Free Formaldehyde Adhesive Based on Lignin-Phenol-Glyoxal Resins for Wood Particleboards.

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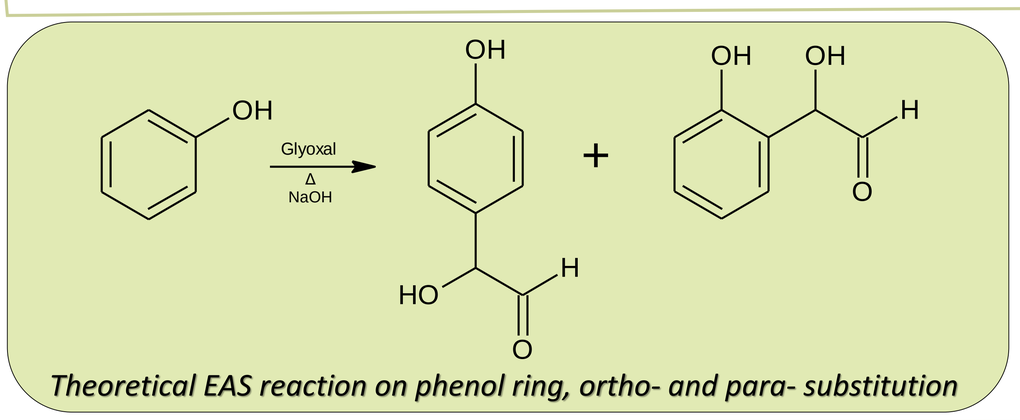
STATEMENT OF THE PROBLEM:

Phenol-Formaldehyde resins (PF) are typically used as highly cross-linked **wood adhesive** due to their performance; however, PF adhesives are generally synthetised from non-renewable petroleum derived raw materials **which include formaldehyde** (highly volatile and toxic compound classified as carcinogenic, mutagenic and reprotoxic). Due to the sustainability and health concerns, sustainable and **low toxicity resins** show a possibility to **replace the petroleum-derived** ones and one way to solve this challenge is the development of sustainable and low toxicity resins to replace oil-based ones is a challenge that could be met by the **use of less volatile and toxic alternative raw materials** could be an alternative resource to replace as much as possible the non-renewable components to achieve more sustainable resins without toxic emissions. The purpose of this study is to develop and analyse alternative adhesives to PF resins through **lignin glyoxilation** by Electrophilic Aromatic Substitution **(EAS)** reactions.



Theoretical EAS reaction on phenol ring, ortho- and para- substitution

METHODOLOGY and MATERIALS (I):

Synthesis of adhesives

To carry out the synthesis of the adhesives, through **EAS reactions** of **phenol** (CAS 108-95-2), which was used as phenolic compound well-known which **was partly replaced by Lignin** (CAS 8068-05-1) of hydroxylated compounds. **Glyoxal** (40 wt %, CAS 107-22-2) was used as an electrophilic agent (and as a **formaldehyde alternative**) and the catalyst used was sodium hydroxide. Different amount of lignin (0-30% wt), and time reactions were tested.

METHODOLOGY and MATERIALS (II):

Characterization of adhesives

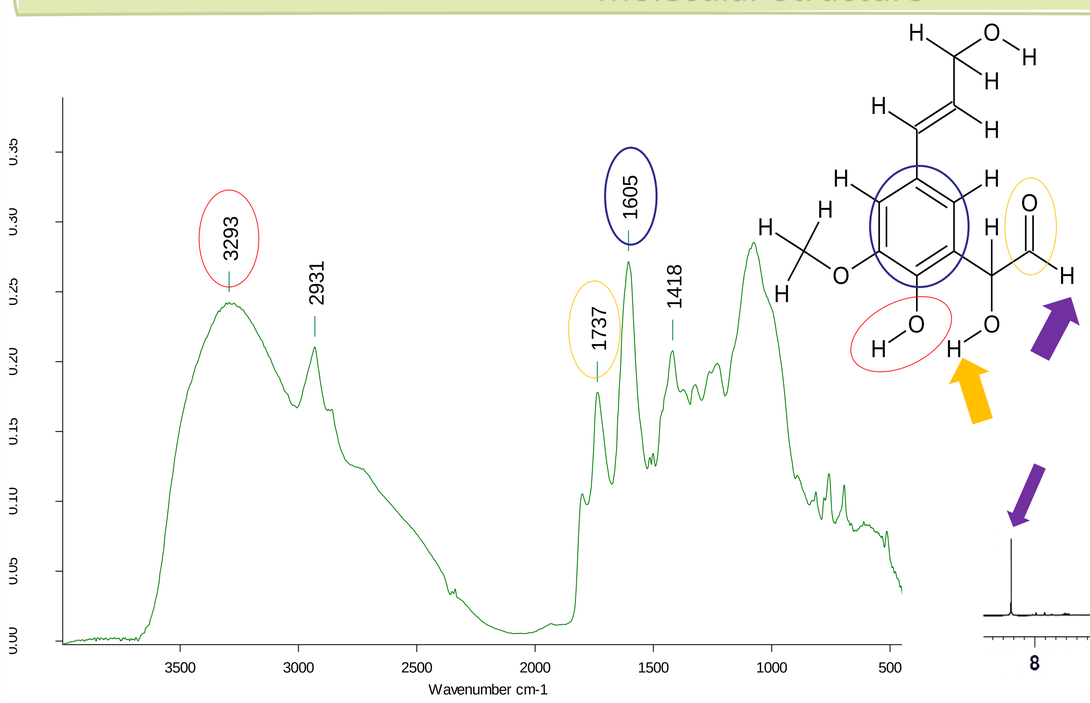
Each adhesive obtained was analysed and studied. **Molecular structure** was characterized by Fourier-Transform Infrared Spectroscopy (**FTIR**), proton and carbon Nuclear Magnetic Resonance (**^{1}H-NMR and ^{13}C-NMR**).

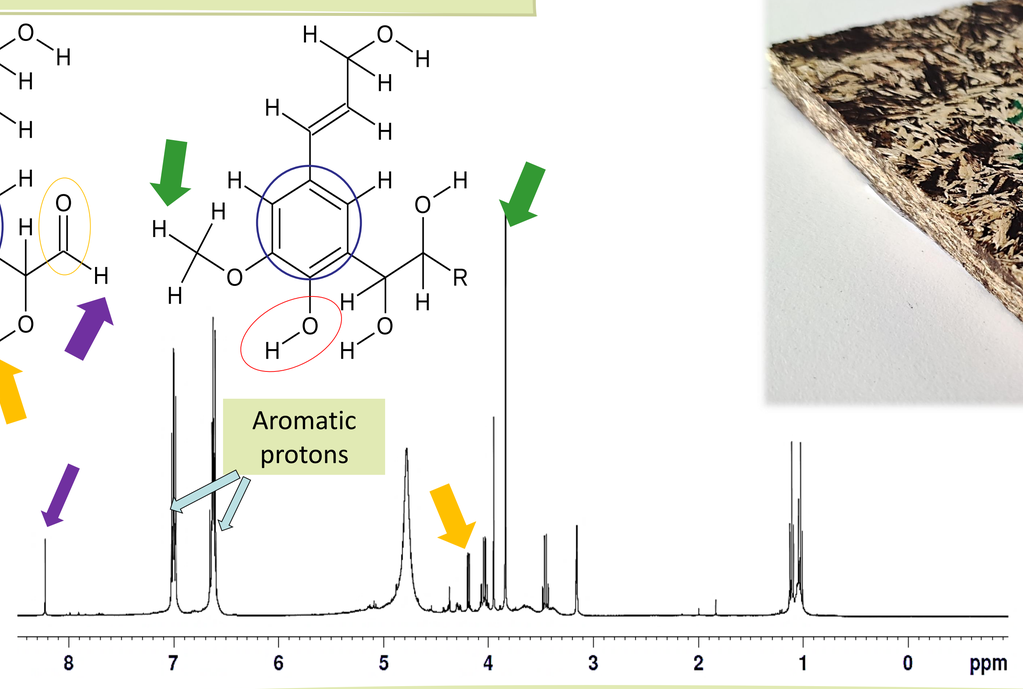
Physical and chemical properties were determined through Thermogravimetric analysis (**TGA,** Q500, N_2, 950ºC, 10ºC/min) and Differential Scan Calorimetry (**DSC,** Q200, 250ºC, 5ºC/min), Brookfield Viscosity (S4) and Solids Content.

Additional properties of the adhesives were evaluated too on small particleboard's specimens as binder capacity as teste by cut resistance, biodegradation ability (*Phanerochaete chrysosporium* ***(PHC)****, Penicillium chrysogenum (****PEC****) and Pseudomonas chlororaphis (****PC****)) and formaldehyde emissions (*UNE EN-ISO 12460-5)

RESULTS

Molecular Structure

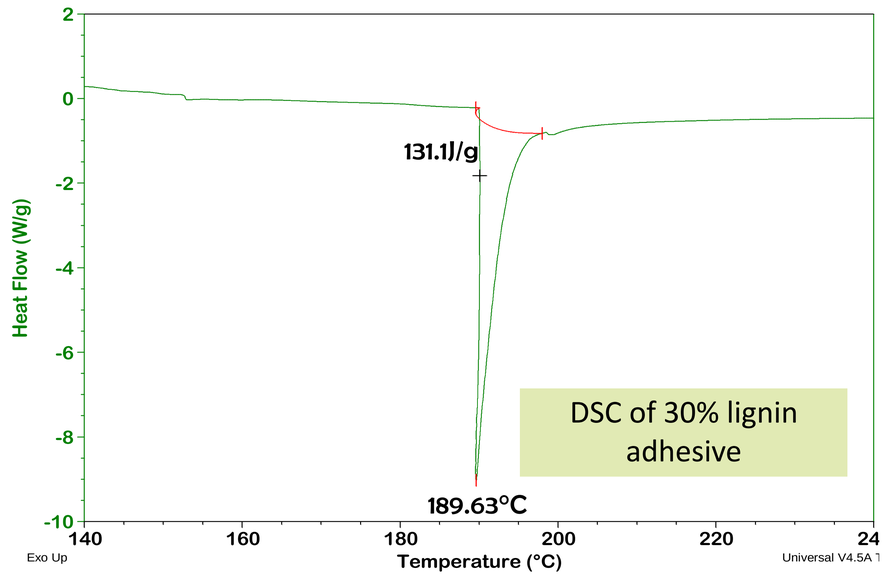





Particleboards specimens

Physical and chemical

Lignin loaded	Curing Temp (DSC)	T descomp (TGA)	Brookfield Viscosity (23ºC)	Formaldehyde emissions	Biodegradation (30 days)
20%	~175ºC	>250ºC	100mPa	Cut step not passed	
30%	~190ºC	>250ºC	166 mPa·s	1,3 mg/100g	37% by PHC



DSC of 30% lignin adhesive

CONCLUSIONS

Lignin-Phenol-Glyoxal adhesives were well-synthesized with **a 30% lignin content** thought **16h reaction**. These adhesives show **no formaldehyde emissions** associated and a potential **biodegradability at 37%** at controlled stage was identified. The alternative PF resins show a chance to use a renewable resource to develop new adhesive resins for wood panels avoiding formaldehyde use and, therefore, its derived emissions.

ACKNOWLEDGMENTS:

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