

Lignin as a bio-based flame retardant additive: Pretreatments overview

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Context

- Lignin is a cross-linked phenol polymers from plant cells wall (Fig. 1).
- It's the third most abundant organic material after cellulose and hemicelluloses.
- Lignin was studied as a flame retardant for various polymers and represents an interesting opportunity to create more eco-friendly and safer plastics and resins.

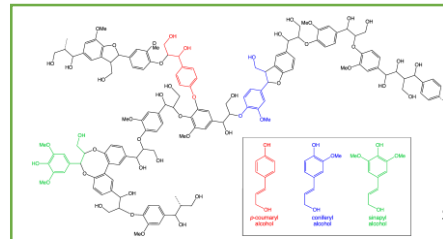


Fig. 1
Lignin
structure

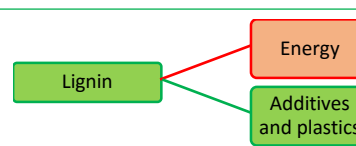
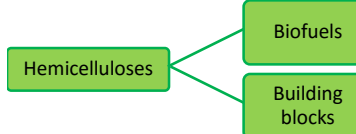
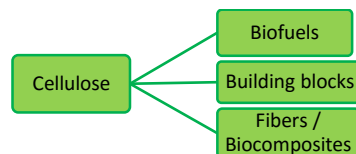
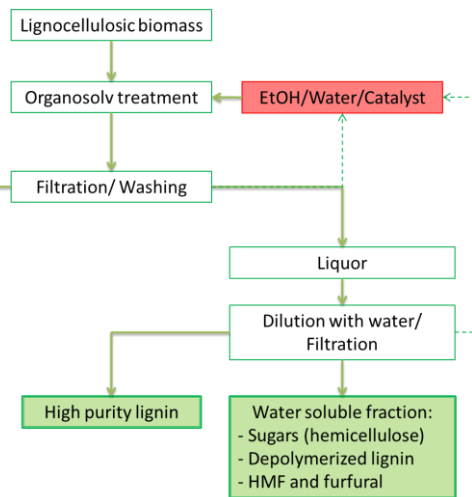
Lignin in flame retardant formulations:

- Chemically modified or not (e.g. phosphorylated)
- Tested in epoxy compounds¹, PLA², PP³, ABS⁴ and polyurethane foam⁵.
- Improvements:
 - Peak of heat release ↓ (30% for phosphorylated lignin 20% in ABS)^{2, 4}
 - Mechanical properties of foam ↑²
 - Level of char residue ↑^{3, 5}
 - Limiting Oxygen Index ↑²
 - Combustion time ↑³

Pretreatment technologies:

- Chemical treatments:
 - Acidic
 - Alkaline
 - Organosolv pretreatments (Fig.2)
 - Ionic liquids...
- Physicochemical treatments:
 - Ammonia fiber explosion
 - Steam explosion
 - Wet oxidation...
- Physical treatments
- Biological treatments

Fig. 2
Organosolv
pretreatment



Valorization of lignin: autonomous or integrated strategies?

- Autonomous biorefinery: separation and valorization of each biomass component from vegetal waste in a dedicated plant.
- Integrated biorefinery: valorization of byproducts from a preexisting process (e.g. lignin from Kraft process in the pulp and paper industry).

Conclusion:

Several technologies can extract lignin with high yields (Organosolv, Kraft,...) and different qualities.

This material is produced in large quantity and is often considered as a byproduct.

Higher value applications like flame retardants are consequently promising valorization ways.

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- Fig.1: <https://upload.wikimedia.org/wikipedia/commons/c/c0/Lignin.png>