IOCM 2025 Conference

The 4th International Online Conference on Materials

3–6 November 2025 | Online

MDPI

The birch residues for obtaining advanced composite packaging

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INTRODUCTION & AIM

According to the European Technology Platform “Materials 2030”, the development of environmentally friendly packaging from biodegradable, renewable materials and recycled polymers is one of nine priority innovation directions, addressing the industry and the research community.

Wood–plastic composite (WPC) is an environmentally friendly composite consisting of a polymer matrix and a wood filler. Its composition includes, along the matrix and the filler, also functional additives. The aim of the work was to study the effect of a biolubricant on the properties of WPC based on a recycled polypropylene/polylactic acid matrix, filled with the modified birch shavings (MBS), and its processing technology for obtaining packaging containers for bulk products and their storage. By blending recycled polypropylene (rPP) and polylactic acid (PLA) at an optimal weight ratio and melting them to obtain a polymer matrix, the advantages of each polymer's properties were combined.

Birch outer bark is a valuable feedstock for obtaining new added-value products through biorefinery. Depolymerisation of the bark’s suberin in the water-alkaline medium is the widely exploited method for the extraction of suberinic acids (SAs), which are a complex of long-chain aliphatic saturated, unsaturated, oxy-, epoxy, mono- and dicarboxylic acids covalently bonded with lignin-carbohydrate structures. In this study, SAs were used as a biolubricant for improving the processing parameters of the WPC proceeded by extrusion with the following injection moulding. SAs were extracted from the birch outer bark by hydrolysis in KOH water solution at 80 °C for 60 minutes and acidified to pH 4.

The WPC samples for tensile and bending tests were prepared using HAAKE MiniLab II and MiniJet II. The content of the modified wood filler in the WPC was 50 wt%. The improvement of the processing parameters from the point of view of energy consumption by decreasing the torque of the extruder screws and the injection pressure for moulding the rPP/PLA-based composite samples as a result of the decrease in the apparent viscosity of the melt in the presence of SAs was shown. The optimal content of the biolubricant in the WPC was found. At this content, the presence of SAs positively affected the mechanical properties of the biocomposite, unlike synthetic lubricants.

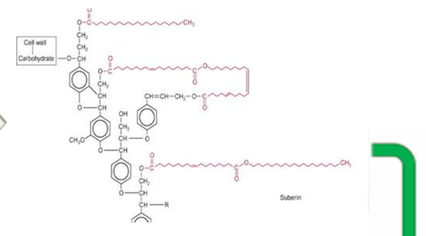
METHODS

Chemical characteristics of initial and alkali-treated milled birch wood shavings

Sample	C, %	H, %	O, %	N, %	O/C	Lignin, %	Cellulose, %	Hemi-celluloses, %
Initial	45.9	6.2	47.5	0.4	1.03	21.5	47.9	26.1
Alkali-treated	44.1	6.3	49.3	0.3	1.12	22.3	58.3	18.2

Obtaining of suberinic acids

Birch outer bark



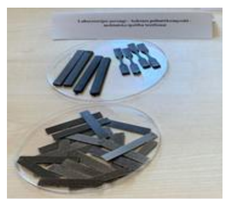
Hydrolysis in KOH

Milled birch wood sawdust

Poly(lactic acid)

rPP granules

Suberinic acids with 25 wt% water content

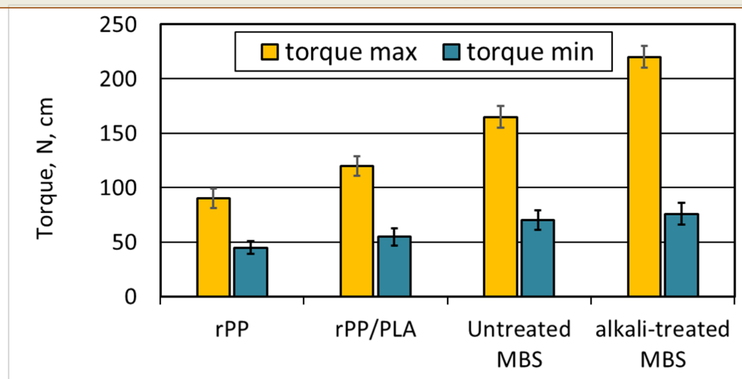


Composite samples for mechanical and wetting tests

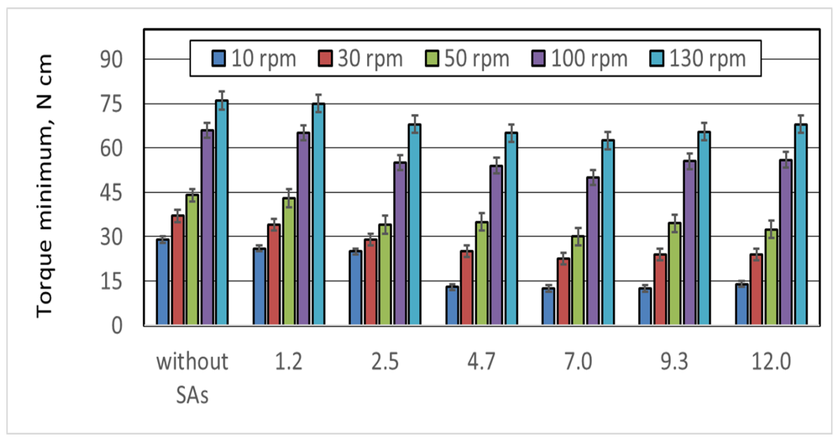
Laboratory equipment for wood-plastic composite processing
HAAKE MiniLab II and MiniJet II, (Thermo Scientific)

RESULTS & DISCUSSION

Maximal and minimum extruder rotor torque for the polymer matrixes and the composite samples

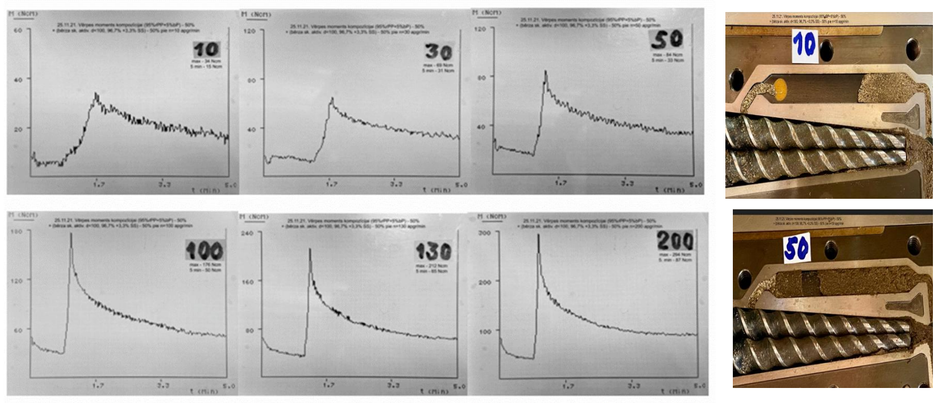


Effect of SAs content on equilibrium torque for the rPP/PLA composite at different rotor speeds

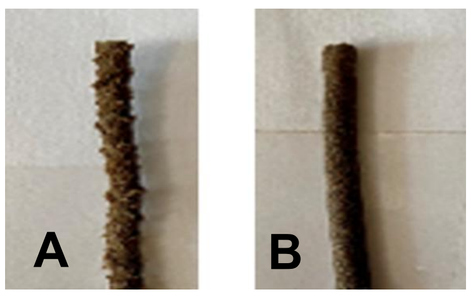


	10 rpm	30 rpm	50 rpm	100 rpm	130 rpm	200 rpm
without SAs	1.2	2.5	4.7	7.0	9.3	12.0

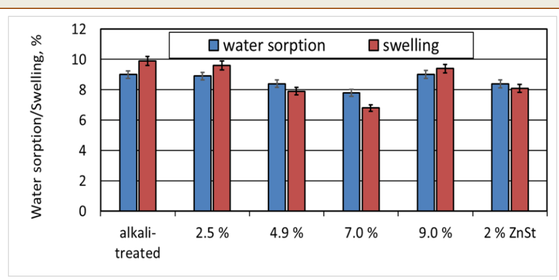
Torque *vs* time curves for the composite with 2.5% SAs content at different rotor speed



Extrudates of the biocomposite obtained without (A) and with SAs (B)



Water sorption and swelling of composite samples with different content of SAs and ZnSt after 24 days



CONCLUSION

The alkali treatment of birch shavings microparticles creates difficulties in the processing process of the wood-plastic composite by extrusion and moulding. The incorporation of suberinic acids as a lubricant in the formulation improves the processing of the composite by reducing the rotor torque and injection pressure. The greatest torque reduction occurs at the optimum SAs content of 7 wt%. Due to the chemical composition of the suberinic acids, including the covalently bound aromatic structures, they can exhibit the property of a coupling agent, improving the properties of the composite.

FUTURE WORK / REFERENCES

Using suberinic acids derived from birch bark as an internal lubricant or partial adhesive in WPCs reduces the need for synthetic lubricants (such as zinc stearate, fatty acids, and waxes) and adds value to bark biorefinery co-products. This supports circular bioeconomy streams for the production of packaging and building materials. Considering this study, migration testing of suberinic acids from the composite to its surface for food contact should be conducted.