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Characterization of Polypropylene Composite Reinforced on Bio-waste from the Production of Tung Oil

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The aim of the conducted study was to develop wood-polymer composites (WPCs) using secondary polymer waste and agricultural technology waste materials, which would have lower environmental impacts than WPCs made from virgin resources. The study focused on developing WPCs based on polypropylene filled with finely dispersed powders of waste products from tung oil production (PP+TOPW composites). Finely scattered powder (with an average grain size of 0.5–1.5 mm) was obtained from crushing and grinding the outer pericarp of tung fruit waste, which resulted from tung oil extraction. Tung oil is produced in Georgia from tung fruit that is grown in Tsalenjikha district, Georgia. In addition, to modify the properties of the WPCs, organic silicon oligomer tetraethoxysilane and powdered aluminum hydroxide were used as additives. The study found that the strength properties of the PP+TOPW composites can be optimized by modifying them with tung oil and other mineral additives. The optimal strength properties were observed at a filler content of 40 wt.%, where the compression and bending strength limits were 63.5 and 36.7 MPa, respectively. The water absorption of the PP+TOPW composites was reduced by modifying them with tung oil. The PP+TOPW composites with a filler content of 30 wt.% showed 0% water absorption, and the water absorption of composites with a filler content of 40 and 50 wt.% (modified with tung oil) was very low, ranging from 0.2–0.8%.

The study also investigated the effect of modifying PP+TOPW composites with tetraethyl orthosilicate (TEOS), which increased all the strength parameters, including impact strength, and reduced water absorption, although not as much as when modified with tung oil. The introduction of a flame retardant, aluminum hydroxide, into the composite composition in the amount of 25–30 wt.% made the composites flame-retardant and low-combustible materials, expanding their potential applications, particularly in construction.

Overall, the study successfully developed WPCs using waste materials with optimized properties, which have potential for various applications, including in construction, due to their flame retardant and low-combustible properties.

Keywords: tung oil production waste, physical and mechanical properties, water absorption, fire resistance.

Introduction

In recent years, wood-polymer composite (WPC) applications have become attractive for the construction industry, packaging, and automotive sectors. However, there is limited research specifically related to polypropylene composite reinforced with bio-waste from tung oil production. Tung oil, being a traditional Chinese wood oil extracted from the seeds of tung trees, has been widely used for over a thousand years to protect wood furniture and buildings due to its biodegradability and non-toxic nature towards humans. WPC polymer matrix is mainly represented by thermoplastic polymers – polyethylene (PE), polypropylene (PP), or polyvinyl chloride (PVC) – polyolefins with attractive mechanical properties, but high waste generation due to consumer use. In the construction industry, WPCs are used as a replacement for natural wood and are mostly made of PP or PE, especially for wet workplaces or sites interacting with liquids, but in the case of façades, the plastic matrix is mainly PVC-based.

Tung oil, derived from the seeds of tung trees, has a long history of use for protecting wood furniture and structures. It is known for its biodegradability and non-toxic nature towards humans. Several studies have explored the beneficial properties of tung oil in relation to wood preservation and enhancement.

Ribeiro et al. (2020) have conducted research on tung oil and its applications. They have discussed various aspects of tung oil, including its composition, extraction methods, and potential uses. While the specific details are not provided, this literature review may have covered the historical significance of tung oil in Chinese culture and its traditional uses in wood protection (Ribeiro et al., 2020).

Xiong et al. (2012) have investigated the non-toxic nature of tung oil. Their study explored the safety aspects of using tung oil as a wood coating, assessing its impact on human health and the environment. The findings would support the longstanding use of tung oil as a safe alternative to other wood preservatives (Xiong et al., 2012).

Regarding the specific applications of tung oil in wood protection and enhancement, He et al. (2019) have discovered that tung oil can be impregnated into Chinese fir (Cunninghamia lanceolata), effectively occluding the pits of the wood and preventing moisture absorption. This finding suggests a potential application of tung oil in improving the dimensional stability and durability of wood products, particularly in terms of moisture resistance (He et al., 2019).

Tang et al. (2019) have investigated the effects of tung oil heat treatment on bamboo. Their study focused on the distribution of tung oil within bamboo cells, such as the cell lumens and cell walls. They found that the heat treatment facilitated the penetration of tung oil into these structures, resulting in improved dimensional stability and hydrophobicity of the bamboo (Tang et al., 2019).

In terms of its drying time, tung oil dries faster compared with other plant oils with similar iodine values, such as linseed and perilla seed oils. This characteristic makes tung oil a preferred choice as a high-quality and high-speed drying oil in the production of paint, varnish, and ink (Shockey et al., 2016; Humar and Lesar, 2013).

About 480 000 t/year of bio-composites (consisting of natural fibers or particles and a binder such as polymer and resin) are produced in Europe (Partanen and Carus, 2021). About 60 000 tons of WPC reinforced with natural fibers like wood are produced in Europe every year, and in this amount, PP-based WPC accounts for 92%; bio-based polymer matrix makes 6%, and PE matrix makes 2%. Wood fibers are used in many variations, but the main contenders for natural fibers are bamboo, flax, and hemp (Partanen and Carus, 2016). A comprehensive overview of the largest producers of biocomposite granulates in Europe shows that 18 of 21 largest producers used PP as polymers and 7 of 18 used recycled PP (Partanen and Carus, 2021).

Producing WPC using secondary polymers produced by recycling primarily causes lower environmental impacts than WPCs produced from virgin resources. There is no doubt that they have a very low environmental impact on global warming, acidification, eutrophication, and greenhouse potential (Ramesh et al., 2022). For example, the benefits of producing WPC by recycling PP in terms of environmental impact are a reduced risk of global warming and the depletion of abiotic resources; besides, wood waste materials are often low-cost materials and have the potential to produce low carbon-based products while putting less strain on forests (Chan et al., 2017). Production WPCs can significantly reduce environmental impacts to manage construction and demolition wood waste (CDW) effectively. In addition, replacing conventional synthetic adhesives with biobased adhesives (starch, tannins, lignin) is considered an environmentally friendly alternative.

For the design of WPCs, research has investigated different varieties of agricultural wood waste materials. Studies of the physical and mechanical properties of composites based on PP and timber industry waste (containing different plywood production industry byproducts) have shown that modification of all composites with the coupling agent maleated polypropylene (MAPP) can considerably improve the physical and mechanical properties (tensile, flexural, impact strength) of WPC. MAPP (5 wt.%) additions also significantly improve the water resistance of WPC. Scanning electron microscopy (SEM) investigations has confirmed the positive action of interfacial modifiers on the strengthening of adhesion interaction between components of wood and PP matrix that give a considerable increase in the exploitation properties of the WPC (Kajaks et al., 2014).

Conducted studies of WPC based on PP and wood particles obtained from agricultural chili pepper waste show that the yield stress, breaking stress, and ultimate tensile stress can be maximized with a proportion of 63.75% PP and 21.25% chili paper wood fiber (Valles-Rosales et al., 2016).

Nowadays, the use of various vegetable oils for forming new products and for the development of additives for polymer/composite applications poses a green chemistry challenge for research and development. In recent years, vegetable oil-derived polymers and composites have been widely used.

In particular, attention was drawn to studies devoted to the research of composites of various types of polymers and renewable resources, and especially to the studies describing the use of tung oil (TO) and its production waste.

Composites based on TO polyurethane and pine wood flour have been studied to obtain high-strength composites. The obtained natural composites had excellent particle-polymer interface and high deformation at break and strength. Composites with 10 and 15 wt.% of pine wood flour present higher tensile ultimate strain. Based on SEM and strength modelling, that was explained by a strong interfacial adhesion caused by physical and chemical bonding (Casado et al., 2009).

TO has been used as a paint and varnish for a long time; however, due to its chemical composition, it can be modified as an environment-friendly biopolymer or other active additive. TO is mainly composed of unsaturated fatty acids: 77–82 wt.% α-elaeostearic acid (chemical structure with three conjugated double bounds), 3.5–12.7 wt.% oleic acid (chemical structure with one double bond), and 8–10 wt.% linolenic acid (chemical structure with three non-conjugated double bonds), and the saturated fatty acids: about 3.03 wt.% palmitic acid and 2.2 wt.% stearic acid (Meiorin, Aranguren, and Mosiewicki, 2015).

The conducted study shows that tung oil with the naturally conjugated triene structure is well fitted to polymerize by cationic polymerization (Samarth et al., 2015). Investigation using tung-oil-based ester as plasticizers shows its applicability for better mechanical properties for PVC resins with well-balanced properties of flexibility and strength (Wang et al., 2018).

The research for developing environment-friendly bio-composites suggests that pulp fiber (PF) could be successfully used as a reinforcement in polylactic acid (PLA)-based composites. The tensile and flexural strength of PLA/PF composite increases by adding epoxidized tung oil (ETO) with 5–10 wt.% content. ETO acts as a plasticizer for PLA; consequently, with a high content of ETO (15 wt.% of fiber), the mechanical properties of the composites are reduced (Nguyen et al., 2020).

The aim of this work is to develop wood-polymer composites with desired physical and mechanical properties based on polypropylene and tung oil production waste, and to study the possibilities of increasing their strength, water absorption and fire resistance using various types of additives, such as tung oil, organosilicon oligomer-tetraethoxysilane and aluminum hydroxide. No works describing the use of tung oil production residues were found in the literature; there are also few examples of modifications of polymer composites with tung oil.

Materials

The experimental part of the study involved the development and testing of the PP+TOPW composites. The composites were produced using a twin-screw extruder and injection molding machine, with different percentages of the tung fruit outer pericarp waste powder as a filler material. The study also investigated the effect of modifying the composites with tung oil, tetraethyl orthosilicate (TEOS), and flame retardant-aluminum hydroxide.

Specifically, the materials used in the experimental part of the study were polypropylene (PP), tung fruit outer pericarp waste powder (TOPW), tung oil, tetraethyl orthosilicate (TEOS), flame retardant-aluminum hydroxide.

Polypropylene homopolymer used as the polymer matrix was manufactured in China. The most prominent fillers were a finely scattered powder of waste tung fruit outer pericarp (with an average grain size of 0.5–1.5 mm) obtained after the extraction of tung oil. This powder was created by crushing and grinding the waste using equipment that resembled a chopper. Modifying additives used were organic silicon oligomer tetraethoxysilane (the empirical formula is $Si(C_2H_5O)_4$, UPAC name – tetraethyl silicate, 98%, Thermo Scientific Chemicals, purity-99.0%) and powdered aluminum hydroxide (the empirical formula is $Al(OH)_3$, IUPAC name – aluminum trihydroxide, powder, < 45 μm).

Tung oil was locally produced in Tsalenjikha district (Georgia) by roasting (120°C) and cold pressing the peeled fruits of tung. The properties of TO used in the experiment were as follows: density – $0.94 \cdot 10^3$ kg/m^3; acid value – 0.47–0.5 mg$_{KOH}$/g; iodine value – 150.6–170.3 g I_2/100 g; saponification value – 194.4–197.2 mg$_{KOH}$/g. The chemical composition of TO was as follows: moisture or impurities – 5–8%; α-eleostearic acid – 77–78%; oleic acid, palmitic acid and linolenic acid – 14–18%.

TOPW was produced by crushing the tung fruit, removing the hard peel and extracting the heart containing the oil that is a necessary technological process before obtaining the oil. As a result of breaking the shell, we get TOPW – a mixture that contains the heart, shell fragments, heart particles, oily dust, and unbroken fruit.

Methods

The samples were evaluated based on their strength in terms of compression, bending, and impact, as well as their viscosity. Additionally, the specific gravity and water absorption of the samples were determined. The specific weight of the samples was calculated using the measuring-weighing method. The measuring-weighing method was used to determine the specific weight of the samples (15 x 10 x 4 mm). The behavior, brittleness, or toughness of specimens under the impact conditions were investigated using the ISO 180:2019 standard – (Plastics — Determination of Izod impact strength), which enables testing on small square samples (ISO 180:2019 – Plastics — Determination of Izod Impact Strength 2023). The compressive strength was evaluated using the ISO 604:2002 standard – (ISO 604:2002 – Plastics — Determination of Compressive Properties 2023) (sample sizes of 10 and 15 mm), and the results were as follows. In terms of the amount of water that may be absorbed, the test samples were evaluated using the ISO 62.2008 standard – (ISO 62:2008 – Plastics — Determination of Water Absorption 2023). In accordance with the standard DIN 4102-1 – (Fire behavior of building materials and elements), when the material's fire behavior has been determined and divides into Class A (A1, A2 - Non-combustible materials) and Class B (B1- Not easily flammable, B2- Flammable, B3- Easily flammable) (DIN 4102-1 - European Standards 2023).

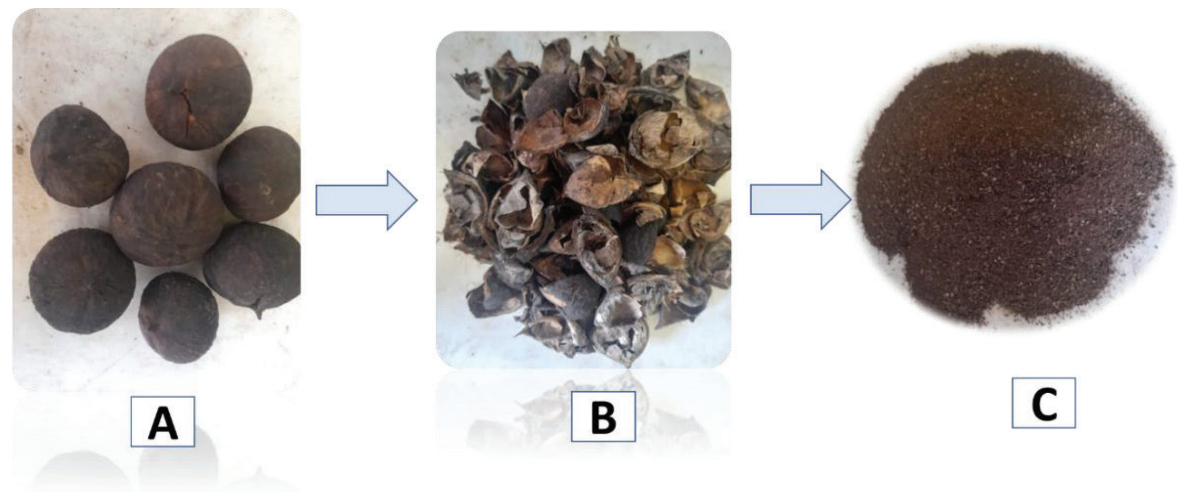
The samples were prepared considering of the standard ISO 1268-1 – (Fiber plastics – Methods of Production of Test Plates) (ISO 1268-1:2001 – Fibre-Reinforced Plastics — Methods of Producing Test Plates 2023). A propeller mill was used to combine the composite elements for 2 to 5 minutes, and then was pre-dried at temperatures ranging from 50 to 70°C. To obtain a homogenous powder, the obtained mixture was sifted using Sieve Shaker-TS-200 with a diameter of the sieve 0.5–1.5 mm. Following that, the material with an average grain size of 0.5–1.5 mm was shaped in pressure molds. The equipment used to make the plates maintained the required temperature and pressure (10 MPa pressure and 170–190°C for 10–15 min).

Polypropylene compositions were modified with tung oil and silicone modifier tetraethoxysilane (TEOS), with the content in the volume of the composite being 10 wt.% and 5 wt.%, respectively; the isopropyl alcohol and toluene were used to dilute the liquids in the required amount. Modified polypropylene compositions were then used to create composite following the proper mixing of the composition with the fillers. It was dried at a temperature of 50–60°C. The subsequent mixing of the composition with polypropylene powder was carried out in the same manner as it had been in the case of the unmodified composition, and the samples were produced using the same technological method. Using unaltered filler powder, the well-known flame-retardant aluminum hydroxide was mixed. This step was carried out.

Experimentation

The tung tree fruit before processing typically consists of an outer pericarp, a fleshy mesocarp, and a hard endocarp that encloses the seed. After processing, the outer pericarp is typically removed, and the seeds are

Fig. 1. *A – tung tree fruit, B – fruit outer pericarp waste, C – finely dispersed waste powder*



extracted and further processed to obtain tung oil. The finely dispersed powder of the tung fruit outer pericarp (*Fig. 1C*) is a waste product generated during the processing of the tung tree fruit, and it was used as a filler material in the development of the wood-polymer composites studied in the research. This waste material was finely ground and processed into a powder form that could be incorporated into the composite material, thereby the use of this waste material as a filler in the composites aimed to reduce environmental impacts and promote the utilization of secondary resources.

Fig. 1 shows the tung tree fruit before and after processing, where you can see the finely dispersed powder of the tung fruit outer pericarp (*Fig. 1C*).

Table 1 in the study presents the physical-mechanical properties and water absorption values of the PP+TOPW composites developed with different percentages of filling. The results show that the percentage of filling has a significant effect on the physical and mechanical properties of the composite materials. Specifically, increasing the percentage of filling from 10 wt.% to 40 wt.% led to an increase in the strength properties of the composites, including the compression and bending strength, as well as the modulus of elasticity. However, further increasing the percentage of filling to 50 wt.% resulted in a decrease in these properties. The water absorption of the composites also decreased with an increasing percentage of filling, with the 30 wt.% filled composite exhibiting zero water absorption. The study suggests that the optimal strength properties of the composite were achieved with a filling percentage of 40 wt.%.

Table 1. *Physical-mechanical characteristics and water absorption of PP+TOPW composites*

N	Composite	Relative density, kg/m^3	Compression strength, MPa	Bending strength, MPa	Impact viscosity, kJ/m^2	Water absorption, %
1.	PP + TRP 30 wt.%	954	48.5	33.5	5.50	0
2.	PP + TRP 40 wt.%	1018	63.7	36.8	4.16	0.85
3.	PP + TRP 50 wt.%	1040	55.2	32.0	4.00	2.11
4.	PP + TRP 30 wt.% modified with TO 10 wt.%	973	40.8	24.0	4.80	0
5.	PP + TRP 40 wt.% modified with TO 10 wt.%	1115	48.5	28.5	4.40	0.2
6.	PP + TRP 50 wt.% modified with TO 10 wt.%	1088	44.6	25.0	3.80	0.8
7.	PP + TRP 40 wt.% modified with TEOS 5 wt.%	1007	68	42.5	5.20	0.6

Results and Discussion

The purpose of the study was to investigate the relationship between the mechanical properties of the composite materials and the concentration of the fillers used in their manufacture. The study focused on composites made using tung waste powder (TWP), tung residue powder (TRP), and tung residue powder modified with TEOS, at concentrations of fillers 30, 40, and 50 wt.%, respectively.

The results of the study, as shown in *Figs. 2–5*, demonstrate that the mechanical properties of the composite materials, such as compression strength, bending strength, and impact viscosity, are dependent on the type and concentration of the fillers (composites including TWP, TRP and TRP treated with TEOS) used. The curves in these figures exhibit maxima at around 40 wt.% of filler concentration, indicating that this concentration provides the best balance of mechanical properties.

The compression strength (MPa) of composites containing tung waste powder (TWP), tung residue powder (TRP), and tung residue powder modified with TEOS was studied to understand the effect of these fillers on the mechanical properties of the composite materials. The results of the study showed that the compression strength of the composites was dependent on the type and concentration of the filler used (*Fig. 2*).

The bending strength (MPa) of composites containing tung waste powder (TWP), tung residue powder (TRP), and tung residue powder modified with TEOS was also investigated in the study. The results showed that the bending strength of the composite materials was dependent on the type and concentration of the filler used. The bending strength of composites containing TWP and TRP, on the other hand, increased with increasing filler concentration up to a certain concentration, beyond which the strength decreased. The maximum bending strength was also observed at around 40 wt.% filler concentration in the case of both TWP and TRP (*Fig. 3*).

Fig. 4 specifically shows the relationship between the bending strength (MPa) of a composite comprising TWP, TRP, and TRP modified with TEOS. The data suggests that the bending strength of the composite increases with the addition of TEOS to TRP, with a maximum value at around 40 wt.%. Overall, the study highlights the importance of optimizing the concentration and type of filler used in the manufacture of composite materials to achieve the desired mechanical properties.

Fig. 2. *Dependance of compression strength (MPa) of composites containing tung waste powder (TWP), tung residue powder (TRP), and tung residue powder modified with TEOS*

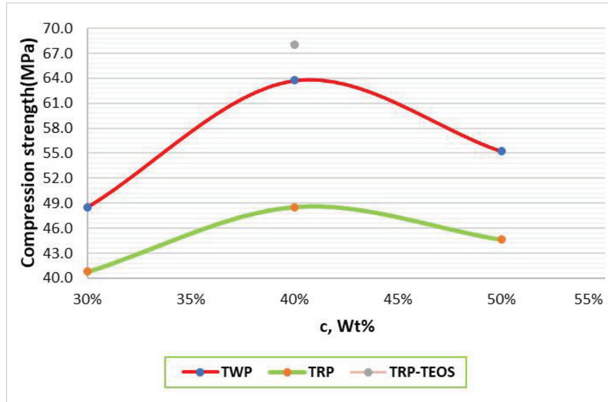


Fig. 3. *Dependance of bending strength (MPa) of composites containing tung waste powder (TWP), tung residue powder (TRP), and tung residue powder modified with TEOS*

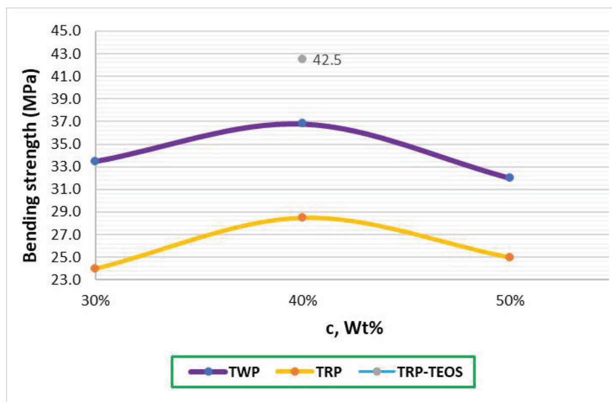
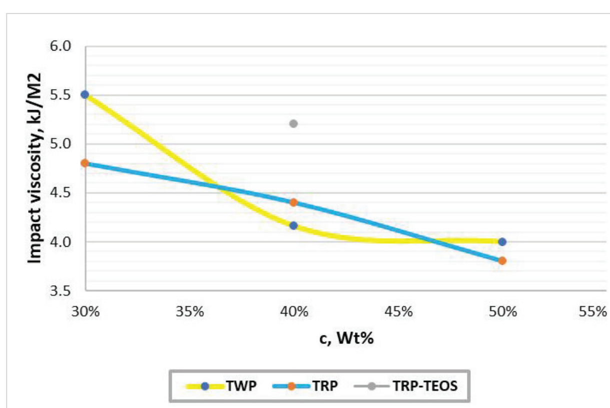


Fig. 4. *Dependance of impact viscosity (kJ/m²) of the composite containing tung waste powder (TWP), tung residue powder (TRP), and tung residue powder modified with TEOS*



The water absorption (%) of composites containing tung waste powder (TWP), tung residue powder (TRP), and tung residue powder modified with TEOS was also studied in the research. The results of the study showed that the water absorption of the composite materials was dependent on the type and concentration of the filler used. *Fig. 5* of the study demonstrates the dependence of the water absorption on the concentration of TWP, TRP, and TRP modified with TEOS. The results showed that the addition of TEOS to TRP reduced the water absorption of the composite material. The water absorption of composites containing TWP and TRP, on the other hand, increased with increasing filler concentration. The maximum water absorption was observed at around 50 wt.% filler concentration in the case of both TWP and TRP.

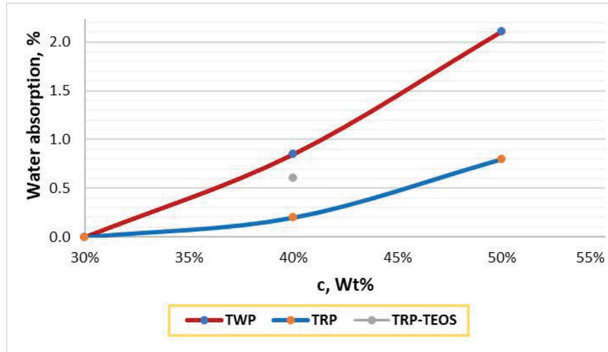
The study highlights the importance of optimizing the concentration and the type of the filler used in the manufacture of composite materials to achieve the desired mechanical properties, including bending strength. It is important to note that the specific properties of the filler and the manufacturing process of the composite can also affect the bending strength and other mechanical properties of the resulting composite material.

In this filling range, composites filled with a fine powder of 30 wt.% tung waste do not sink in water, and their relative density increases with an increase in filler. The optimal strength properties of the composite are revealed at a filler content of 40 wt.%. The strength limits of this filling are 63.5 and 36.7 MPa in compression and bending, respectively. However, at the same time, when the amount of filling increases, the impact viscosity index of the samples decreases from 5.50 kJ/m^2 to 4 kJ/m^2.

Modifying the filler with TO (10 wt.%) in the studied series of fillers did not improve the strength characteristics of PP+TOPW composites, but their decrease was observed. However, it should be noted that this fact did not have a significant effect on the impact strength; more precisely, its indicators were practically preserved. Previously, a study has already been conducted on this issue (Kalia et al., 2009), according to which the chemical treatment of cellulose-containing fillers in some cases leads to a deterioration in the mechanical properties of the composites, which can be explained by the formation of new chemical bonds due to the brea_ king of old ones, in particular, between filler fibers.

Modification with TO significantly affected the water absorption of the samples. The water absorption indicators

Fig. 5. *Dependance of water absorption (%) of composites containing tung waste powder (TWP), tung residue powder (TRP), and tung residue powder modified with TEOS*



of PP+TOPW composites with a filler of 40 and 50 wt.% (modified) are approximately 3.5–4 times better. It should be noted here that both types of composites with a filling of 30 wt.% are highly hydrophobic materials – water absorption is 0%. At the same time, with a higher filling, the water absorption indicators are very low (0.2–0.8% in the case of modification with TO), which is even less for the water absorption of polypropylene composites filled with classical wood sawdust by 40–50 wt.%, the water absorption indicators of which is more than 3%.

It is known from previous studies that composites filled with porous and water-absorbing cellulose are easily degraded and disintegrated. Therefore, when such a detail is made of a composite, which quickly fails due to operation (atmospheric influences, wear, disposable tableware, etc.), it is not necessary to reduce water absorption or hydrophobicity. Modifying cellulosic-filled composites to reduce their water absorption is acceptable when long-term strength is required.

To increase the strength of PP+TOPW composites, a polymeric structure modifier TEOS was used. In 40 wt.% of the composite with optimal properties, it was introduced in an amount of 5 wt.%. This is presented in *Table 1*, item 7, which shows that the modification with TEOS increased all strength parameters: compression strength increased by 6.7%, bending strength by 15.5 %, impact viscosity by 25 %, and it reduced the water absorption of the material, although not as much as it was shown when modified with tung oil.

It is important to use mainly fire-resistant materials in construction and other fields, which applies primarily to polymer composite materials since they are combustible materials.

Table 2. *Physical-mechanical properties of PP+TOPW composites modified with aluminum hydroxide*

Composite	Relative density, kg/m^3	Compression strength, MPa	Bending strength, MPa	Impact viscosity, kJ/m^2	Water absorption, %
PP + TRP 25 wt.% + $Al(OH)_3$ 25 wt. %	1140	53.1	31.6	4.5	0.3
PP + TRP 30 wt.% + $Al(OH)_3$ 30 wt.%	1190	51.0	28,5	4.0	2.5

The development of non-combustible materials is achieved by introducing special flame-retardant substances into the initial composition of the PP. Aluminum hydroxide has recently been successfully used to improve the fire resistance of plastics. Aluminum hydroxide in plastics can absorb heat and reduce combustion. It absorbs hot gases, excludes further heating and decomposition of polymers, and reduces flammability of materials.

Table 2 presents the physical-mechanical properties of aluminum hydroxide-modified PP+TOPW composites filled with 50 and 60 mass %, where finely dispersed TWP and aluminum hydroxide powders are taken in equal amounts. The properties of the obtained composites are satisfactory, although the water absorption rate of the composite filled with 60 wt.% equals 2.5%.

The samples used for the experiment (120 x 15 x 5 mm in size) were tested for combustibility and ignition (by ISO 4589-84) by the so-called different method, i.e., using the "fire tube" tool. The process of checking the samples was carried out as follows: the sample was placed in the device by hanging in the center of the pipe of the device, the flame of the stove was applied for heating for 2 minutes; after stopping the flame supply, the time of burning of the material and extinguishing of the flame on it was recorded. Examination of unmodified polypropylene composites filled with tung wood waste showed that they are usually are flammable materials, corresponding to class B2 according to standard DIN 4102-1; this is since the samples lost more than 20% of their weight when exposed to the lamp flame for 2 minutes and continued to burn for more than 1 minute after being removed from the flame. A positive effect was observed after 25% by weight of aluminum hydroxide was applied. In this case, the mass loss of the samples after the end of the experiment did not exceed 15%, and the flame disappeared after a few seconds. The best results were observed when using a composite material containing aluminum hydroxide (30 wt%). The weight loss of the samples after firing was a maximum of 7–10%; it should also be noted that these samples are not independently fired. Therefore, these materials belong to the B1 class according to the standard DIN 4102-1, a series of hardly flammable and weakly combustible materials, which determines the possibility of their use in construction and in such fields where it is necessary to provide fire-resistant materials.

Fig. 6 shows the samples used in the experiment and some products made using them.

Fig. 6. *PP+TOPW composites test samples and products made during the study*

Conclusions

For the first time, wood-polymer composites based on finely dispersed powders filled with polypropylene from waste products from the production of tung oil (PP+TOPW composites) were developed.

It was experimentally established that the physical-mechanical and hydrophobic properties of PP+TOPW composites depend significantly on the filler concentration, and composites with extreme properties are obtained with a filling of 40% by weight. The strength limits of this filling are 63.5 and 36.7 MPa in compression and bending, respectively.

Modification of PP+TOPW composites by adding tung oil (10 wt.%) in the filler did not improve the strength characteristics of the composites; in contrast, its reduction was observed. However, at the same time, the indicators of the impact force were practically preserved. The composites with a filling of 30 wt.% are highly hydrophobic materials; water absorption is 0%, with a higher filling (40–50%), the water absorption indicators are very low (0.2–0.8% in the case of modification with tung oil), which is even less on the water absorption of polypropylene composites filled with classical wood sawdust by 40–50 wt.%, the water absorption indicators of which are more than 3%.

Modification of the obtained PP+TOPW composites with tetraethoxysilane (5 wt.%) improved its functional properties and increased the strength parameters: compression strength increased by 6.7%, bending strength by 15.5%, and impact viscosity by 25%.

The introduction of a flame retardant aluminum hydroxide in the amount of 25–30 wt.% into the composition of the MPC made the composites flame-retardant and low-combustible materials. According to the standard DIN 4102-1, these materials belong to the B1 class, a series of hardly flammable and weakly combustible materials, which determines the possibility of their use that expanded their scope, especially in construction.

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