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LIGNIN BASED BINDERS: AN INDUSTRIAL REALITY, LATEST DEVELOPMENTS

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Strong Interest in Lignin And Lignin Based Resins For Wood Products @UPM

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UPM-Kymmene, group sales 2016 10.5 bn €, listed on Helsinki stock exchange

UPM Biorefining

Biofuels
Pulp
Plantation operations

3.6 million tonnes of pulp

~1,3 million tonnes of lignin in black liquor

UPM Biochemicals

Focus on wood-based biorefinery concepts

Lignin Team working on lignin application development since more than 8 years

Focus on lignin-based resins for wood products.

Excellent collaboration with current and future lignin producers.

UPM Plywood

Largest plywood producer in Europe with ~ 1 mio m^3 capacity

Positioned as quality-leader in birch plywood (transportation, concrete formwork), also for special applications like LNG

➔ **access to pilot facilities**
➔ **sparring**

UPM Biochemical‘s LPF Resin Technology

- Developed and validated in cooperation with Europe‘s largest phenolic resin consumer, UPM Plywood, and Chimar Hellas, allows for up to 80% substitution of petro-based phenol, without compromising performance.
- We offer UPM BioPiva™ lignin product, including access to our lignin based resin technology
- Strong patent portfolio
- Versatile for broad range of phenolic resin applications and production configurations

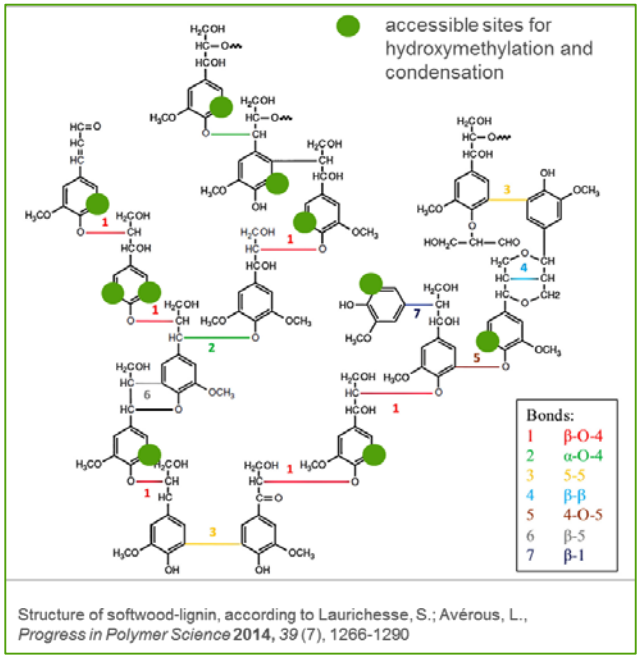
Benefits:

cost benefit

renewable content

non-toxic

less FA



Structure of softwood-lignin, according to Laurichesse, S.; Avérous, L., *Progress in Polymer Science* **2014,** *39* (7), 1266-1290

UPM WISA® BIOBOND by UPM Plywood

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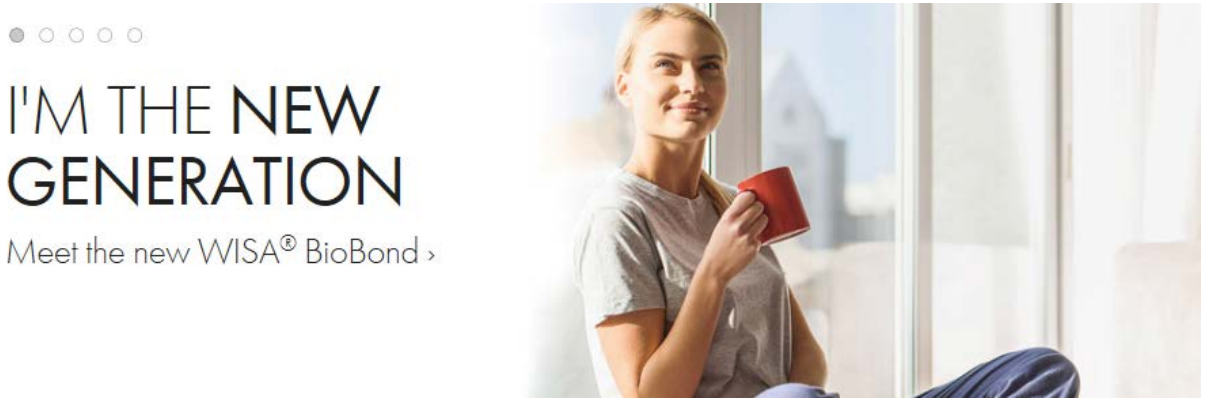
Officially launched in Oct 2nd 2017 http://www.wisabiobond.com/



- The underlying lignin-phenol resin technology, based on UPM BioPiva™ lignin raw material is ready to be rolled out globally, through UPM Biochemicals, in co-operation with selected industry partners.

Lignin Based Resins
Running Smoohly in Industrial Production

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- Birch plywood production on roller line - no change in production parameters needed
  - open time up to 40 min
  - glue factor ~155 g/m^2 (per single glue line)
  - prepress 6-8 bar/ 8min
  - hot press 130°C
  - press factor 0.75 min / mm

- Panel thicknesses from 6.5 mm to 30mm
- Glue mix stable and workable up to 48 hours
- Good runnability!

mechanical testing EN 314-1	panels with PF-reference	panels with LPF-500 resin*
Shear strength after soaking [N/mm^2]	2,5	2,5
Shear strength after boiling [N/mm^2]	1,9	1,9
WF [%] after boiling	>90	>85
3-point bending test (along grain direction)		
Bending strength [N/mm^2]	72	76
Modulus [N/mm^2]	8350	8650

*50% phenol replacement

DSC Shows High Resin Reactivity

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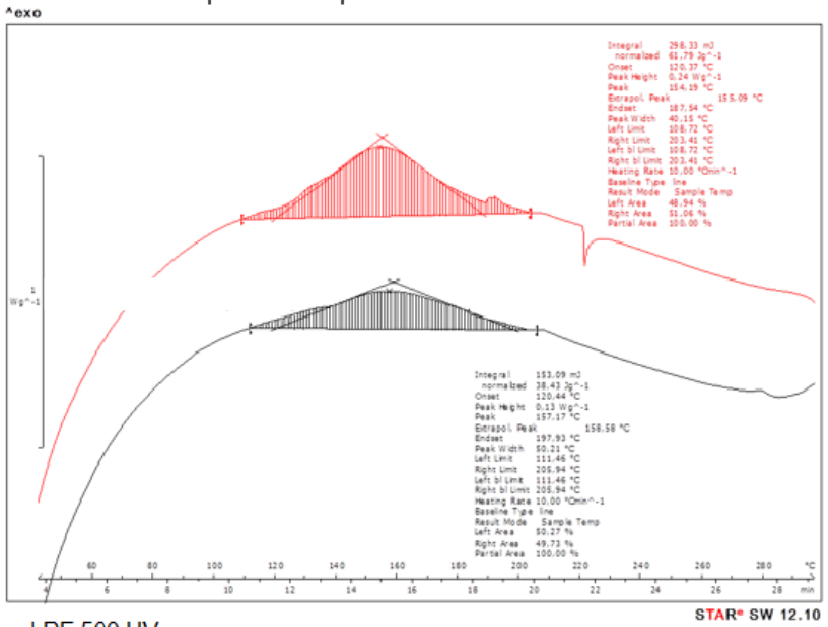
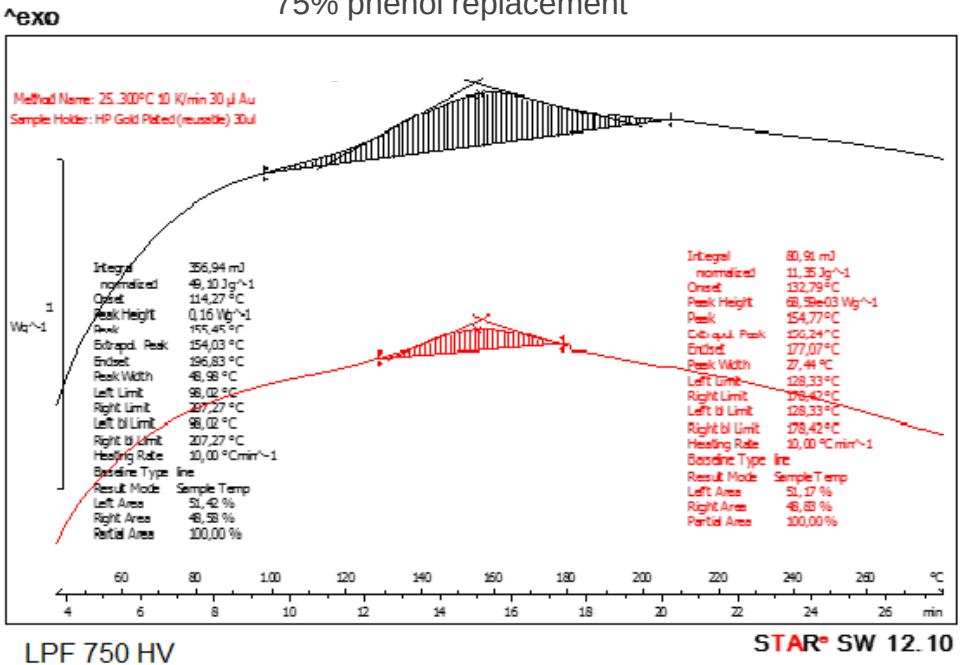
50% phenol replacement



LPF 500 HV

onset: 120 °C
peak max. 154 °C

75% phenol replacement



LPF 750 HV

onset: 114 °C
peak max. 155 °C

Formaldehyde Emissions from Panels Are Typically Very Low

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Formaldehyde release EN 717-2

Determination of formaldehyde release by gas analysis method

	Average emission [mg/m²/h]
LPF500 resin Birch uncoated, 9-ply, 12mm	**0.11***
PF resin reference Birch uncoated, 9-ply, 12mm	**0.1- 0.2***

*E1 limit by EN717-2 ≤ 3.5 mg HCHO/(h·m²)

Formaldehyde release EN 717-1 - *chamber method*

	formaldehyde conc., ppm
LPF500 resin Birch uncoated, 9-ply, 12 mm;	**0.01****
PF resin reference Birch uncoated, 9-ply, 12mm	**0.01-0.02****

determinated by Fraunhofer WKI

**E1 limit by EN 717-1 ≤ 0.124 mg/m³ air / ≤ 0.1 ppm

LPF resin Formulations, Now Running Also on Curtain Coaters

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- Surface tension properties of LPF resins are different compared to PF resins
- Can be adapted by using commercial surfactants to obtain stable curtain
- Panel properties equal to reference

Pilot curtain coater unit from Raute

PF based formulation

LPF based formulation

LPF resin Formulations, Now Running Also on Curtain Coaters

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- 3-ply, 9.5 mm panels from North-American spruce
- Curtain coater: glue viscosity 2100-2600 cp (90 °F)
- Glue factor 126-137 g/m^2 (26-28 lbs/1000f^2)
- Line speed 109-113 m/min (360-370fpm)
- Prepress 6-8 bar/ 6min
- Hot press 284°F
- Press factor 0.5 min / mm

	PS1 vacuum pressure test				
	No of panels	No of Plies	Thickness, mm	Shear, psi	WF, %
LPF500 resin based formulation	20	3	9.5	143	>90
	PS1 Boil and dry test				
	No of panels	No of Plies	Thickness, mm	Shear, psi	WF, %
	20	3	9.5	132	>90

Vacuum pressure test

Boil-dry-boil test

Further Applications on the Way!

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OSB

Laminated veneer lumber

Thermally fused laminates

Surface Films

Summary

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Lignin, a 100% bio-based, non-toxic, non-hazardous raw material is available, in industrial quantities, at constant and conrolled quality. Various types and modifications will further broaden the application spectrum.

Focus on implementation
Lignin-based phenolic resins are becoming the ‚new normal', in the global plywood-industry because **.... they work**, while providing additional benefits to resin producers and their customers.

Aiming higher
Lignin and lignin-based resins will open the door towards a new generation of binders, also for other applications in the wood-products industry.

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