Development of low-formaldehyde emission biobased adhesives based on lignin

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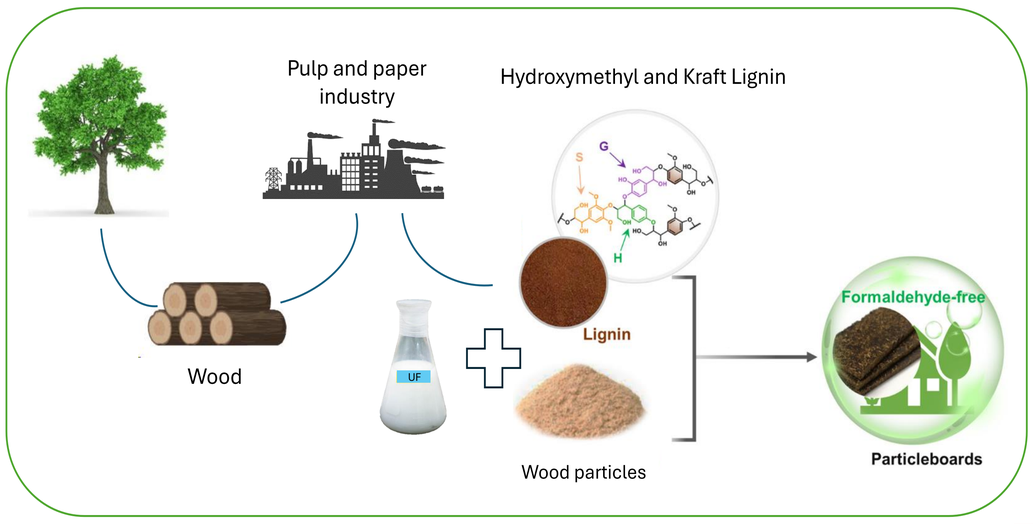
Context



Objectives

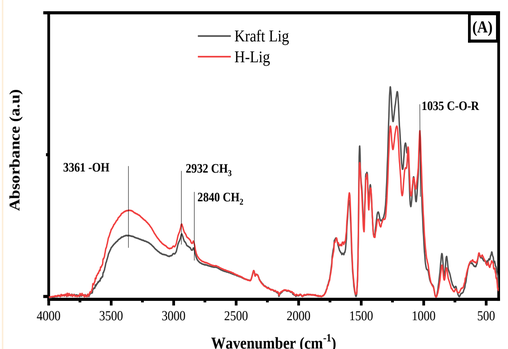
1-Develop low-formaldehyde emission biobased adhesives using kraft lignin and hydroxymethylated lignin for particleboard production.

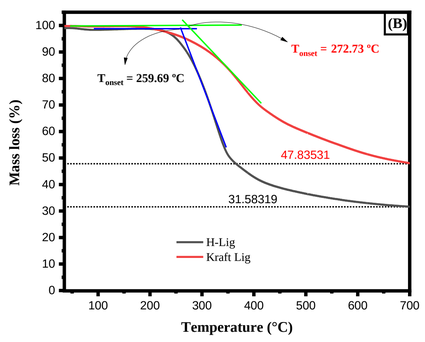
2-Investigate the performance of lignin-based adhesives in terms of bonding strength, water resistance, and formaldehyde emissions compared to traditional formaldehyde-based adhesives

3-Optimize the formulation and processing conditions of lignin-based adhesives to achieve properties comparable to or better than conventional adhesives used in the panel industry.

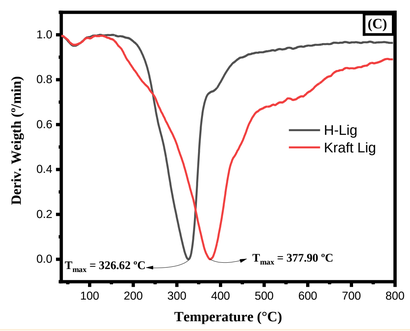
Results

1. Structural and thermal properties of lignins





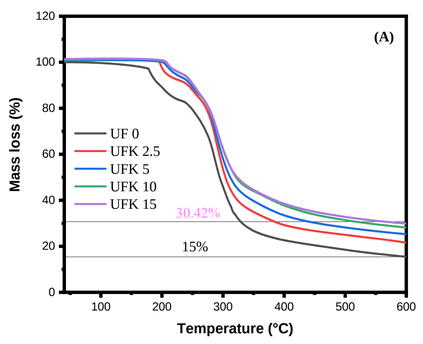
Lignin type	Kraft	Hydroxymethylated
SO_4^{2-}(µg/g)	15467	369
Total sugars (%)	1.54 – 1.59	27.56
Molecular weight (g/mol)	14200 – 15665	20,000 - 25,000
H:G:S	0:100:0	1:29:70

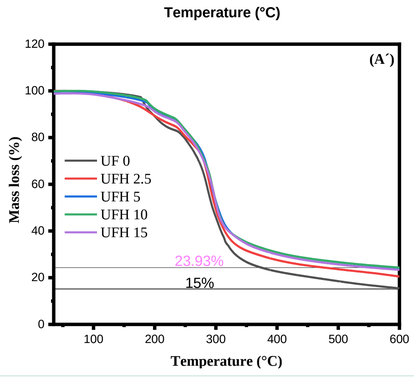


1. Physical properties of reinforced UF resins

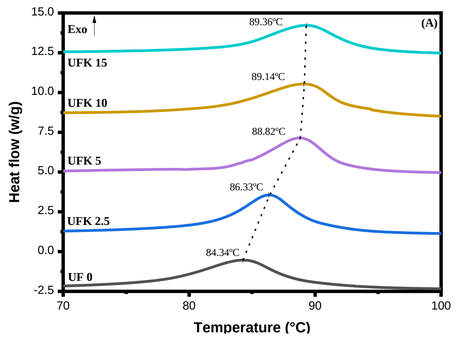
Formulations	Solid content (%)	Viscosity (Cp)	pH	Gel time (s)
UF-0	70.11	275	8.12	121 ± 13.4
UFK-2.5	70.37	423	8.43	145 ± 13,5
UFK-5	70.71	578	8.52	150 ± 11.3
UFK-10	70.04	624	8.15	165 ± 36.6
UFK-15	70.15	945	8.32	191 ± 42.4
UFH-2.5	69.8	**528**	8.31	115 ± 10
UFH-5	69.13	**1164**	8.27	105 ± 5.7
UFH-10	69.76	**1532**	8.18	120 ± 2.1
UFH-15	69.54	**4591**	8.14	127 ± 3.1

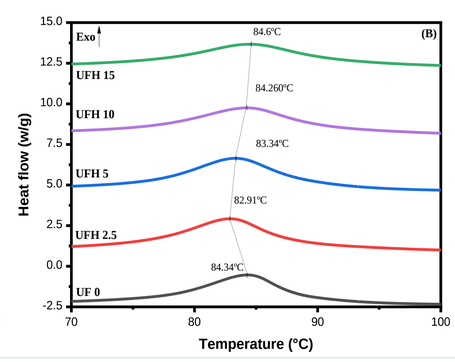
2. Thermal analysis of UF formulation



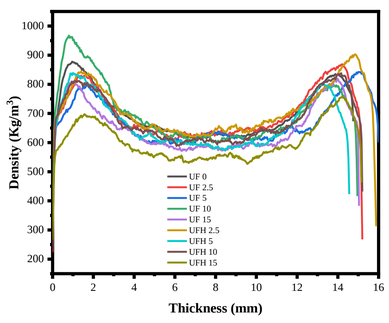


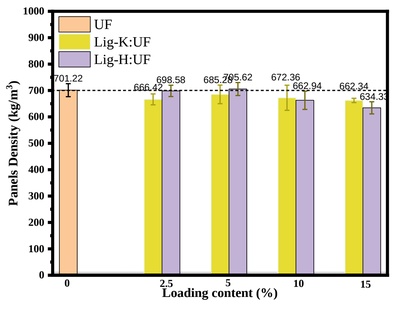
3. DSC analysis of UF formulation



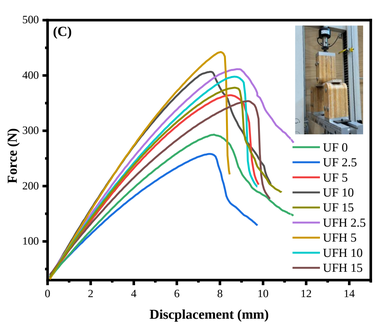


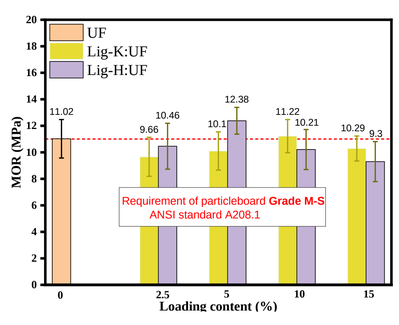
1. Density profile of elaborated particleboards

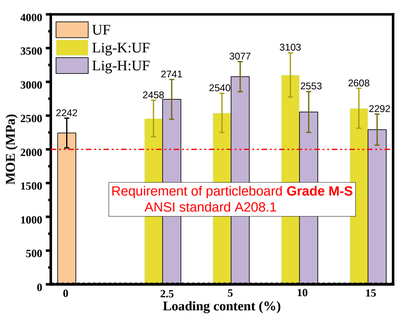


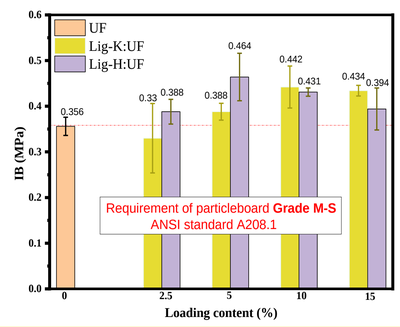


2. Bending properties of elaborated particleboards

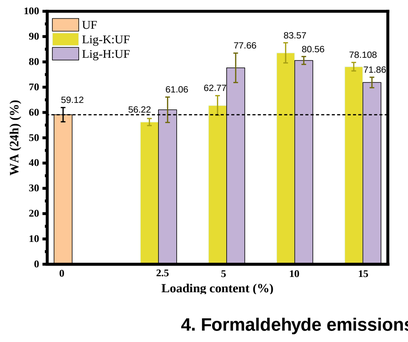


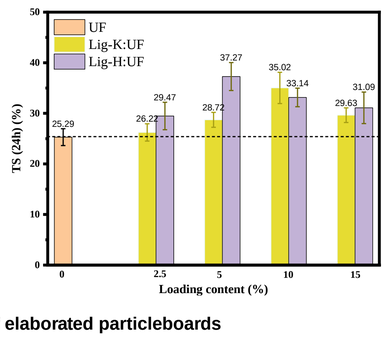




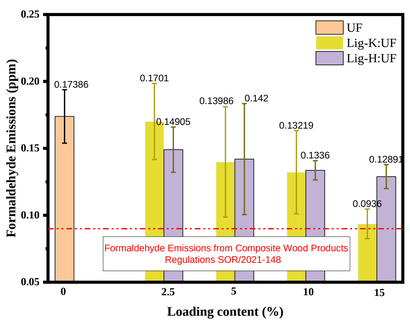


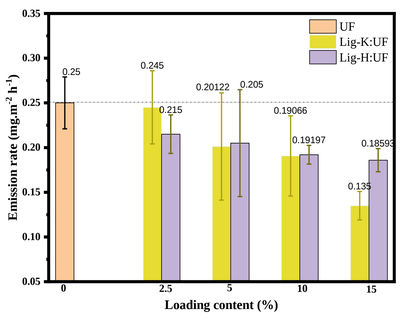
3. Physical properties of elaborated particleboards



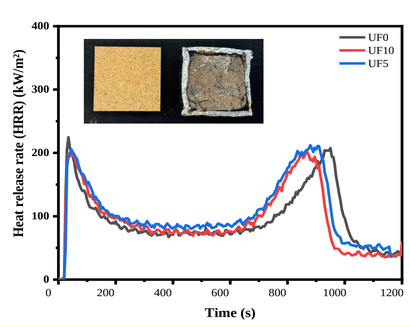


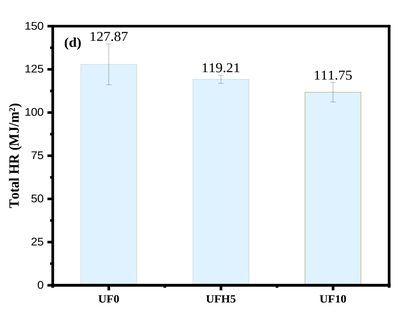
4. Formaldehyde emissions of elaborated particleboards





5. Fire retardant properties of elaborated particleboards





Conclusions

- All panels exhibited similar density profiles, but the bending properties indicated that the optimal formulations were those containing 10% kraft lignin and 5% H-lig, surpassing the requirements for particleboards Grade M-S according to ANSI Standard 208.1.
- However, poor physical properties were observed in all panels due to the introduction of lignin, which contains more hydroxyl groups. These groups increased the panels' affinity for water, resulting in higher water absorption.
- Formaldehyde emissions were significantly reduced with the partial replacement of UF resin, with a more pronounced reduction observed for kraft lignin due to the presence of sulfate groups, which act as scavengers for formaldehyde molecules.
- The optimal formulations containing kraft lignin exhibited lower low heat release rates during combustion compared to the reference panels. This behaviour is attributed to the improved thermal stability of UF resin in the presence of lignin and the sulfate groups, which function as fire-retardant agents.

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