



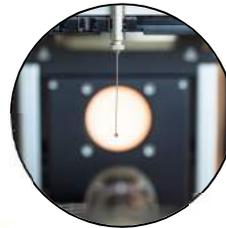
Base-catalyzed depolymerized lignin for wood adhesives

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Higher value from lignin

RESINS (PF, PU, epoxy)

- Adhesives
- Coatings
- Composite materials
- ...



SURFACE ACTIVE AGENTS

- Concrete and gypsum plastizers
- Dispersants
- Binders

CARBONISED MATERIALS

- Carbon fibers
- Carbon black
- Activated carbon



LIGNIN

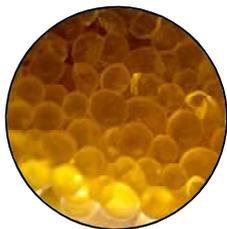
- Kraft
- Soda
- Sulphonates
- Organosolv
- ...

FUELS & CHEMICALS



THERMOPLASTIC MATERIALS

- Composites
- Hot melt adhesives



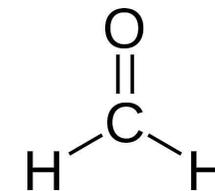
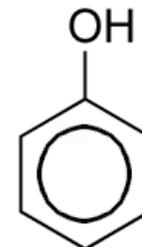
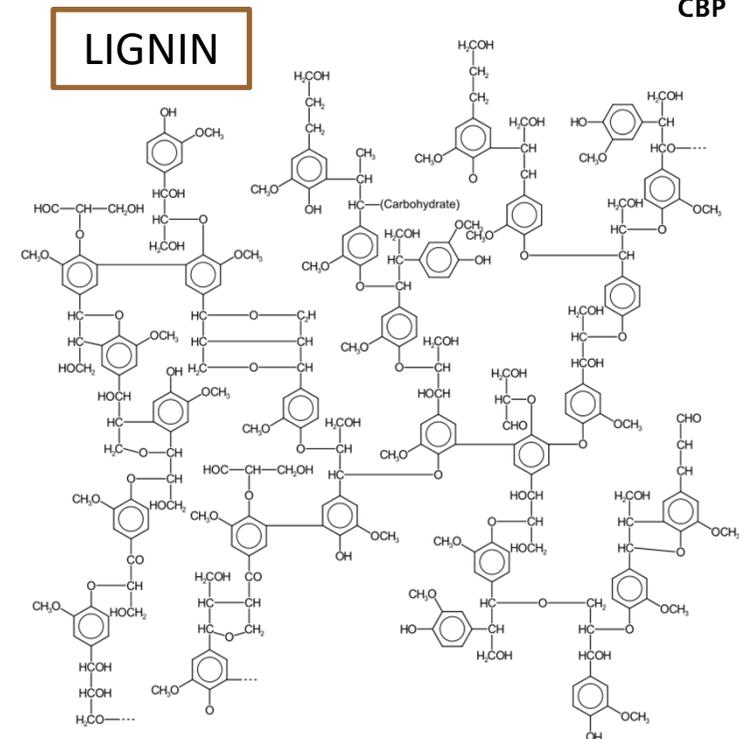
RUBBER PRODUCTS

- Reinforcement fillers
- Antioxidants
- Softeners
- Fire retardants



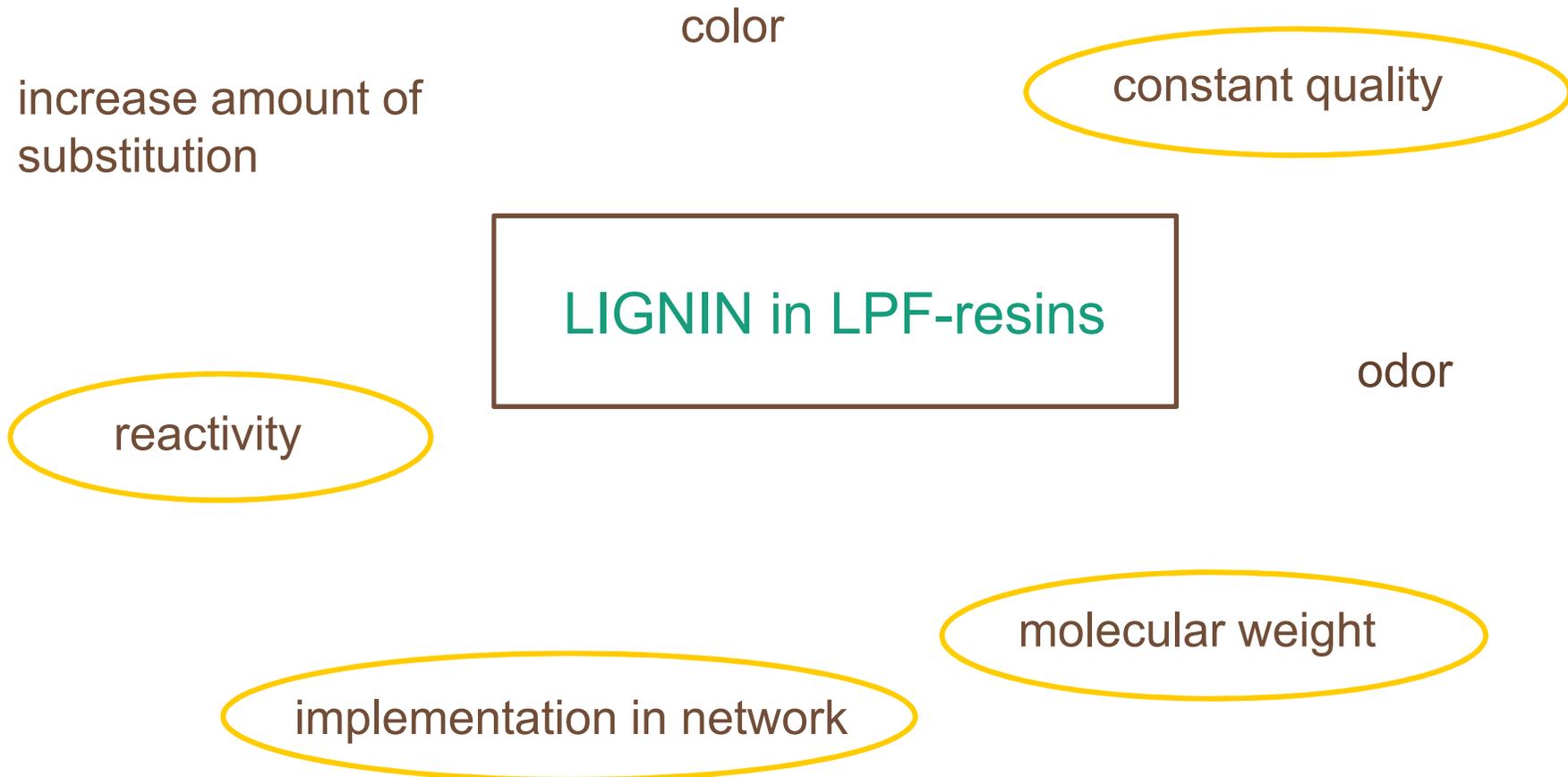
Lignin-based PF-resins

- Use of lignin in PF-resins started in 40's
 - phenol: fossil-based raw material
 - phenol (1000-1500€/t) *estimated*
 - tech. lignin (600-800€/t)
 - lignin: renewable resource (P&P industry)
 - bio based polymer with aromatic units
 - similarity to phenol
- State of technology:
 - substitutions of 40% phenol

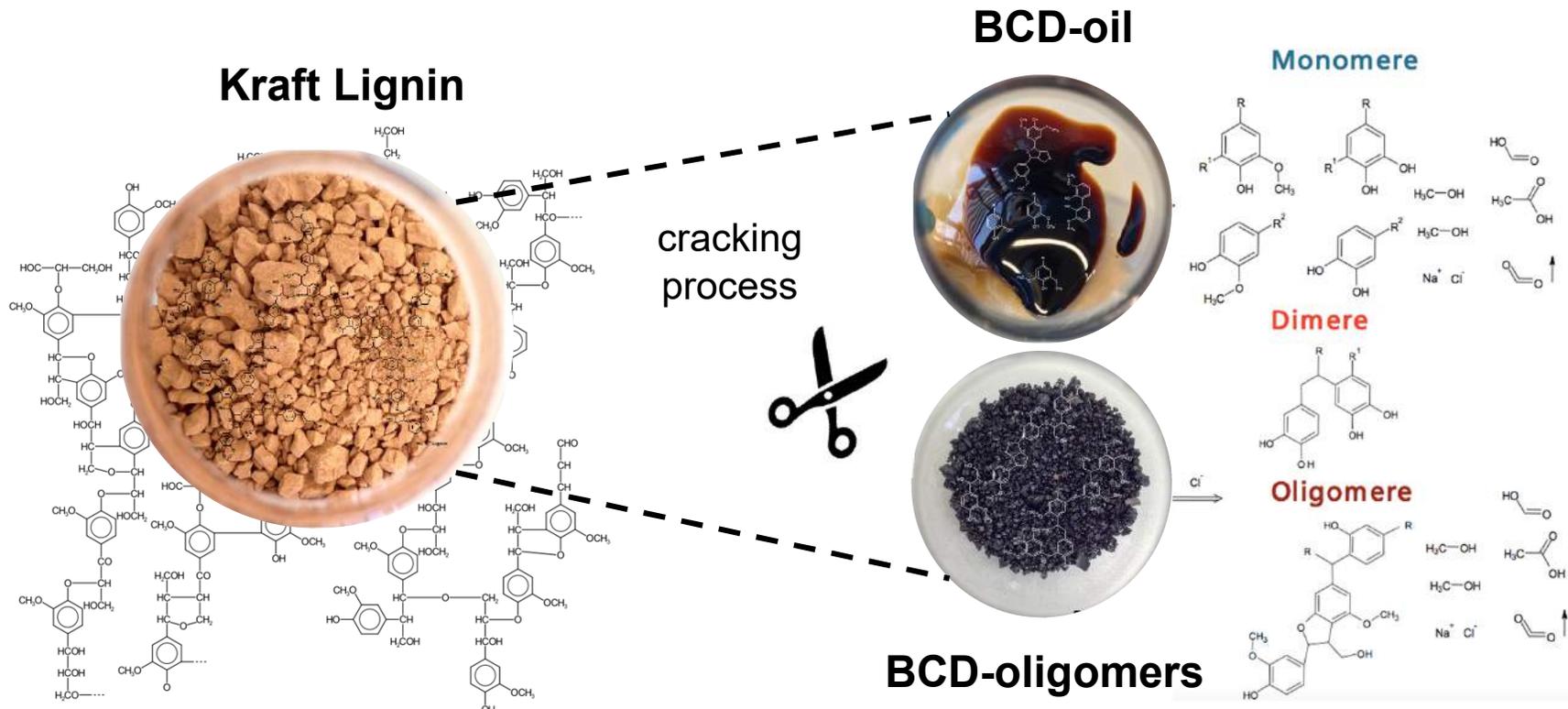


FORMALDEHYDE

Challenges of using lignin



Base-catalyzed depolymerisation



- Process parameters: **250 - 340°C**, 250 bar, **5 - 15 min**, pH 12 -14, ≤ 5 wt% **alkaline sodium hydroxide solution**, ≤ 10 wt% lignin

Lignin properties

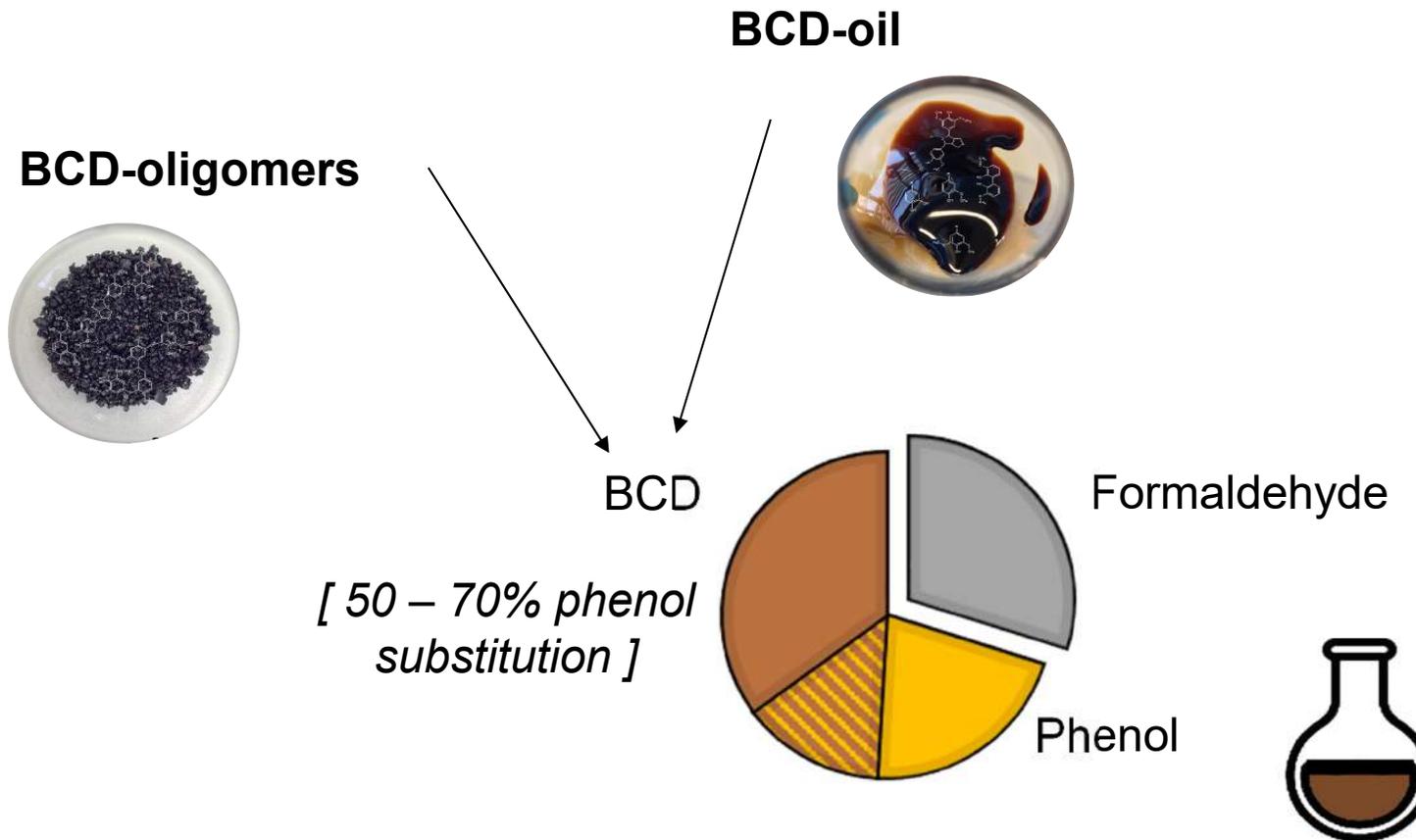
Lignin Type	Yield (%)	Ash Content (%)	Mn (g/mol)	Mw (g/mol)	PD	Texture
Kraft lignin		1.3	1350	9850	7.3	Powder
BCD olig.	40	0.2	750	2250	3.0	Powder
BCD oil	15	0.02	150	300	2.0	Liquid

- Homogenous / smaller lignin fractions
- More similar to phenol
- Better distribution of all components
- Higher network density in LPF-resin



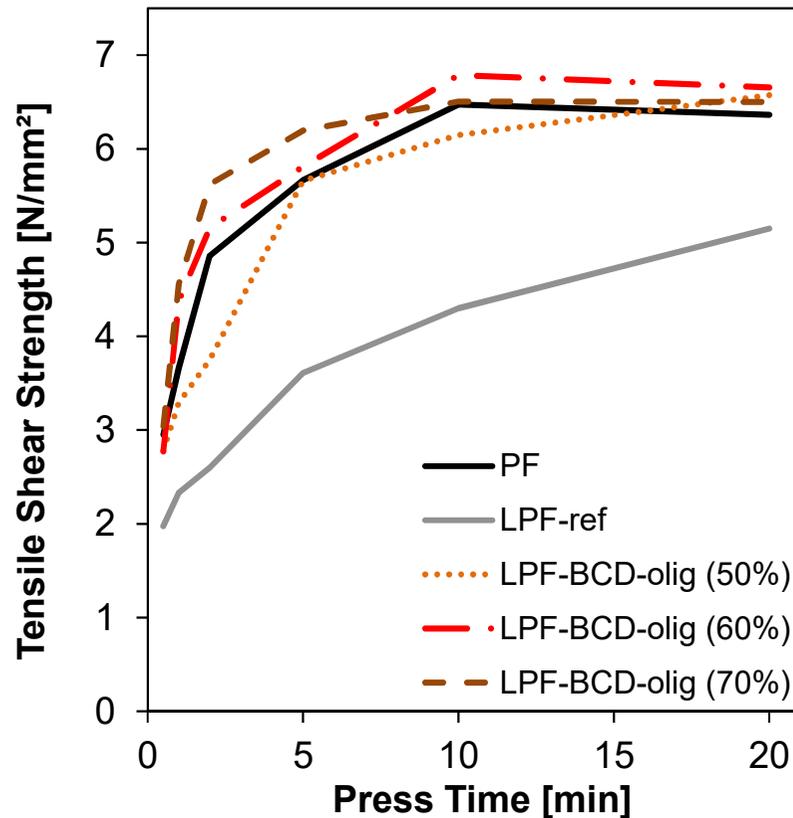
**Higher reactivity
better adhesive properties
higher bonding strength**

LPF resole synthesis

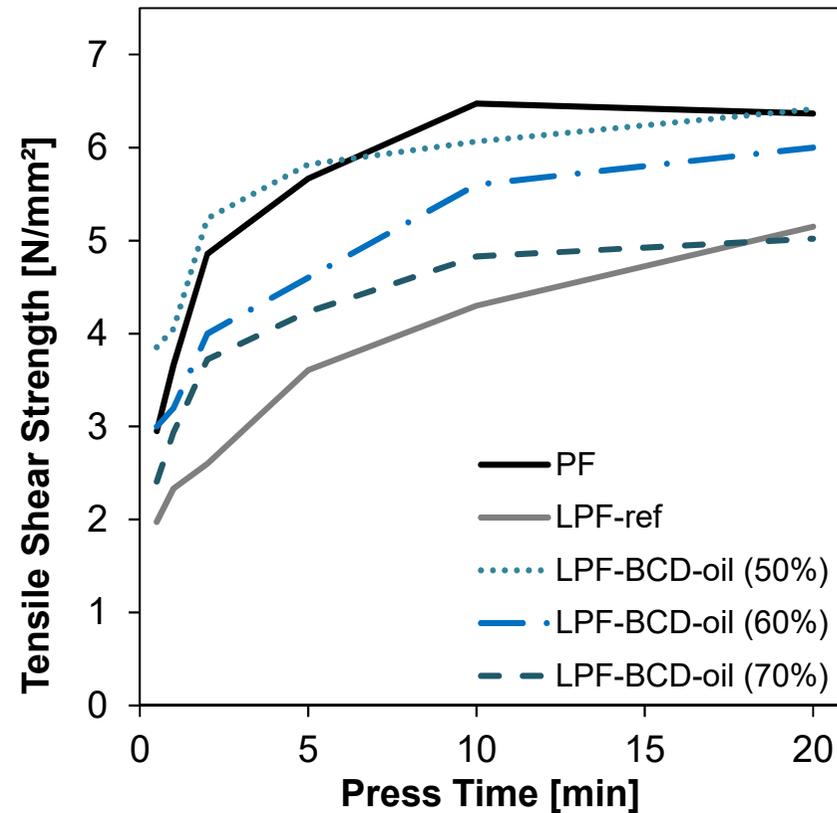


Bonding strength development

LPF BCD-olig.

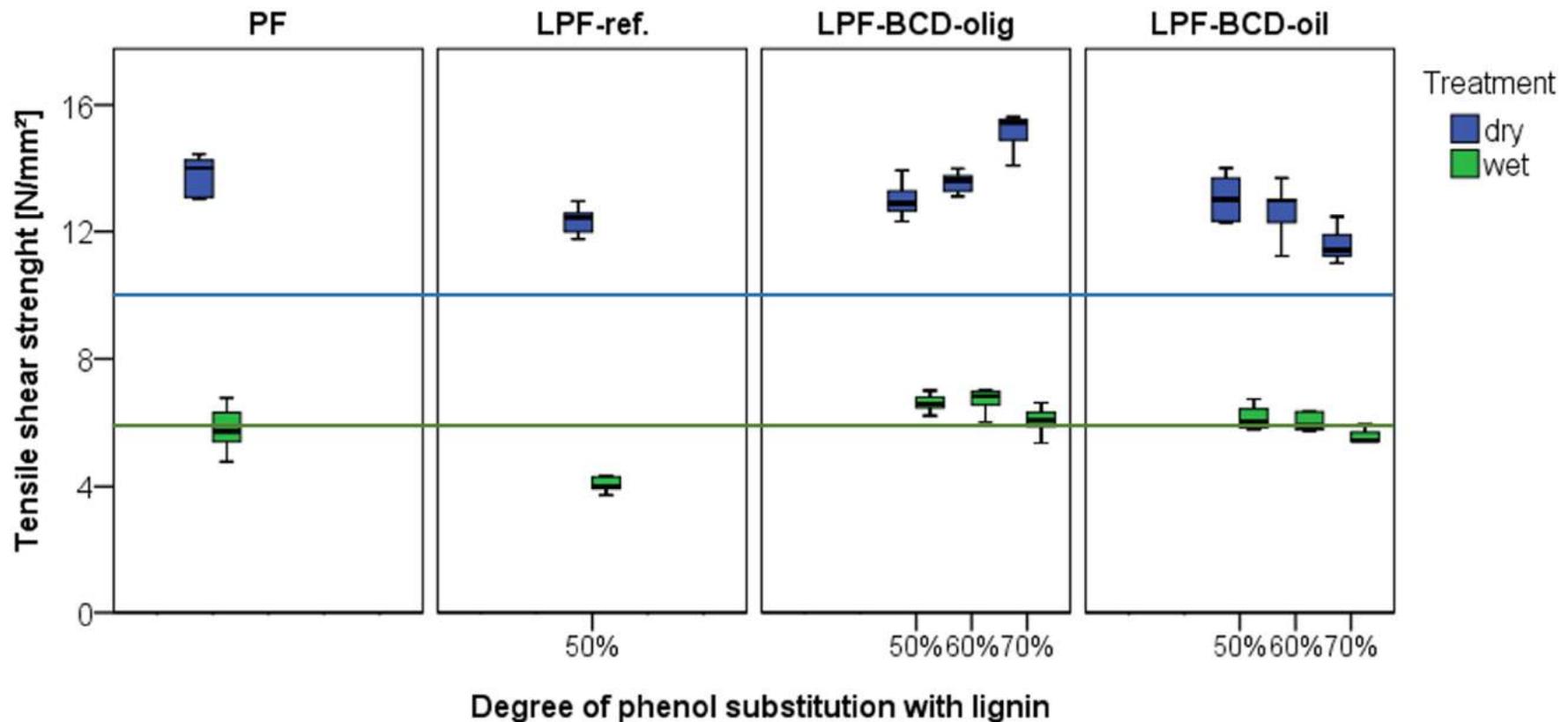


LPF BCD-oil.



Solt et al. (2018) *Polymers*, 10, 1162

Tensile shear strength of solid wood EN 301



Solt et al. (2018) *Polymers*, 10, 1162

Conclusion

- Up to **70% phenol** substitution with BCD-lignin
- **BCD-olig.** showed better performance than BCD-oil
- Speed of bond strength development is comparable to PF ref.
- Good water-stability

→ Base-catalyzed depolymerized lignin is an interesting raw material for PF resins

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