the water, then water drops were delicately removed with a tissue, and the samples were weighed.

2.3.5. Static Contact Angle

In order to test the hydrophobic properties of the products, the static contact angle was determined on pine wood. The size of the tested samples was $150 \pm 2; 75 \pm 3$, and the thickness of $20 \pm 2$ mm. Preparations were applied with a brush in the amount of $200 \pm 20$ g/m$^2$. The samples prepared in this way were conditioned for 7 days in the environmental chamber (at the temperature of $20 \pm 2^\circ$C; RH 65 ± 5%). The measurements were taken by means of the OCA14 optical goniometer (Data Physics). Deionized water was used as a measurement liquid. Water drops with a volume of 5 µL were placed automatically using a pipette directly on the sample located on the measurement table, keeping the same minimum height of the needle above the tested surface. Five seconds after the placement of a drop, at least 10 measurements were taken for each sample. Images of a drop were registered by a camera. The contact angle was measured using the control program after prior determination of a baseline and the contour of a drop.
2.3.6. Determination of Changes in Wood Color

The test was performed in order to check the change in color (yellowing) of oil during the polymerization process and later exposure to wood. The aging procedure was performed in the QUV chamber using water spraying. Pine wood samples were of the following size: $10 \times 75 \times 150$ mm (the latter dimension represents the size along the fibers). Preparations were applied with a brush in the amount of $200 \pm 20$ g/m$^2$. The samples prepared in this way were conditioned for 7 days at a temperature of $20 \pm 2$ °C and humidity of $65 \pm 5\%$. The color test was performed prior to the exposure to the deteriorating impacts and after 1 and 6 weeks of exposure in the chamber. Measurements were taken in the same areas where the color on the unaged wood was tested. The color was determined on pine wood using the Spectraflash 300 double-beam spectrophotometer featuring a pulsed xenon lamp and the $d/8^\circ$ measurement geometry in the wavelength range of 400–700 nm (accuracy–10 nm). The measurement surface was 18 mm$^2$. The aging procedure in the QUV chamber was performed in line with the following parameters: EN 927-6, step 1—condensation ($45 \pm 3$ °C, 24 h); step 2—144 h consisting of 48 cycles of 3 h consisting of steps 3 and 4; step 3—UV ($60 \pm 3$ °C, 2.5 h, irradiance set point $0.89$ W/(m$^2$ nm) at 340 nm); step 4—spray (0.5 h), 6 l/min–7 l/min, UV off). Test duration: 12 weeks (2016 h).

2.3.7. Resistance of Treated Wood to the Impact of Colonizing Fungi

Resistance to Colonization by the Fungi Causing Molding

Biological testing was performed on the basis of methodological assumptions of ASTM D 5590. This method involved a visual evaluation of the level of colonization by molds. The mixture of the following testing fungi cultures was applied: Aspergillus niger van Tieghem (A.n.), Trichoderma viride Pers. Ex S.F. Gray aggr. (T.v.), and Paecilomyces variotii Bainer (P.v.). Fungi were cultivated on an agar–malt medium (20 g of agar, 30 g of malt extract, 1 L of water) with added Czapek-Dox mineral (4 g/L). The wood was exposed in the cultivation chamber at constant temperature ($28 \pm 1$ °C) and humidity ($80 \pm 5\%$) for a period of 28 days. The colonization index (Table 2) of the wood surface by fungi was determined after 7, 14, 21, and 28 days of the test. Part of the samples was aged according to PN-EN 84.

### Table 2. The scale of colonization of the wood surface by molds according to ASTM D 5590.

| Index | Description                                           |
|-------|-------------------------------------------------------|
| 0z    | No colonization of the wood surface by fungi, visible zone of inhibition |
| 0     | No colonization of the wood surface by fungi          |
| 1     | 1%–10% of the wood surface colonized by fungi        |
| 2     | 11%–30% of the wood surface colonized by fungi       |
| 3     | 31%–60% of the wood surface colonized by fungi       |
| 4     | More than 60% of wood surface colonized by fungi     |

Resistance to Decay Caused by C. puteana

Impregnated samples in the following size: $7 \times 25 \times 50$ mm (the latter dimension represents the size along the fibers) were exposed to Coniophora puteana (Schumacher ex Fries) Karst., BAM Ebw 15 species causing brown rot of wood. The fungus was cultivated on the agar–malt medium (20 g of agar, 50 g of malt extract, 1 L of water). Methodological assumptions of EN 113 and EN 839 were used in the testing procedure. The wood mass loss occurring as a result of exposure to samples of Coniophora puteana was determined after 8 weeks of testing. The infected wood was exposed in the cultivation chamber to constant humidity conditions ($70 \pm 5\%$) and temperature ($21 \pm 1$ °C). Part of samples were aged according to PN-EN 84.
2.3.8. ANOVA Analysis

GNU PSPP software (version 1.6.2) was used to conduct the statistical and variance analysis. One-way ANOVA study and the Tuckey HSD test with a confidence level of 95% (p < 0.05) were used to compare the significance of the difference between the obtained results.

3. Results and Discussion

3.1. Non-Volatile Content

The highest non-volatile content at 105 °C was observed in non-polymerized linseed oil heated for 12 h (Product reaction 1). The addition of VTMOS and catalyst of silylation to reaction slightly reduced the non-volatile content. This change arises from the addition of relatively low molecular weight silane to the reactive mixture. Then, silane is subject to the thermal reaction featuring the emission of volatile low molecular weight compounds [12]. This conclusion is supported by the trend visible in the chart below—the longer the reaction time, the higher the volume of volatile low molecular weight compounds.

Exposure of oil samples at the temperature of 125 °C in the cases of the reaction with VTMOS made it possible to observe the presence of volatile substances, which may suggest the formation of a by-product or decomposition of the resulting product. A likely reason for a growth in the volume of volatile substances at the temperature of 125 °C was the formation of by-products in the form of organosilicon compounds containing ether and ester bonds [12]. Detailed results of the analysis of volatile substance volumes are presented in Figure 1.

![Figure 1. Non-volatile content in modified and unmodified linseed oil.](image)

3.2. Dynamic Viscosity

The viscosity of silylation reaction products was several times lower than the viscosity of the product of the 12 h linseed oil radical polymerization reaction (reaction product 1, Figure 2). Low viscosity, just slightly higher than the viscosity of non-polymerized linseed oil, was the desired effect as it increases the depth of penetration of the product into the wood. The viscosity of VTMOS-modified linseed oil slightly increased during its storage which is most likely related to further curing of non-reacted organosilicon compounds during the thermal reaction. These not-significant viscosity changes allow classifying products as stable during storage. The above observations with the influence of “ene” reaction for oil were described by Tambe et al. [23]. The viscosity of the resulting soybean oil was, opposite to the linseed oil described in this paper, unaffected by the silylation reaction and remained low (32 cPs). Observed differences were carefully described in an article by Depczyńska et al. [22], where the differences were explained through the different compositions of fatty acids in oils.

3.3. Absorption of Vapor from Humid Air

The analysis of vapor absorption from humid air into the pine wood indicates that every protection positively impacted the reduction of this parameter (Figure 3). In the first 4 h of wood exposure against humid air, distinctly higher (approximately 70%) water
absorption by unprotected wood compared to the wood protected with reaction products no. 3 and 4 were seen. After 24 h of testing, no significant differences between specific variations of the reactions no. 2–4 were observed. In a longer time perspective of storing wood in humid air conditions, a tendency to absorb less water by the wood impregnated with modified oil became conspicuous. Wood treated with a product of reaction no. 3 or 4 had a reduced water absorption rate. The wood treated with products of reactions no. 1 and 2, after 96 h of testing, had not protected the wood against water. Its absorption was at a similar level to the absorption of water from humid air in untreated pine wood. The results confirmed that the new products that were obtained in reactions no. 3 and 4 increase the hydrophobic nature of wood in long-term exposure to humid air environments.

**Figure 2.** Viscosity of linseed oil and silylation reaction products.

**Figure 3.** Absorption of water vapor by untreated pine wood and pine wood protected by the tested products.

### 3.4. Absorbability

The absorbability test confirmed that all tested products of the reactions reduce water absorption in pine wood (Figure 4). An approximately 50% reduction of absorbability relative to untreated wood could be observed for every tested product. The best result was obtained again for the wood protected with the products of reactions no. 3 and 4. The tests performed showed significant differences for pine wood between the following data: Untreated Wood—Product Reaction 1; Untreated Wood—Product Reaction 2; Untreated Wood—Product Reaction 3; Untreated Wood—Product Reaction 4; Product Reaction 1—Product Reaction 3; Product Reaction 2—Product Reaction 3
Similar to the treatment of pine wood, the treatment of spruce wood reduced the absorption of water compared to untreated wood (Figure 5). Differences were observed in wood impregnation with products of reactions no. 1–4. Polymerized linseed oil reduced water absorption by over 50% compared to unprotected wood. However, the products modified with silane reduced water absorption by approximately 20%. The differences in the tests performed for pine wood and spruce wood are mainly found in comparing two key parameters, i.e., the anatomy of specific species and the viscosity of oils. Spruce wood is a species that is difficult to saturate, which causes the applied preparations to concentrate on its surface, but white parts of pine wood that are easy to saturate will quickly absorb oils with low viscosity. The tests performed showed significant differences between the following data: Untreated Wood—Product Reaction 1; Untreated Wood—Product Reaction 2; Product Reaction 1—Product Reaction 2; Product Reaction 1—Product Reaction 3; Product Reaction 1—Product Reaction 4. Temiz et al. [24] and Humar and Lesar [6] also reported that linseed oil reduced water absorption in wood. The first research team used the oil as a by-product of the ThermoWood thermal modification process. Linseed oil and hydrogen peroxide prepared the treatment agent [24]. The results indicated that the samples treated with bio-oil had lower water absorption than the control group. A second research team confirmed that linseed oil impregnation of spruce and beech wood reduces short and long-term water uptake of liquid water [6].

Figure 4. Absorbability of pine wood untreated and treated with the tested products.

**Figure 5.** Absorbability of unprotected spruce and the spruce protected by the tested products.

### 3.5. Static Contact Angle

The static analysis of the measurements of static contact angles (Figure 6) has confirmed that the obtained products after application on wood and drying are characterized by high hydrophobicity. The highest result for the contact angle was observed for pine
wood protected by the product of the reaction no. 1. The probable reason of the higher hydrophobic properties was the lower viscosity of the new preparations (reactions no. 2–4) and, thus, better wood penetration. Despite the fact that natural oils do not form a coating, the significantly higher viscosity of the product in reaction no. 1 impeded its penetration into the wood and formed a much more uniform coating on the wood surface.

3.6. Change of Color of the Protected Wood

The impact of wood protection with the products of the reactions no. 1–4 on its change in color has been presented in Figure 7. The oil application caused a color change (\(\Delta E > 5\)) visible to the naked eye in each case. The product of the silylation reaction (no. 2, 3, 4) affected a change of the wood color to a lower extent than the product of reaction no. 1 (polymerized linseed oil). The observation of the b monochromatic component that demonstrates yellowing of the sample seems to be particularly significant, and it is often perceived as a defect in the industry. The highest values were observed for polymerized linseed oil in this area.

Figure 8 presents the results of spectrophotometric measurements for pine wood impregnated with oils no. 1–4 and exposed to aging factors for one week and six weeks. Comparison of a change in color of the samples after one week and after six weeks shows that the polymerized linseed oil during its curing process in the wood (the first week) has changed the color of wood (\(\Delta E > 20\)) distinctly, and then, during the subsequent five weeks, the color did not change significantly. Similarly to the described linseed oil, the products of the reaction of linseed oil with VTMOS changed the color of wood significantly after
approximately one week, and then the color of wood changed to the one that was tested on the samples just after their impregnation.

![Figure 8](image_url)

**Figure 8.** The change in the color of the wood protected with preparations exposed to the impact of aging factors in the periods of 1 week and 6 weeks; \( \Delta L, \Delta a, \Delta b \) monochromatic components and \( \Delta E \) parameter.

3.7. **Resistance of Wood to Biological Impacts**

The wood treated with polymerized linseed oil (product of reaction no. 1) was resistant to tested fungi for approximately 7 days. After 14 days, almost the entire surface of the samples was infected. Leaching significantly shortened the period of resistance of wood to mold because just after a week, more than 30% of the wood surface was infected. The wood impregnated with the preparation obtained in reaction no. 4 had the highest resistance. After 7 and 14 days, less than 30% of the surface was infested by tested fungi. Specific attention should be paid to the fact that no significant differences were observed when comparing wood samples that were leached and unleached. It is confirmed by the observations mentioned previously that preparations protected the wood against the impact of water, and, as a result, they were also washed out to a lesser extent. The product of reaction no. 4 limited the development of fungi-causing mold until the end of the test, i.e., to the 28th day of exposure to degrading factors. Detailed results of the test are presented in Figure 9. The tests performed showed significant differences between the following data: Untreated Wood—Product Reaction 4; Untreated Wood—Product Reaction 4 (EN 84); Product Reaction 1—Product Reaction 4 (EN 84); Product Reaction 1 (EN 84)—Product Reaction 4; Product Reaction 1 (EN 84)—Product Reaction 4 (EN 84).

![Figure 9](image_url)

**Figure 9.** Resistance of the wood protected against the impact of fungi-causing mold.
The mass loss of wood that had not been subjected to impregnation was more than 20%, proving how active C. puteana is. In the same conditions of wood exposure, the samples protected with polymerized linseed oil had little resistance to the fungus, and the average mass loss of the washed and unwashed wood was 12.4 and 11.5%, respectively. Impregnation of wood with the product of reaction no. 4 increased wood protection against the decay fungus, and the mass loss was 3.6 and 2%, respectively. Detailed test results are summarized in Table 3. The tests performed showed significant differences between the following data: Product Reaction 1—Product Reaction 4; Product Reaction 1—Product Reaction 4 (EN 84); Product Reaction 1 (EN 84)—Product Reaction 4; Product Reaction 1 (EN 84)—Product Reaction 4 (EN 84). Compared with the literature discussion, product reaction 4 more effectively protected pine wood against C. puteana fungi than non-modified linseed oil. It gives new possibilities for utility linseed oil protection of wood in more hazardous applications than the literature presented [6,24–26].

Table 3. Resistance of the wood protected against C. puteana.

| Sample ID                  | Wood Moisture Content [%] | Mass Loss  |
|---------------------------|--------------------------|-----------|
| Product Reaction 1        | 36.9 ± 6.3               | 12.4 ± 1.8|
| Product Reaction 1 (EN84) | 30.1 ± 4.2               | 11.5 ± 9.4|
| Product Reaction 4        | 19.9 ± 1.7               | 3.6 ± 0.7 |
| Product Reaction 4 (EN84) | 19.5 ± 1.5               | 2.0 ± 0.8 |
| Untreated wood/fungi activity | 67.9 ± 5.4           | 21.8 ± 1.8|

4. Conclusions

Linseed oil silylation with an organosilicon compound containing a vinyl group (Vinyltrimethoxysilane—VTMOS) that may react with unsaturated bonds contained in fatty acids made it possible to synthesize products showing high stability in storage. Long-term storage of the silylation process products has not changed their viscosity. Impregnation of wood with the resulting products contributed to the increased resistance of protected wood to water exposure compared to unprotected wood, which could translate to the increase of wood resistance to exposure to colonizing and decay fungi. As far as the utility aspect is concerned, it was observed that the process of running the silylating reaction is a crucial parameter limiting the level of wood protection relative to the factors causing biodegradation and biodeterioration. The wood protected with the reaction product in which the linseed oil was prepolymerized for 3 h and silylated for 6 h had the highest durability of all completed syntheses. The resulting synthesized products may show potential as semiproducts used to develop preparations used in wood protection, especially as a stable and hydrofobic substrate for resin and emulsion production. This topic should become a continuation of the efforts described in this study.

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