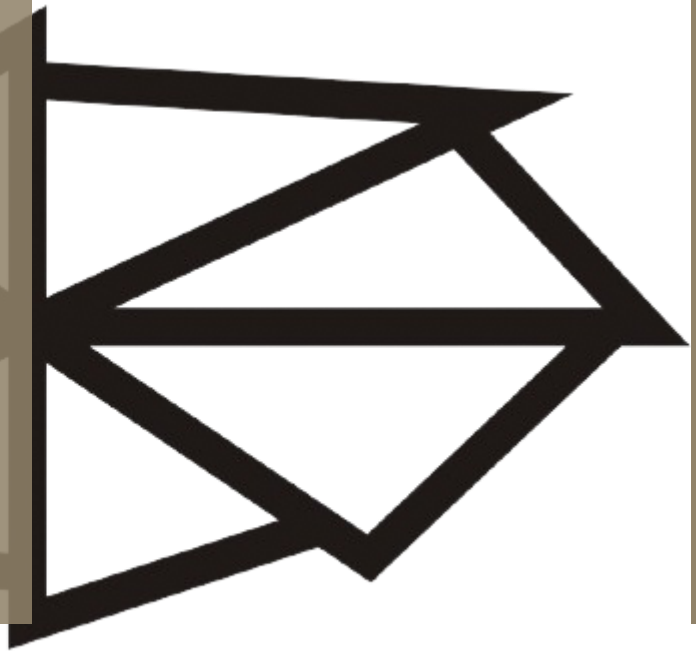
Colloquium
APVV 22-0034
VEGA 1/0027/24

Assoc. prof. Dr. Iveta Čabalová
hotel Tenis, Zvolen
September 26, 2024



TECHNICAL UNIVERSITY IN ZVOLEN

Grant Schemes

1. **APVV 22-0034:** Valorization of Waste Polymers from the Automotive Industry for the Production of Industrially Interesting Composites with Improved Properties

2. **VEGA – 1/0027/24:** Innovative Possibilities of Plastic Waste Processing in the Automotive and Construction Industry, Its Recovery in Wood Composite Materials with Improved Properties

UNIVNET "University Research Association for Waste Recovery, especially from the Automotive Industry" No. 0201/0082/19

Why? Reason!

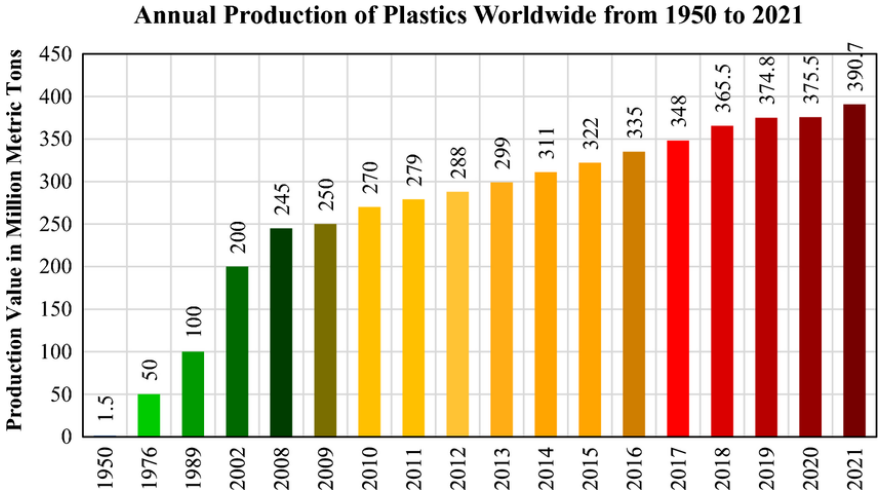


Fig. 1. Worldwide production of plastics from 1950–2021 (in million metric tons) Haque et al. (2023)

- Every month, each European produces an average of three kilograms of plastic waste.
- This amount could triple by 2060.
- Only about **40%** of end-of-life plastic in Europe is actually recycled

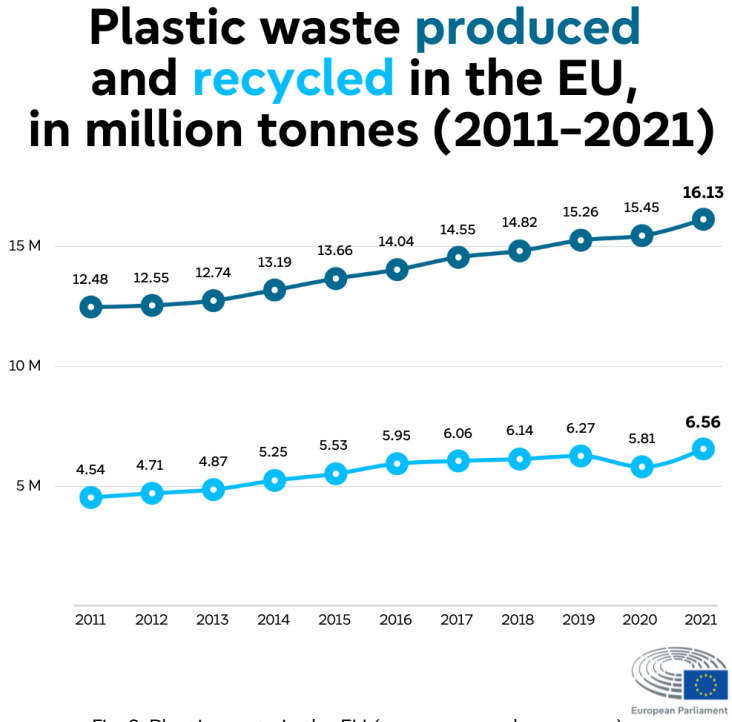


Fig. 2. Plastic waste in the EU (www.europarl.europa.eu)

Source: Eurostat [env_waspac] · most recent data available (2021)

Plastics in Automobiles

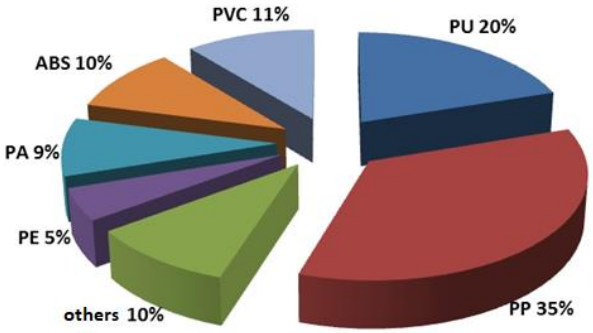


Fig. 3. The proportion of plastics in cars (Olexová et al. 2008)

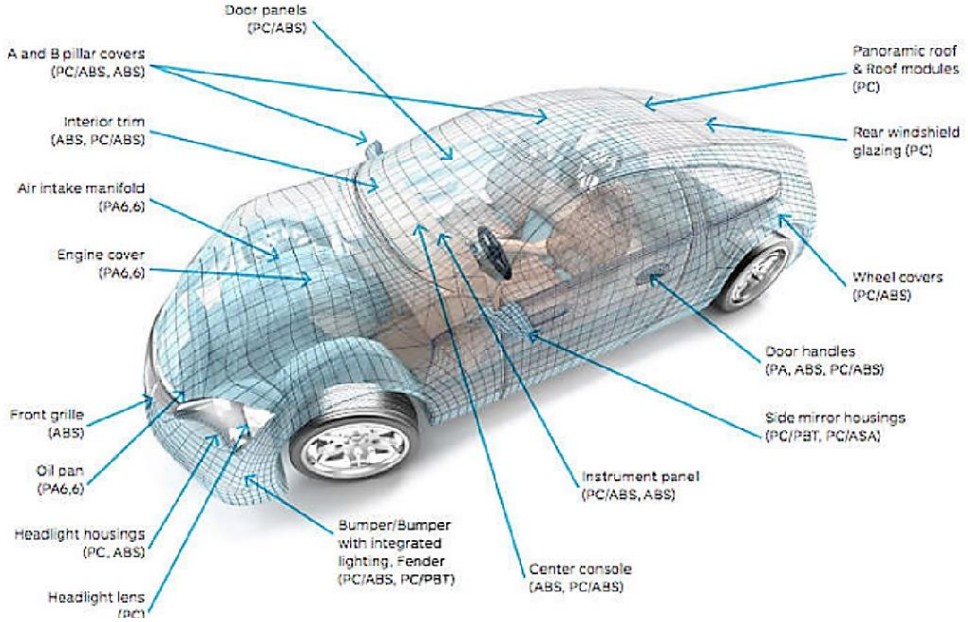


Fig. 4. Technical plastics used in an automotive vehicle (Oliver 2014)

Slovakia

- four established car manufacturers - Volkswagen, Stellantis, Kia, Jaguar Land Rover + Volvo (from 2022)
- 184 manufactured cars per 1,000 inhabitants (year 2022)

Research Procedure

01 Production of single-layer particleboards (PBs) with rubber/plastic content (10%, 15%, 20%)

02 Production of three-layer PBs with rubber/plastic content (10%)

03 Connection with practice

04 Creation and production of new wooden composites with rubber/plastic content in cooperation with practice

05 Patent applications, utility models and production of materials in the commercial sphere

Single-layer PBs

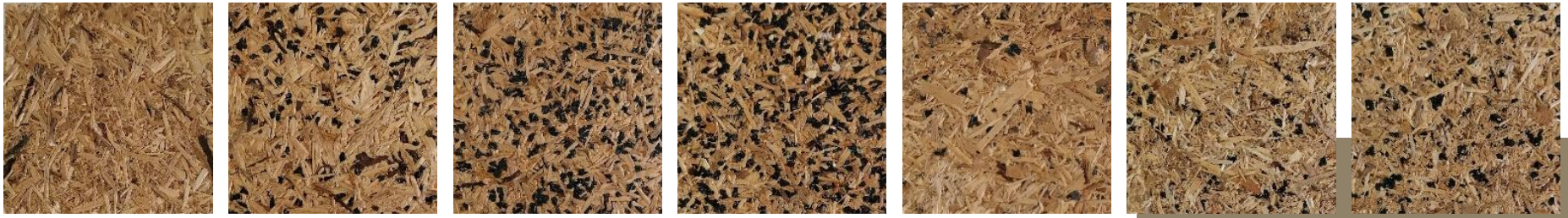
- composite board: wood chips + waste polymer
- wood chips: spruce (fraction: 0.25 – 4.0 mm)
- waste polymer: granulate from plastic and rubber parts of old cars (fraction: 1.0 – 4.0 mm)
- hot pressing
- board size: 360 x 280 x 15 mm

Sigle-layer PDs Processing

- granulate admixture: 10%, 15%, 20%
- board weight: 971 g
- pressing temperature: 240 °C
- pressures: 30 MPa, 15 MPa, 7.5 MPa
- production time: approximately 6 minutes

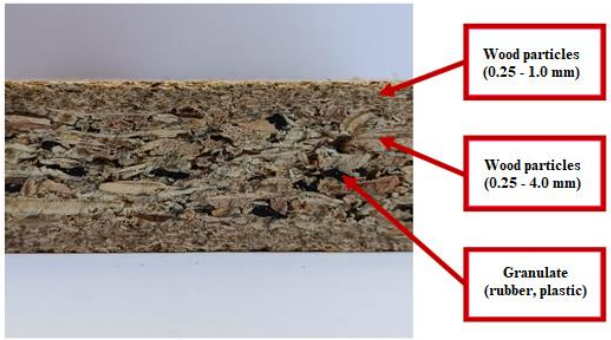
Samples of single-layer PBs

Sample Type	Signification
PB	Particleboard
PB10	Particleboard with 10% of waste plastic filler
PB15	Particleboard with 15% of waste plastic filler
PB20	Particleboard with 20% of waste plastic filler



PB T10 T15 T20 R10 R15 R20

PBs: Single- and Three-Layer



What PBs analyzes were performed? TUZVO

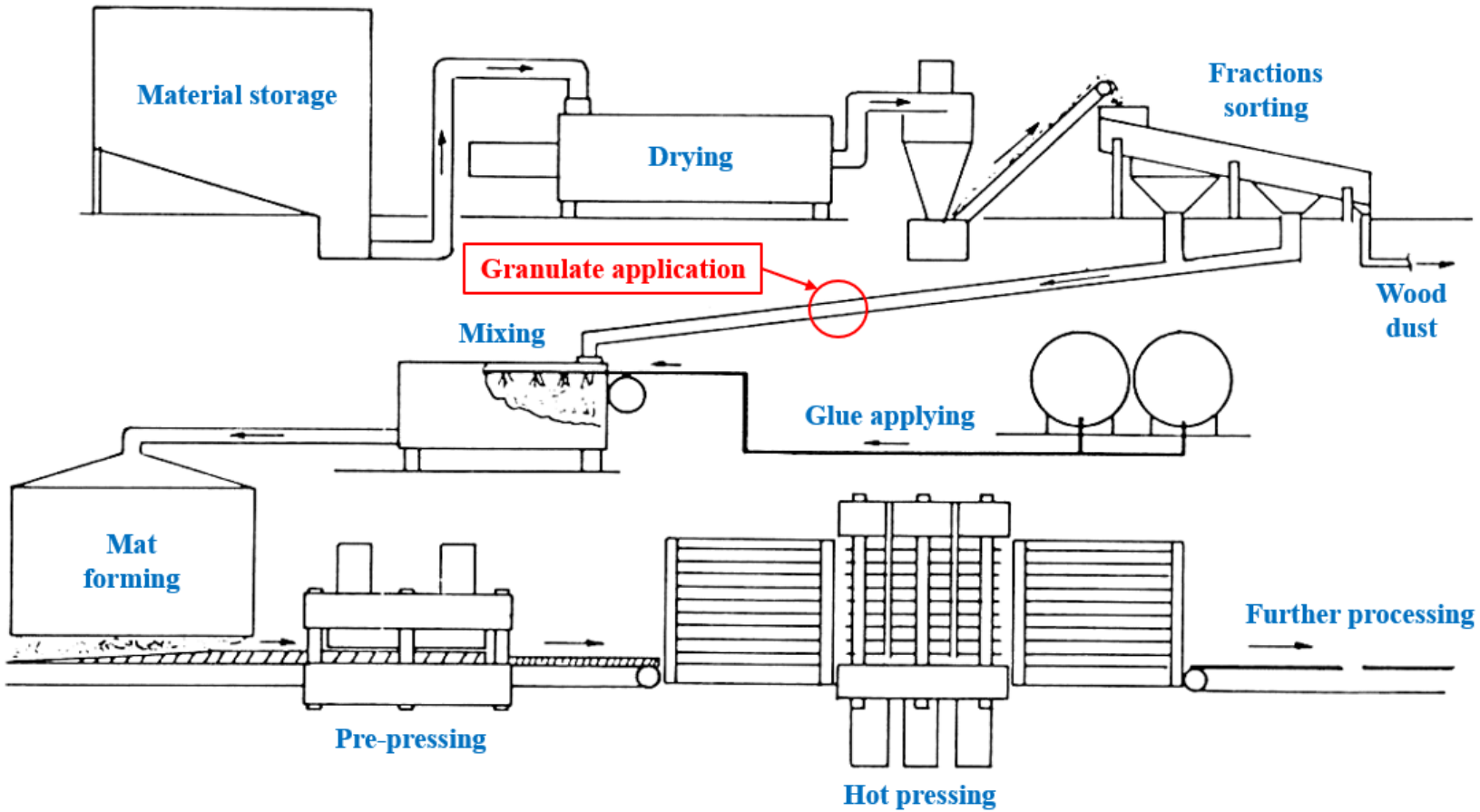
1. Mechanical properties: tensile and bending strength
2. Physical properties: water absorption and thickness swelling.
3. Morphological properties: digital microscopy and SEM analysis.
4. Thermophysical properties: thermal conductivity and diffusivity, specific heat capacity.
5. Acoustic properties: sound absorption coefficient.
6. Fire properties: ignition temperature, material burning rate, calorimetry
7. Chemical properties: VOCs
8. Ecotoxicology

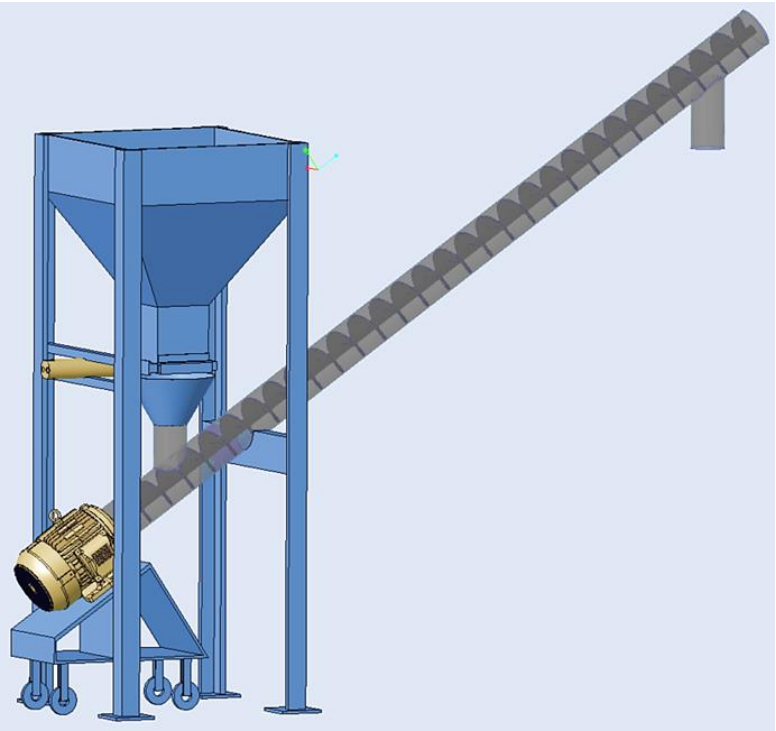
What are the properties of the new PBs?

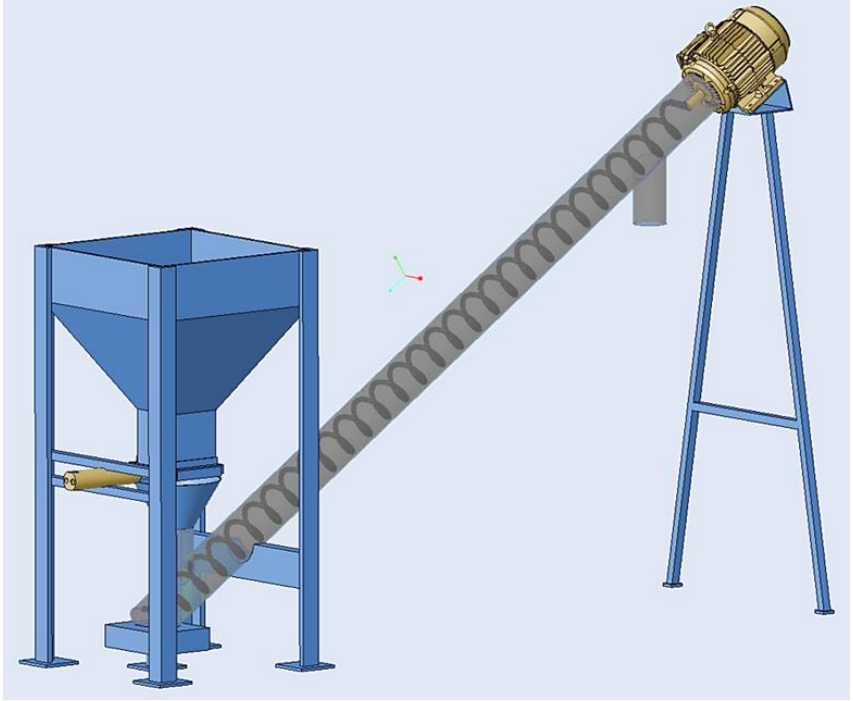
The new composites, combined wood-plastic boards, had, compared to the usual PBs:

1. Higher bending strength;
2. Comparable or lower tensile strength (depending on filler content);
3. Lower water absorption and thickness swelling;
4. Slightly worse thermal conductivity and diffusivity;
5. Comparable or slightly worse fire-technical properties;
6. From the point of view of GC-MS analysis, there is no health risk at higher temperature;
7. Lower leachability into water, so they represent a lower risk for the aquatic environment.

The Proposed Transport System

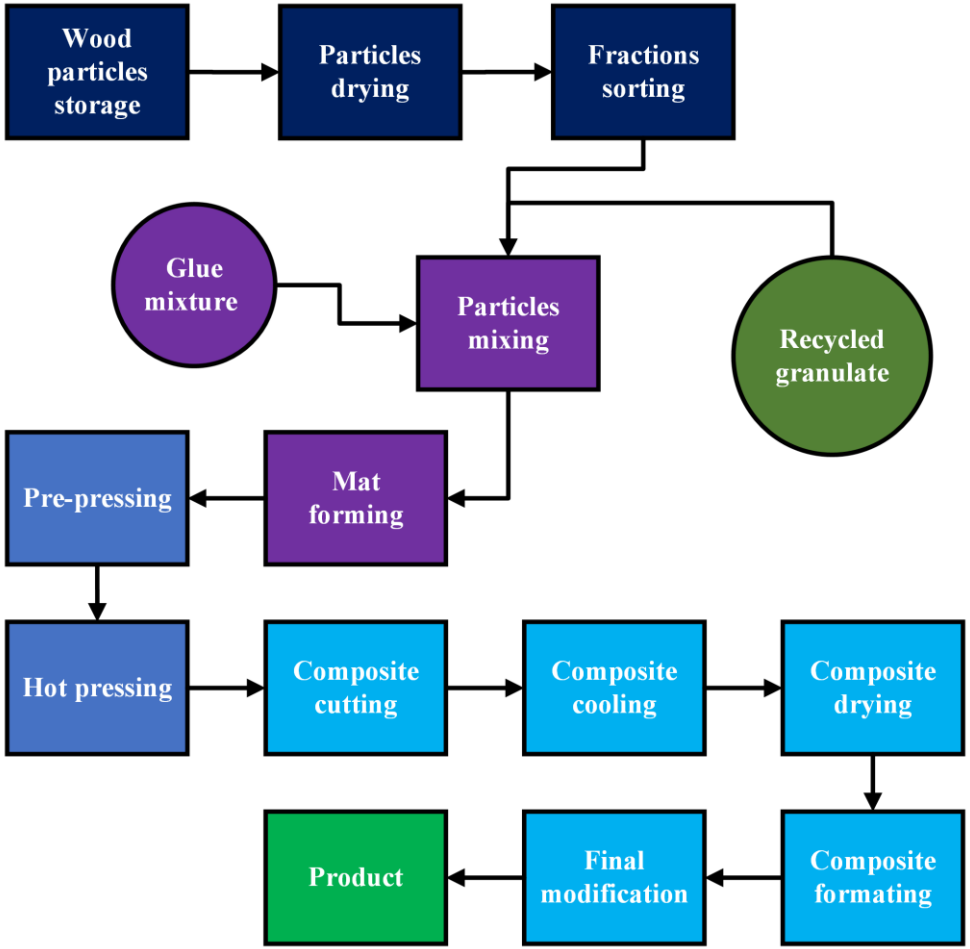






Construction giant

Design Scheme of the Technological Process for the Production of PBs



Three-Layer PB – Material.

- Spruce wood chips 0.25 – 4.0 mm, moisture content of 5 %, KRONOSPAN, a.s., Zvolen
- Plastics: ALUEX s.r.o., Zvolen: Fuel tanks, coated bumpers, and uncounted bumpers
- Rubber: AVE Kechnec, a.s., Košice: tires and mixture of carpets an isolation
- Content filler of 10 %
- Urea-Formaldehyde adhesive

What PBs analyzes were performed?

1. Mechanical properties: tensile and bending strength – **Turkey**.
2. Physical properties: water absorption and thickness swelling - **Turkey**.
3. Morphological properties: SEM analysis – **Prague**.
4. Thermophysical properties: thermal conductivity and diffusivity, specific heat capacity.
5. Acoustic properties: sound absorption coefficient.
6. Fire properties: ignition temperature, material burning rate, calorimetry.
7. Chemical properties: VOCs
8. Ecotoxicology

Outputs

V3

Articles

Mancel, V., Krilek, J., Čabalová, I., Réh, R., Osvaldová, M., Darabošová, A. Evaluation of selected mechanical and physical properties of particleboards containing waste plastics. In: Wood research. 2024. zv. 69, č. 1, s. 169-178.

Hybská, H., Mordáčová, M., Samešová, D., Čabalová, I. Ecotoxicological tests of the particleboards containing rubber waste. In: Wood research. 2023. zv. 68, č. 4, s. 758-767.

Krilek, J., Čabalová, I., Výbohová, E., Mamoňová, M., Ťavodová, M., Melicherčík, J., … Giudice, V. L. Assessment of the chipping process of beech (Fagus sylvatica L.) wood: knives wear, chemical and microscopic analysis of wood. Wood Material Science & Engineering, 2023, 19(2), 473–484.

O2

Čabalová, I., Krilek, J. Assesment of the quality of spruce wood (Picea Abies, L.) for the particleboards production. In: 30 Jubileuszowa konferencja naukowa „Postęp naukowo-techniczny i organizacyjny w rolnictwie": zeszyt streszczeń. 2024. s. 94.

Krilek, J., Čabalová, I., Darabošová, A., Mancel, V. Material recycling of plastics from automobiles, their utilization in the particleboards. In: 30 Jubileuszowa konferencja naukowa „Postęp naukowo-techniczny i organizacyjny w rolnictwie": zeszyt streszczeń. 2024. s. 95.

Outputs

V2

Articles

Darabošová, A., Mancel, V., Čabalová, I., Krilek, J., Olgun, Ç., Tor, Ö., Öncel, M. Hodnotenie mechanických a fyzikálnych vlastností trojvrstvových drevotrieskových dosiek s obsahom odpadového plastu z automobilov. In: Mobilné energetické prostriedky - Hydraulika - Životné prostredie - Ergonómia mobilných strojov: vedecký recenzovaný zborník z XII. Medzinárodnej vedeckej konferencie. Zvolen: Technická univerzita vo Zvolene, 2023, s. 26-32.

Krilek, J., Melicherčík, J., Čabalová, I., Gendek, A., Aniszewska, M., Findura, P., Prístavka, M. Hodnotenie opotrebenia nožov gravimetrickou analýzou a 3D skenovaním. In: Mobilné energetické prostriedky - Hydraulika - Životné prostredie - Ergonómia mobilných strojov: vedecký recenzovaný zborník z XII. Medzinárodnej vedeckej konferencie. Zvolen: Technická univerzita vo Zvolene, 2023, s. 83-88.

Mancel, V., Čabalová, I., Krilek, J., Réh, R., Darabošová, A., Osvaldová, M. Hodnotenie vybraných fyzikálnych a mechanických vlastností kompozitov drevo-plast. In: Mobilné energetické prostriedky - Hydraulika - Životné prostredie - Ergonómia mobilných strojov: vedecký recenzovaný zborník z XII. Medzinárodnej vedeckej konferencie. Zvolen: Technická univerzita vo Zvolene, 2023, s. 132-140.

Ťavodová, M., Krilek, J., Čabalová, I., Stančeková, D. Posúdenie vhodnosti aplikácie PVD povlaku pre zvýšenie životnosti sekacieho noža. In: Mobilné energetické prostriedky - Hydraulika - Životné prostredie - Ergonómia mobilných strojov: vedecký recenzovaný zborník z XII. Medzinárodnej vedeckej konferencie. Zvolen: Technická univerzita vo Zvolene, 2023, s. 178-184.

Čabalová, I., Výbohová, E., Mamoňová, M., Krilek, J. Zmeny v štruktúre bukového dreva počas štiepkovania. In: Mobilné energetické prostriedky - Hydraulika - Životné prostredie - Ergonómia mobilných strojov: vedecký recenzovaný zborník z XII. Medzinárodnej vedeckej konferencie. Zvolen: Technická univerzita vo Zvolene, 2023, s. 16-25.

Outputs

D1

Krilek, J., Čabalová, I., Réh, R., Melicherčík, J., Mancel, V. Drevotriesková kompozitná doska na báze gumy: úžitkový vzor č. 9716.

Krilek, J., Čabalová, I., Réh, R., Melicherčík, J., Mancel, V. Drevotriesková kompozitná doska na báze plastu: úžitkový vzor č. 9718.

Krilek, J., Čabalová, I., Réh, R., Melicherčík, J., Mancel, V. Drevotriesková kompozitná doska na báze plastu a spôsob jej výroby: prihláška č. 66-2022.

Krilek, J., Čabalová, I., Réh, R., Melicherčík, J., Mancel, V. Drevotriesková kompozitná doska na báze gumy a spôsob jej výroby: prihláška č. 67-2022.

Patents and Utility Models

In the Process...

Scientific mongraph

Čabalová, I., Kučerová, V., Bubeníková, T. Zmeny v štruktúre smrekového dreva počas jeho dlhodobého skladovania

Research paper

Čabalová, I., Krilek, J., Bubeníková, T., Ružiak, I., Nemec, M., Lee, S.H., Lubis, M.A.R., Darabošová, A., Mancel, V., Kristak, L., Todaro, L., Lo Giudice, V.. Utilization of Waste Rubber from Automobiles in the Manufacturing of Particleboards and Evaluation of Its Selected Properties. EJWWP

Colloquium

CD ISBN 978-80-228-3430-8
All paper of research team from CD

Future Project Goals

STEP 1

Three-layer PBs properties evaluation

STEP 2

Utility models, Patents, Research papers

STEP 3

Dissertation thesis – Ing. Anna Darabošová (August, 2025)

Connection with Practice

KRONOSPAN, s.r.o.

Production of particeboards containing plastic

VERÓNY, a.s.

Production of wood-cement boards with rubber content

Construction Industry

Production of sound-insulating composites - plan

Connection with Practice

KRONOSPAN

VERÓNY

References

1. Haque, M.K., Uddin, M., Kormoker, T. et al. Occurrences, sources, fate and impacts of plastic on aquatic organisms and human health in global perspectives: What Bangladesh can do in future?. Environ Geochem Health 45, 5531–5556 (2023). https://doi.org/10.1007/s10653-023-01646-0
2. Plastic waste and recycling in the EU: facts and figures: https://www.europarl.europa.eu/topics/en/article/20181212STO21610/plastic-waste-and-recycling-in-the-eu-facts-and-figures
3. Olexová, M., Kicková, M., Herditzky, A. 2008. Plastové komponenty ako neoddeliteľná súčasť automobilu v dnešnej dobe, Available on: https://www.sjf.tuke.sk/transferinovacii/pages/archiv/transfer/12-2008/pdf/104-105.pdf
4. Oliver, G. M. Plastics and composites are reshaping car design, IHS report shows, 2014

Thank you for your attention!

Assoc. Prof. Dr. Iveta Čabalová
Technical Univerzity in Zvolen
Faculty of Wood Sciences and Technology
Department of Chemistry and Chemical Technologies
T.G. Masaryka 24
960 01 Zvolen
Tel.: +421 45 5206 375
cabalova@tuzvo.sk

TECHNICAL UNIVERSITY IN ZVOLEN