Lignocellulosic biomass fractionation with deep eutectic solvents: a tunable step towards lignin applications

2eme journée scientifique et technique de l'IPHC
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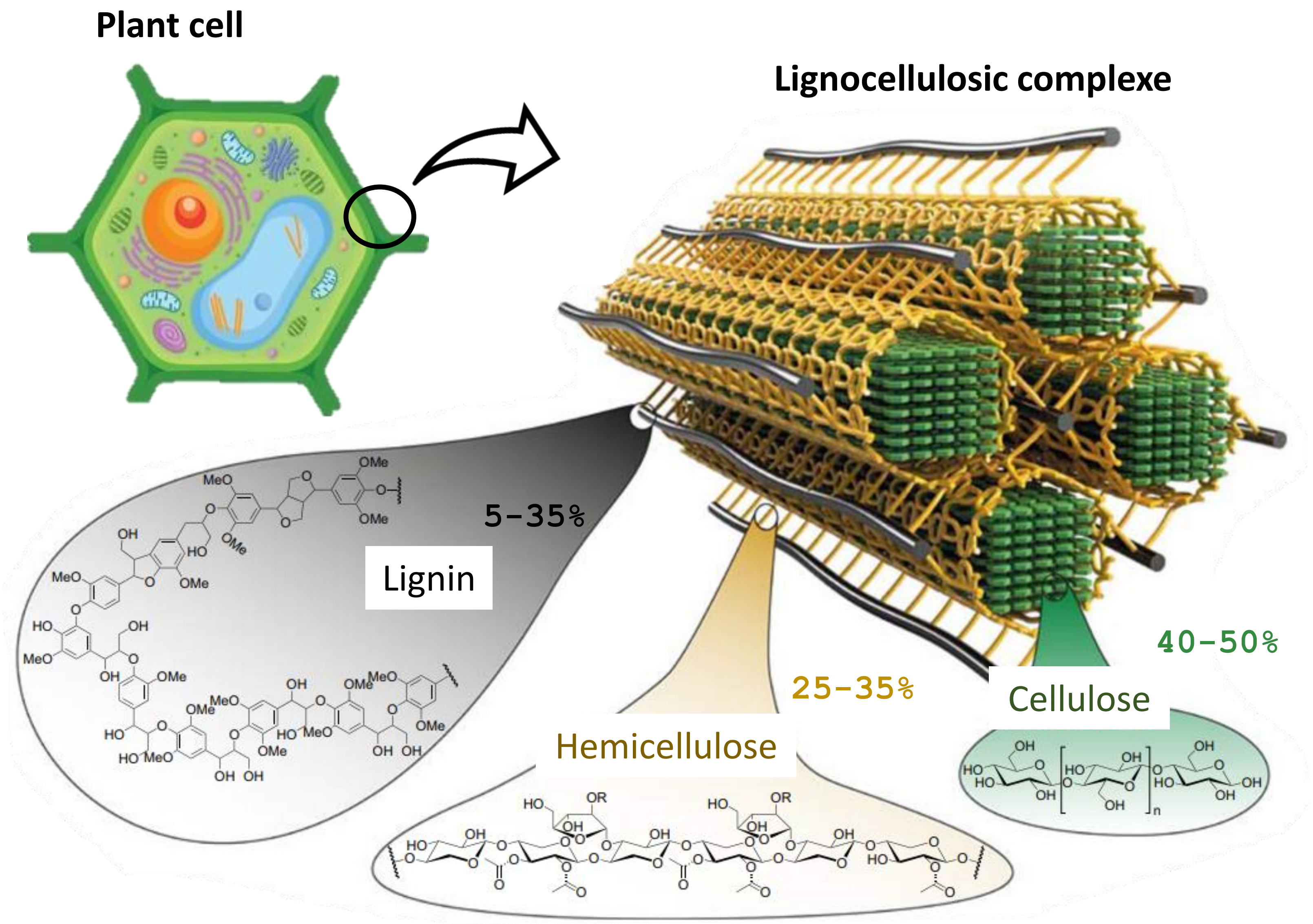
➢ Lignocellulosic biomass

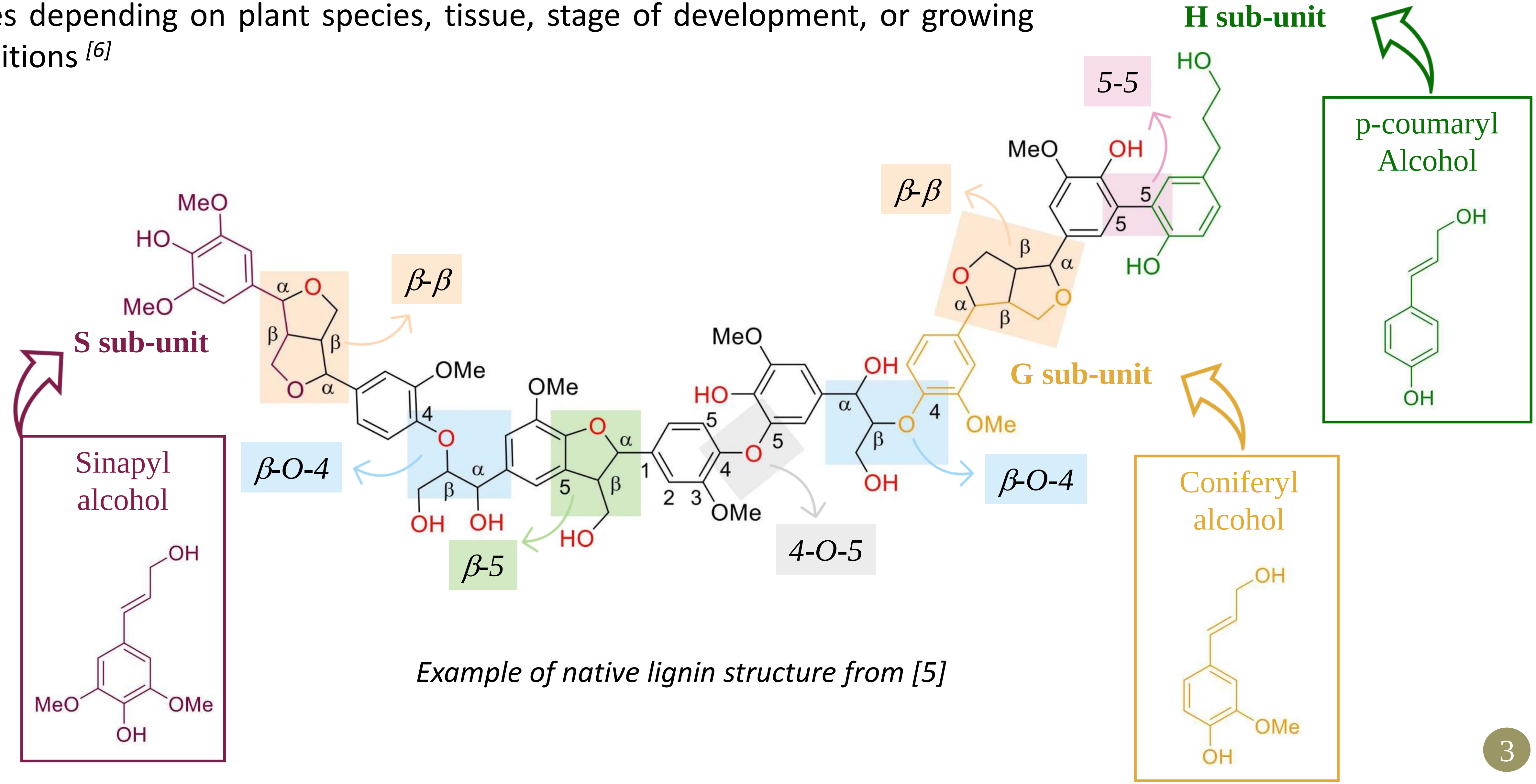
- 300 billion tons of lignin in the biosphere [2]
- The most abundant natural source of aromatic molecules on Earth [3]
- Major by-product of the paper, sugar, and biofuel industries [4]



Main biopolymers from plant cell wall [1]

➢ Lignin structure

Varies depending on plant species, tissue, stage of development, or growing conditions [6]

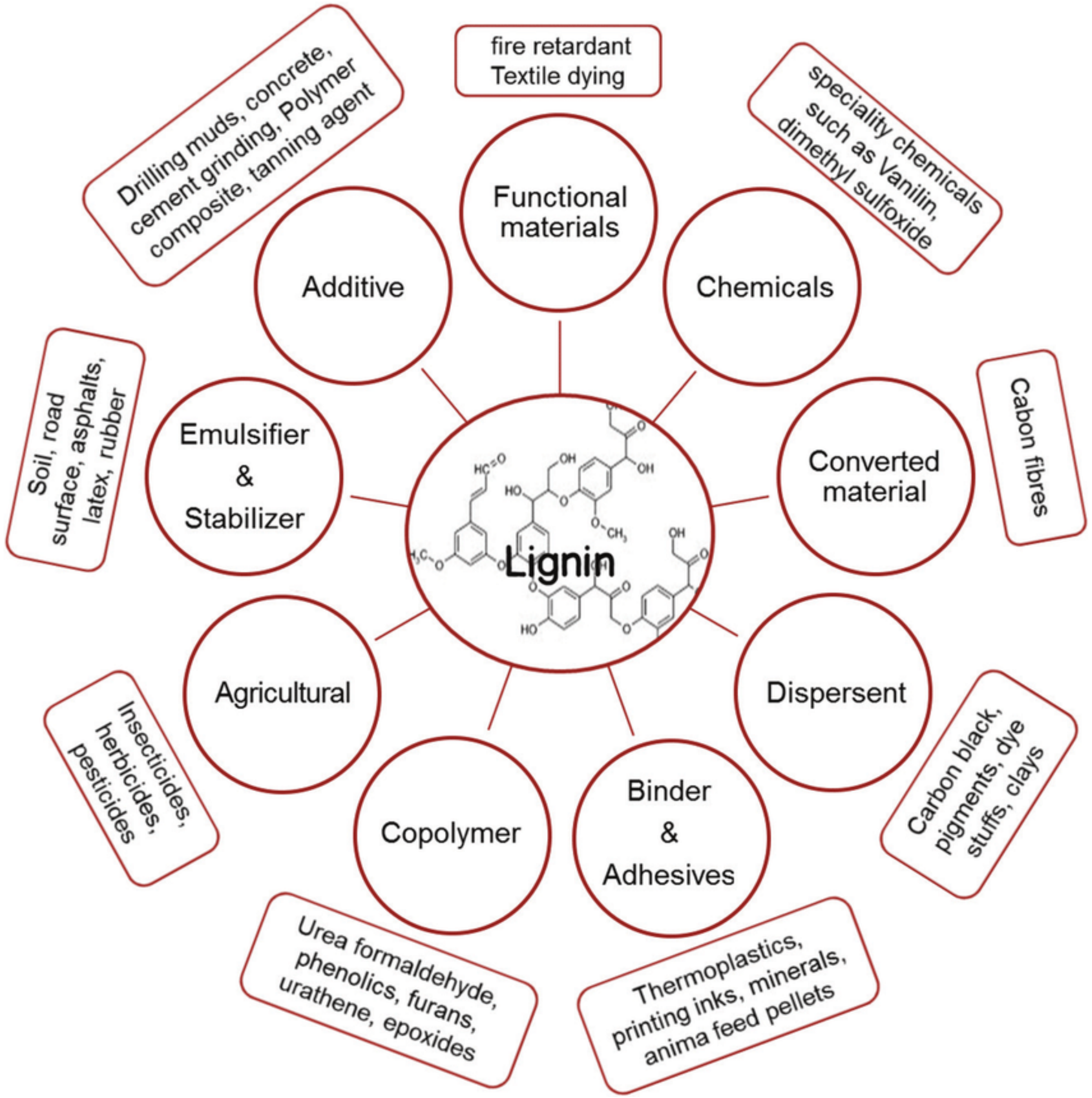


Example of native lignin structure from [5]

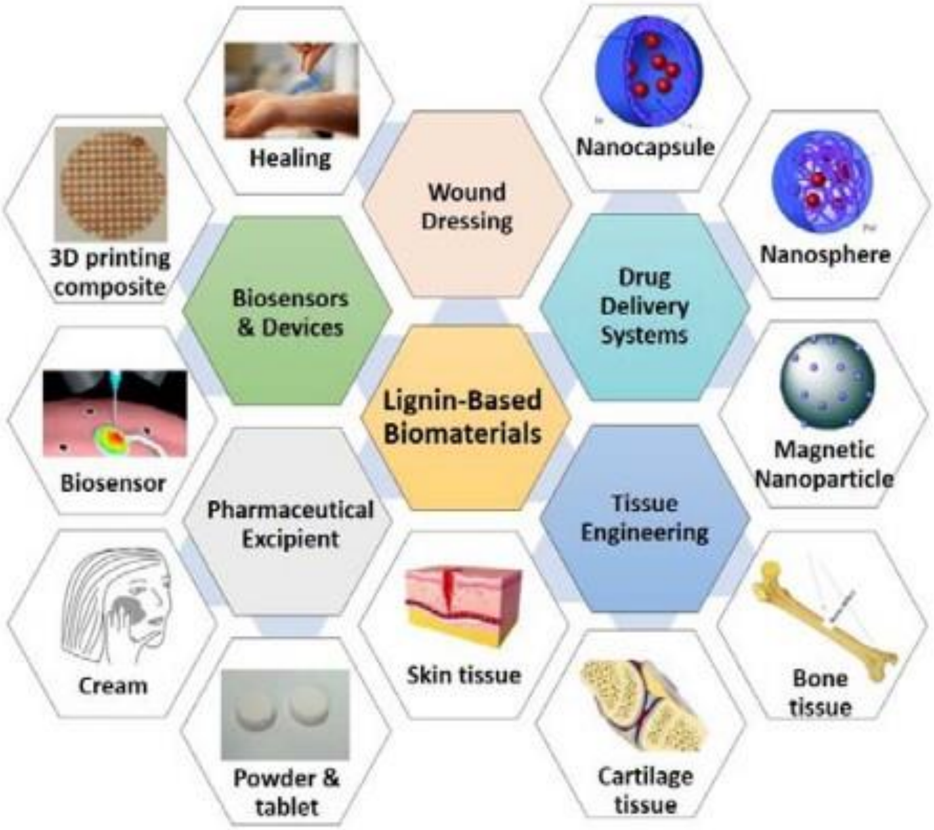
➢ Why lignin is so interesting?

Can be used:

- as macromomecule
- after depolymerization
- as lignin nanoparticles (LNPs)



Lignin current and potential global applications [7]



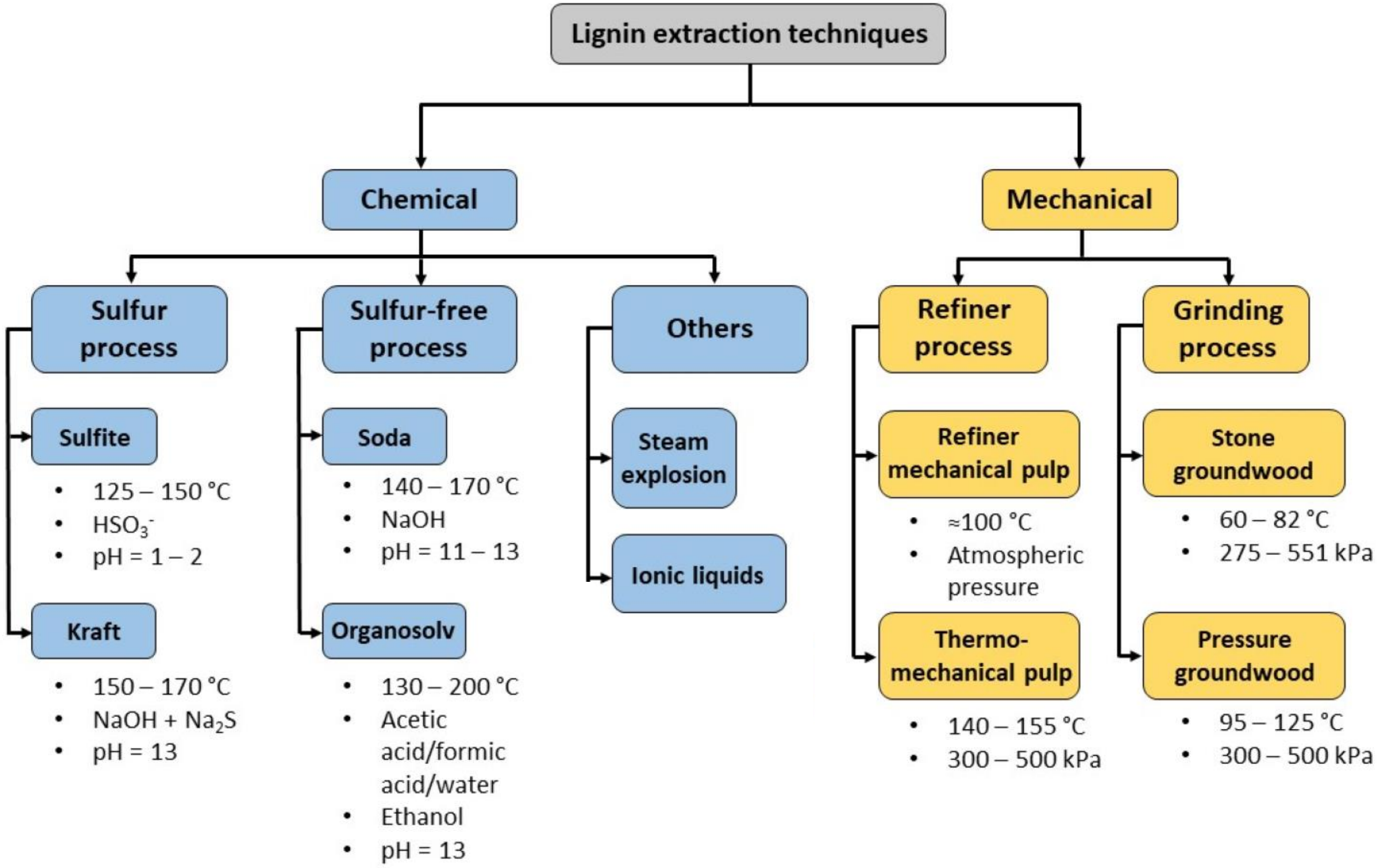
Lignin current and potential medical applications [8]

➢ Lignin extraction in Cellulose 1st biorefineries

Concept focuses on cellulose recovery of high purity

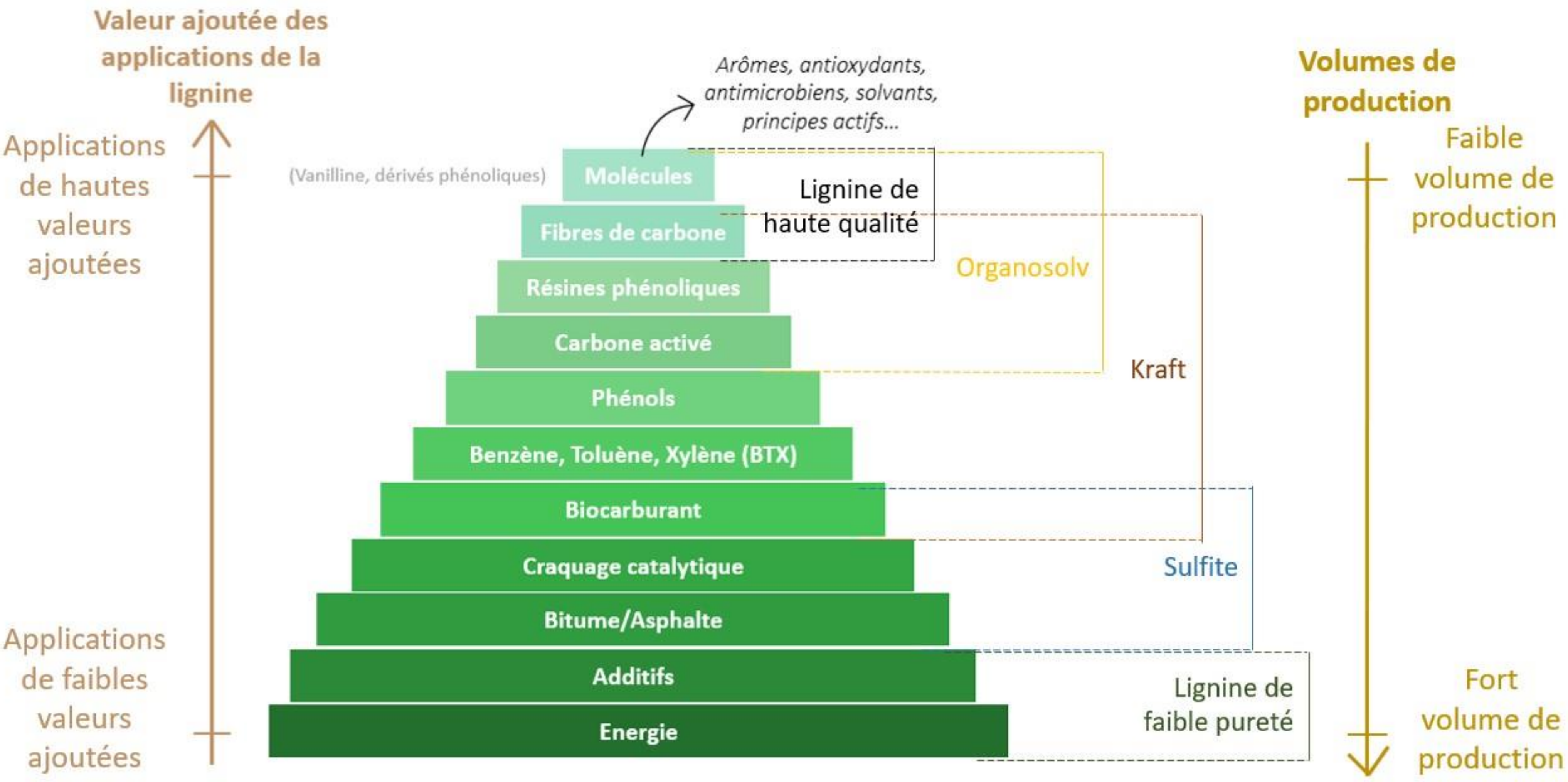
<u>Drawbacks</u>

- Harm for the environment
- Concentrated acid process is corrosive
- Large amount of water is needed for washing (Alkali NaOH)
- Solvents recycling complexity
- High cost of chemicals and toxicity of some ionic liquids
- High energy demands for combined methods
- Lignin of low quality



From [9] and [10]

➢ Relationship between lignin added value and fractionation process



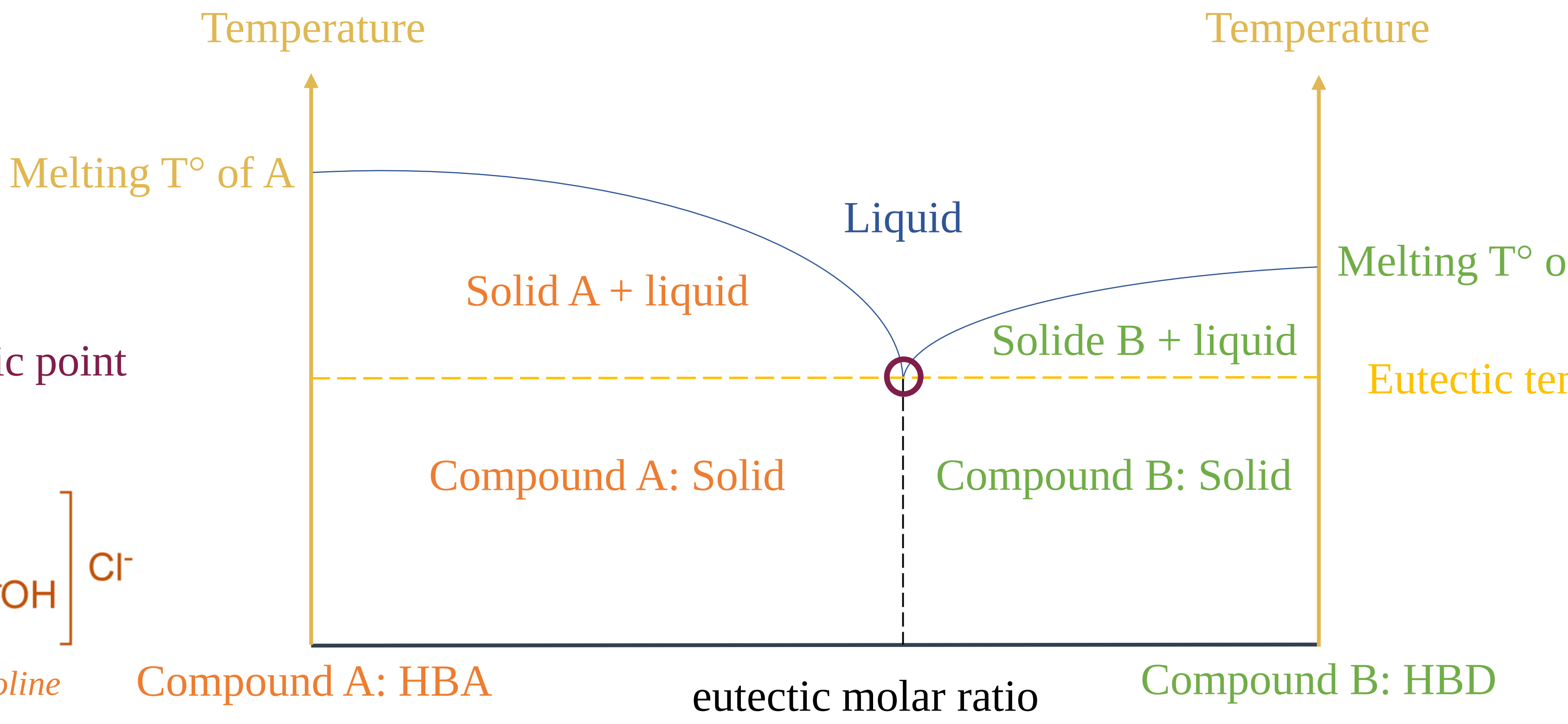
Industrial valorisation of lignin and relation with fractionation process from [11]

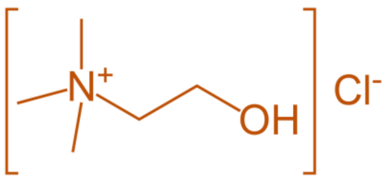
➢ Deep eutectic solvents (DES)

DES = Mix at a specific molar ratio of a least 1 Hydrogen bond acceptor (HBA) + 1 Hydrogen bond donor (HBD)

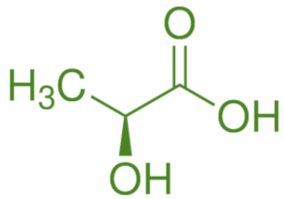
- Easy to prepare
- Biodegradable
- Non-toxic
- Mild conditions
- Sustainable
- Low cost

○ Eutectic point





Example: choline chloride

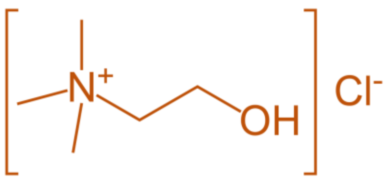


Example: L-(+)-lactic acid

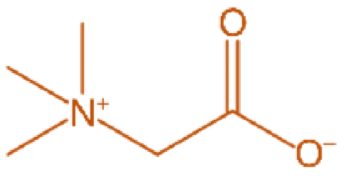
Phase diagram of a eutectic mixture from [12]

➢ Examples of DES composition

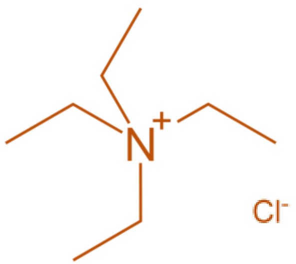
Hydrogen bond acceptor



Choline chloride (B4 vitamin, pet food)

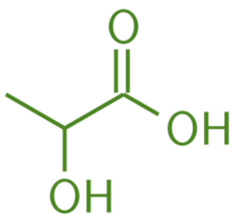


Betaine (beetroot pigment essential for liver function)

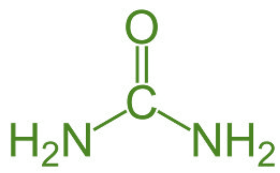


Tetraethylammonium chloride

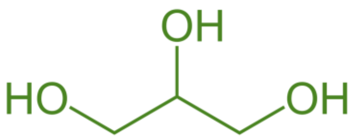
Hydrogen bond donor



Lactic acid (organic compound necessary for carbohydrate metabolism))

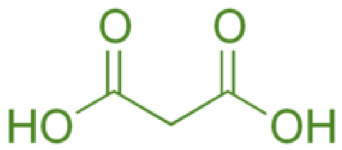


Urea (molecule resulting from the breakdown of proteins)

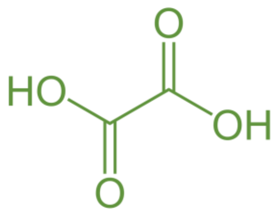


Glycerol (molecule naturally present in all oils and fats)

Ethylene glycol (mainly used in the manufacture of antifreeze and polyester fibers)



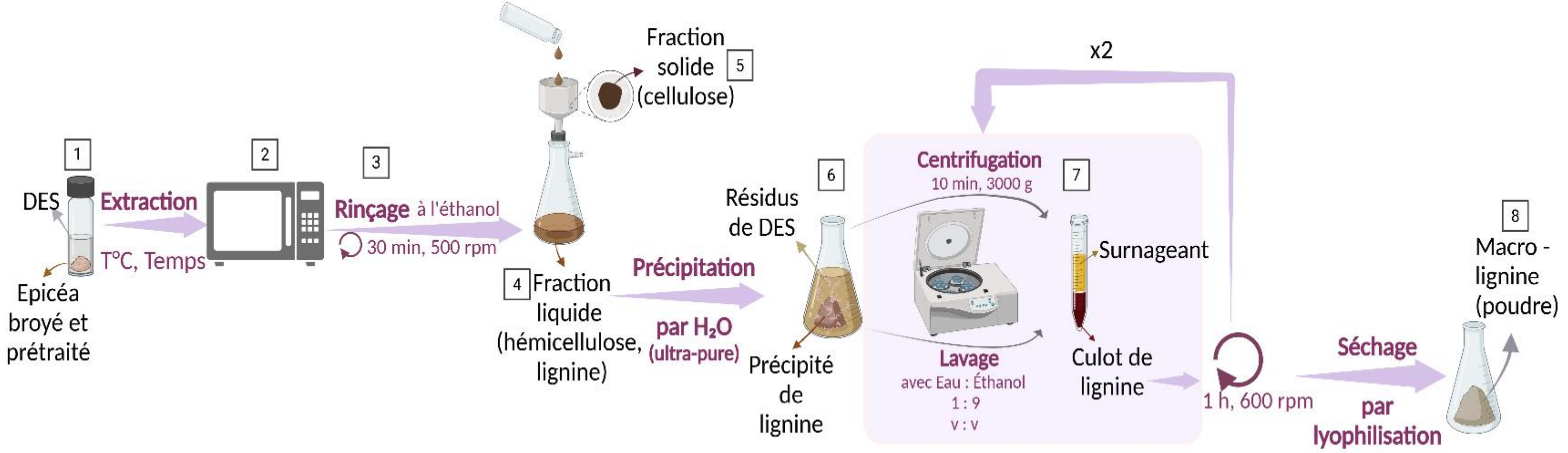
Malonic acid (a cellular poison found after oxidation of apple juice)

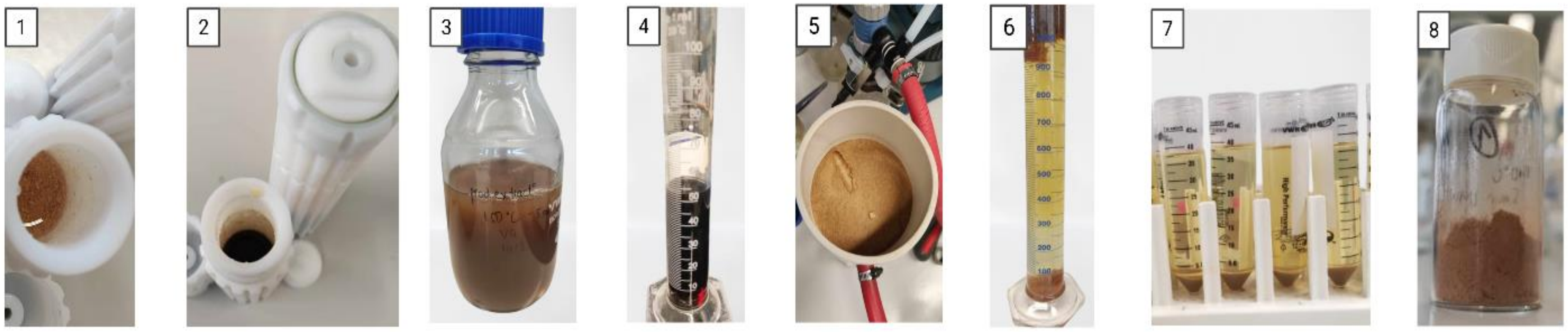


Oxalic acid (bleaching agent)

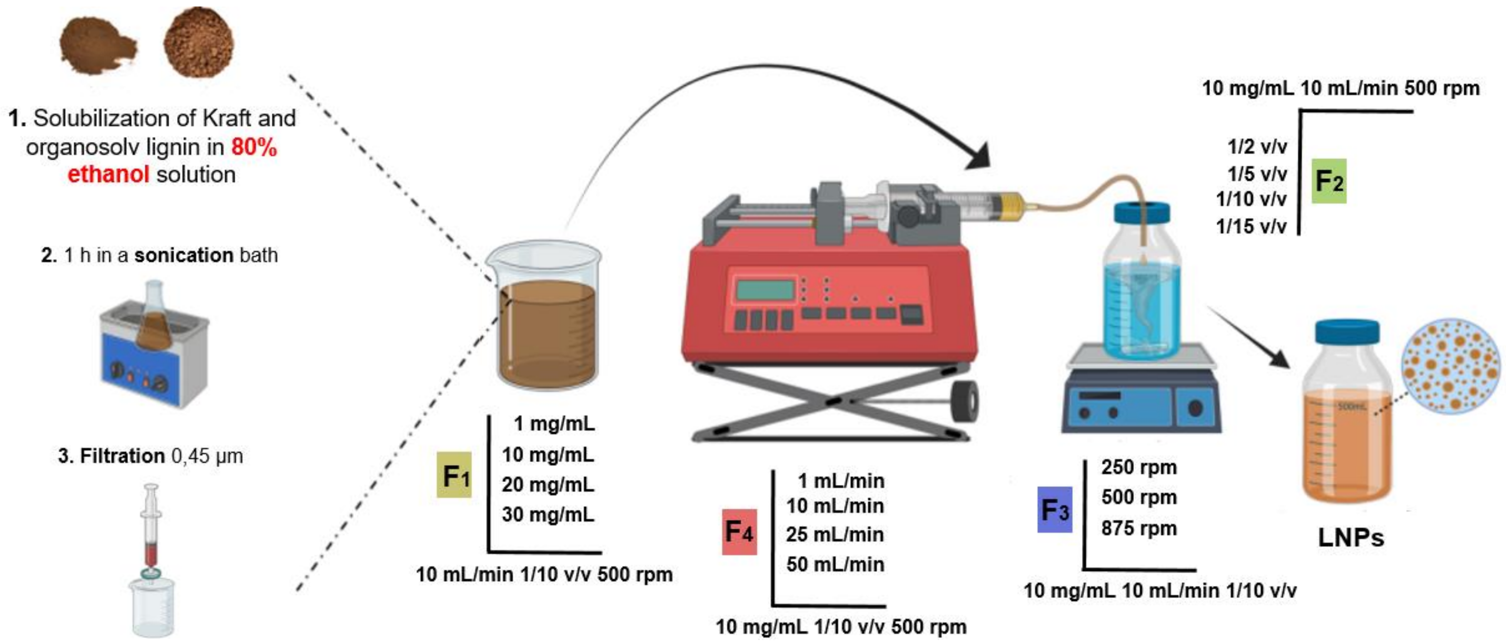
DES examples from [13]

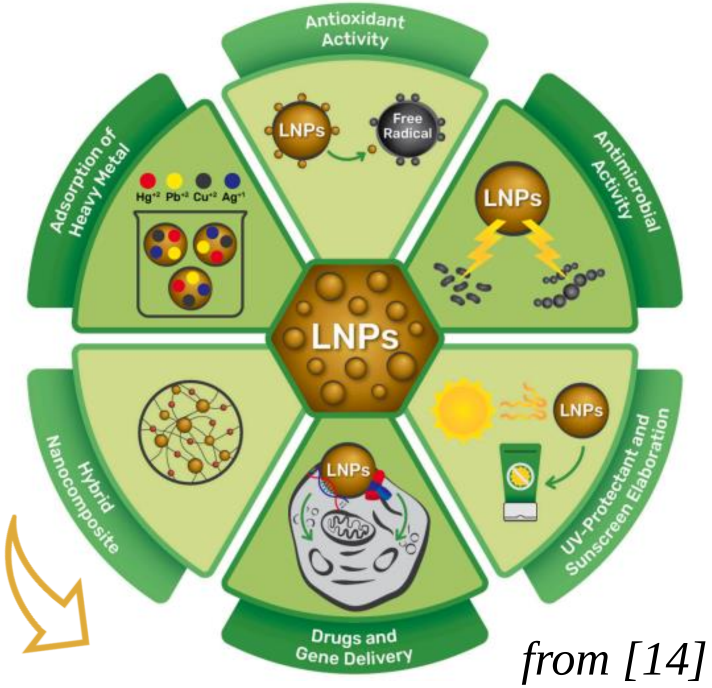
➢ Lignin fractionation process





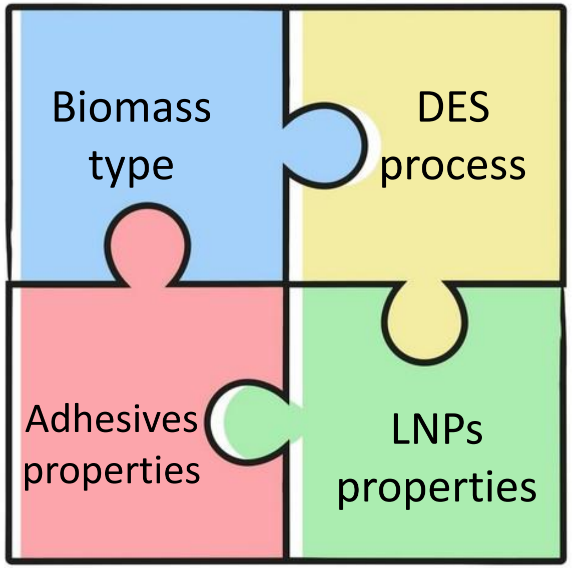
➢ Lignin nanoparticles (LNPs) production and applications





from [14]

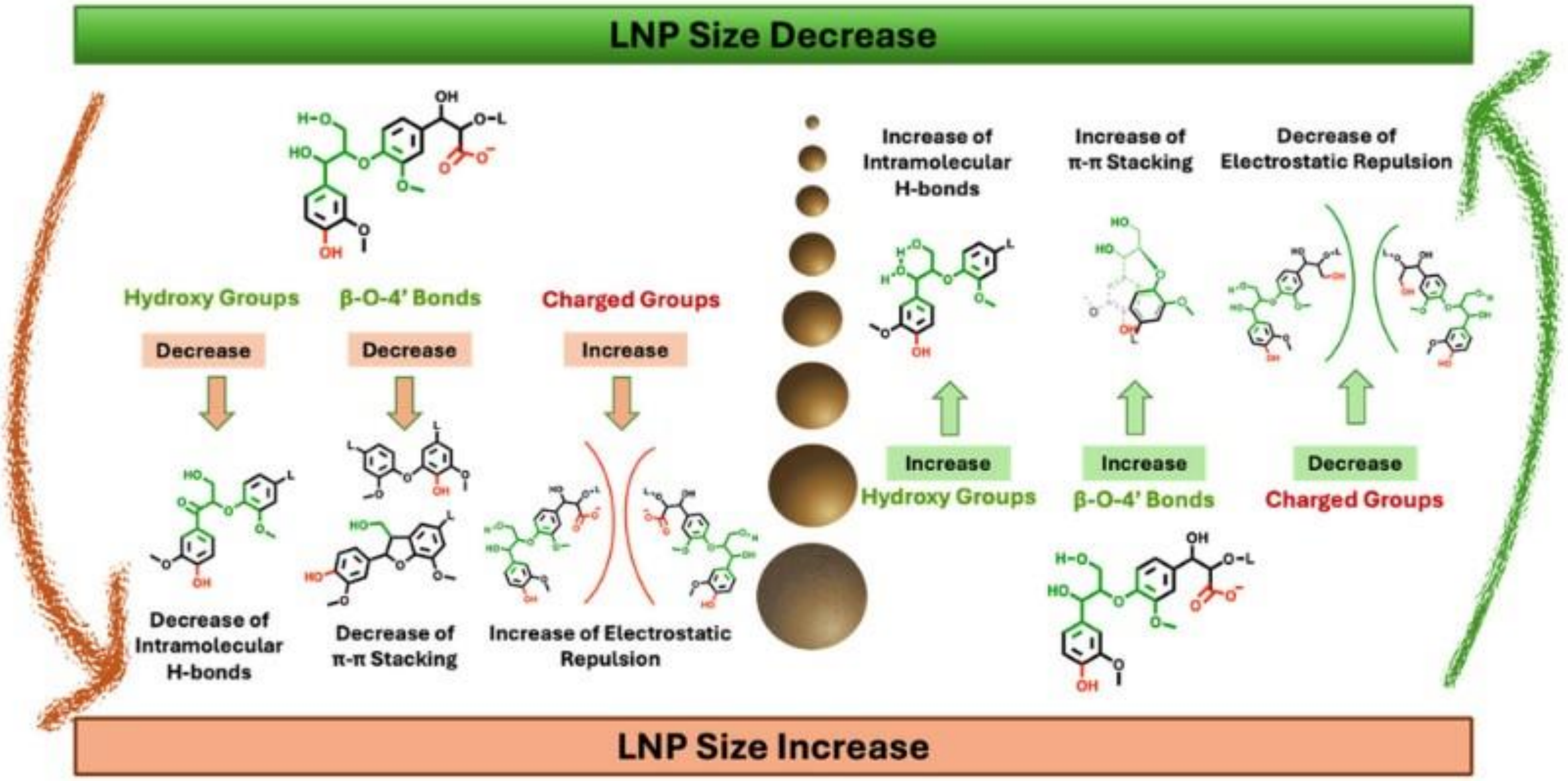
Adhesive for construction sector



Main objectives of
Iliass Kadmiri's PhD thesis

➢ LNPs properties: What are we looking for?

- Good Lignin fractionation yield
- High Lignin purity
- High Hydroxy groups content
- High B-O-4' Bonds



Parameters affecting LNPs size from [15]

➢ Example of ^{31}P NMR results

- Good Lignin fractionation yield
- High Lignin purity
- High Hydroxy groups content
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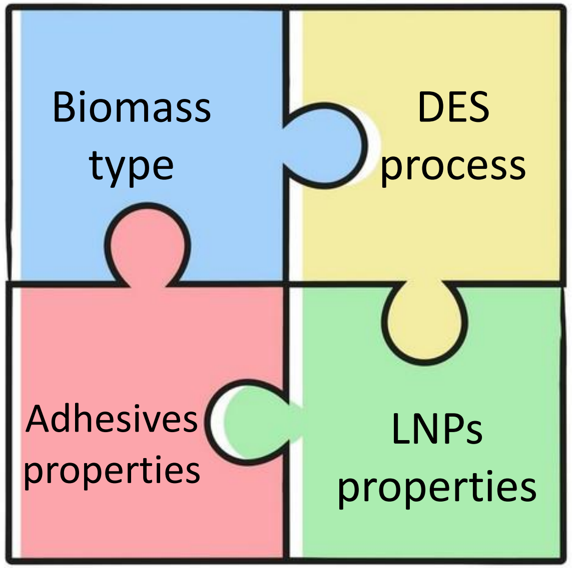
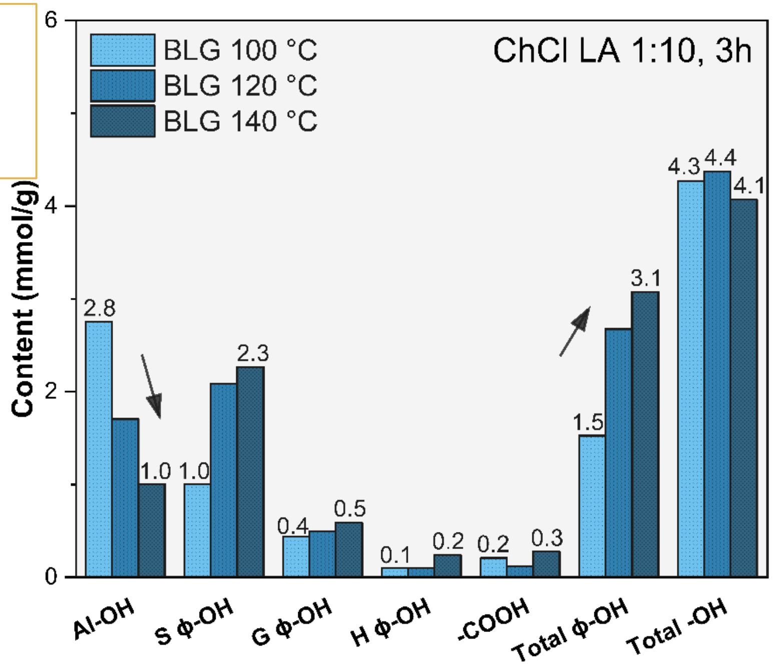
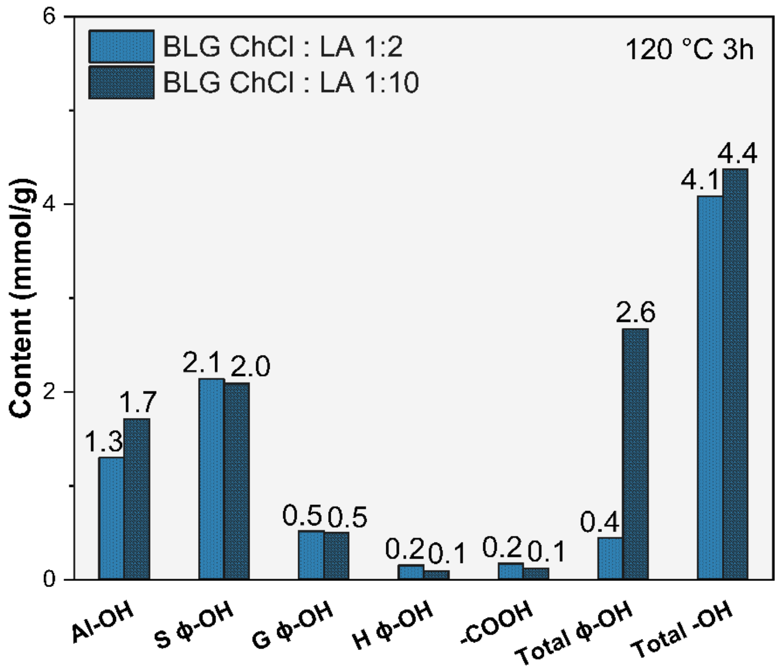
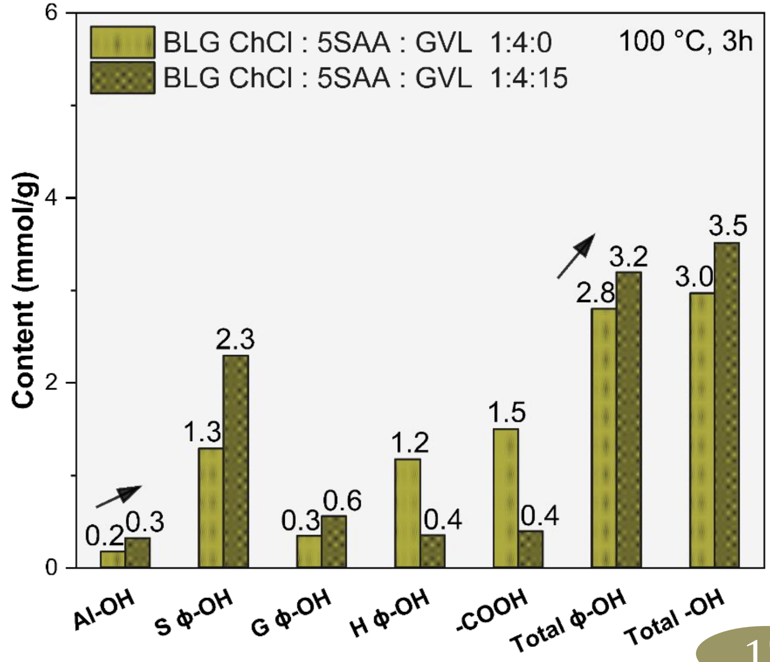






- Inverted correlation of aliphatic and phenolic groups with increasing temperature.
- Harsh conditions increase the yield but also the phenolic content of the lignin



Production of tailored DES (composition, process parameters) depending on application

Thanks for your attention

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