INTEGRATED BIO REFINERY CONCEPTS AS A CRUCIAL APPROACH FOR ECONOMICALLY REASONABLE BIO-BASED PRODUCTION PROCESSES

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Case scenario: Side Stream - Recycled wood for LC-Bio Refinery

Waste wood collection

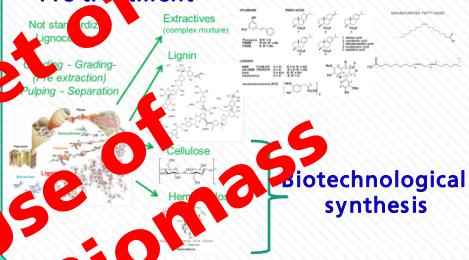
Recycling into RW classes: RW AI, AII, AIII & AIV

Standardization, e.g.

Further step to the proposed target of Cascading Use of Lignocellulose Biomass

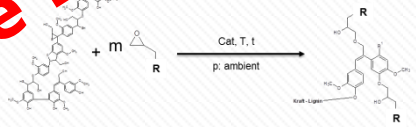
Bio refinery processes

Pre treatment

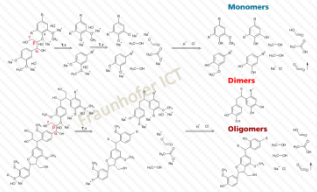


Biotechnological synthesis

Lignin functionalization



Lignin degradation



Targets

- **Extractives**
  - resin acids
  - FA
  - pinosylvin
- **Polysaccharides**
  - Alcohols,
  - Dicarboxylic acids,
  - PHA
  - Bio gas
  - Sugars

  etc.
- **Lignin**
  - Poly aromatic polyols
  - Poly aromatic lipophilic compounds
  - Monomer oxy-aromatic compounds
  - Oligomer poly phenolic compounds

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Situation: Waste wood in EU, based on results of project EraNet ww – "DEMOWOOD" (JAN 2011-Dec 2013)

- > 50 Mio t waste wood/ a in EU (28 members), some examples

- Germany: ~8.5Mio t/a (class AI: 15-20%, AII & AIII: 60-65%, AIV: ~15%)
- Finland: ~8.5 Mio t/a
- Slovenia: ~200.000 t/a with growth rates of more than 5%/ a

Class A I

Class A II & A III

Class A IV - hazardous waste

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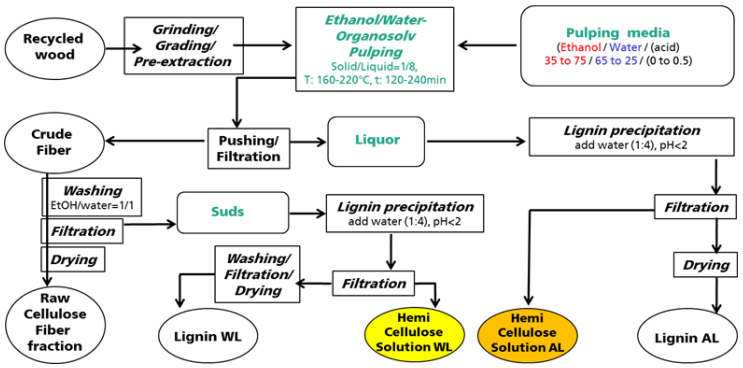
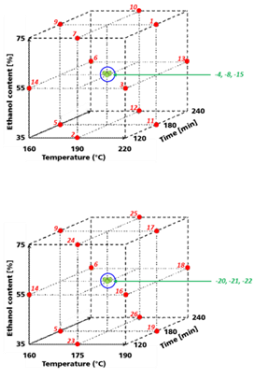
Case scenario: Side Stream - Recycled wood AI for LC-Bio Refinery

Sample	Lignin %	Poly glucane polysaccharides %	Non poly glucanes %	Ash %	Extractives (Soxhlet) %	Acetic acid %	Water %	Total %
RW AI	33,95	39.5 +/-0,69	16.2 +/- 0,29	0,48 +/-0,02	1.16	2.64	7.7	101.63

Potential deconstruction process: ethanol/water-Organosolv cooking



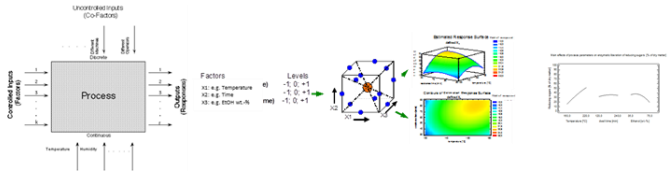
Support by DoE (Box-Behnken)



Type

Auto-catalyzed E/W-Organosolv

Acid-catalyzed E/W-Organosolv



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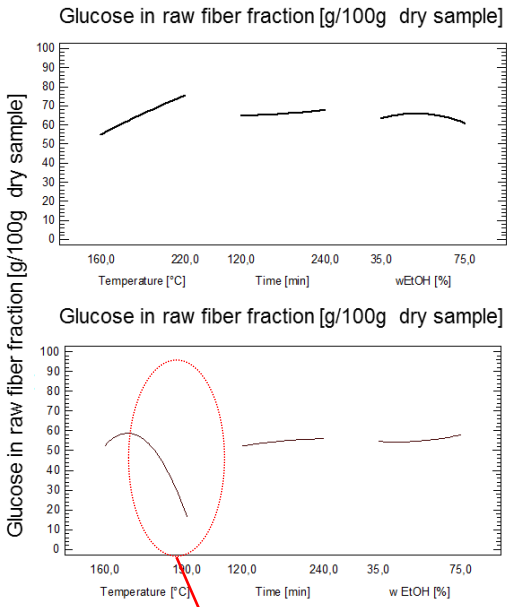
INTEGRATED BIO REFINERY CONCEPTS AS A CRUCIAL APPROACH FOR ECONOMICALLY REASONABLE BIO-BASED PRODUCTION PROCESSES

Characteristics of raw pulp

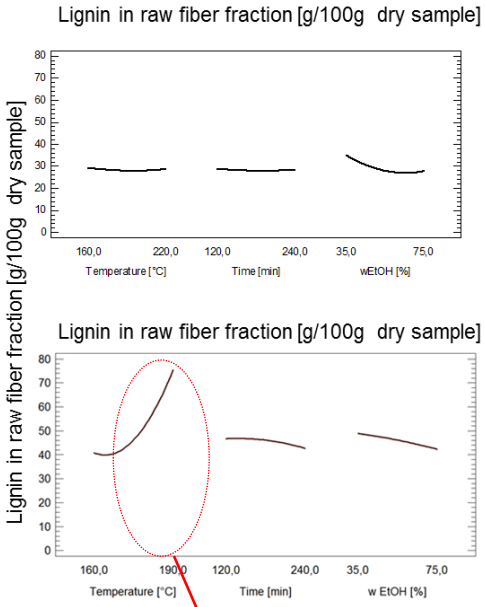
Type

Glucose in raw pulp



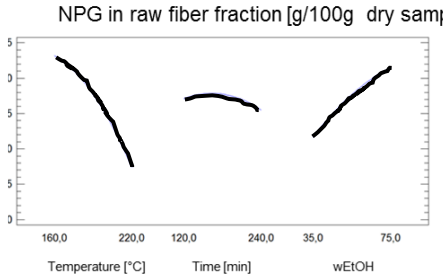
Cooked over raw pulp

Lignin in raw pulp



Hydrolysis lignin

NPG in raw pulp



NPG as mannose, xylose, galactose, arabinose not found in raw fiber fraction.

Auto-catalyzed E/W-Organosolv

Acid-catalyzed E/W-Organosolv

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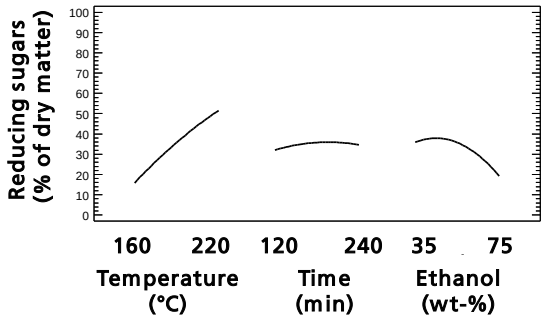
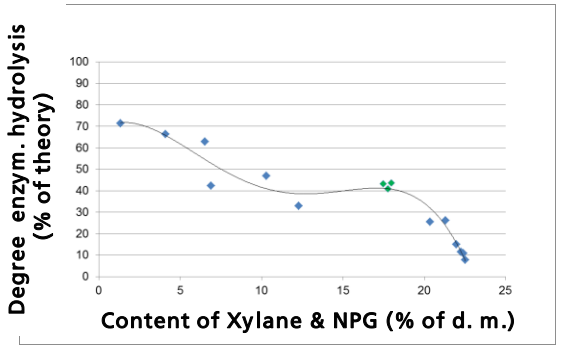
INTEGRATED BIO REFINERY CONCEPTS AS A CRUCIAL APPROACH FOR ECONOMICALLY REASONABLE BIO-BASED PRODUCTION PROCESSES

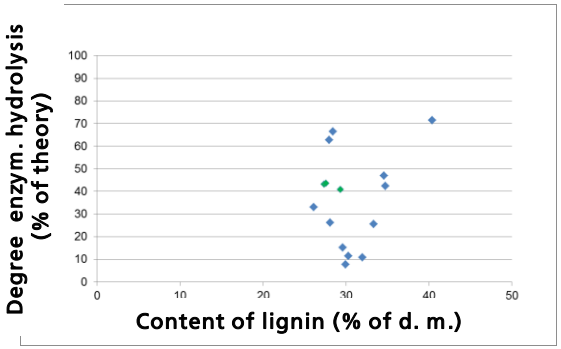
Characteristics of raw pulp – release of reducing sugars by enzymatic hydrolysis of raw pulp

Type

Release of reducing sugars

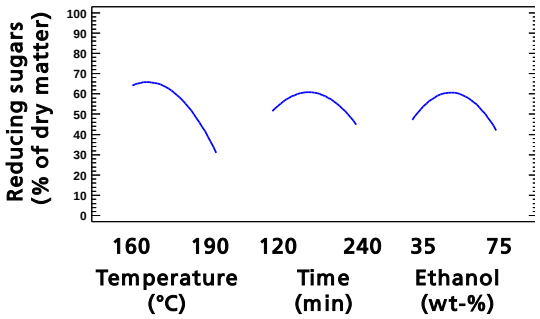


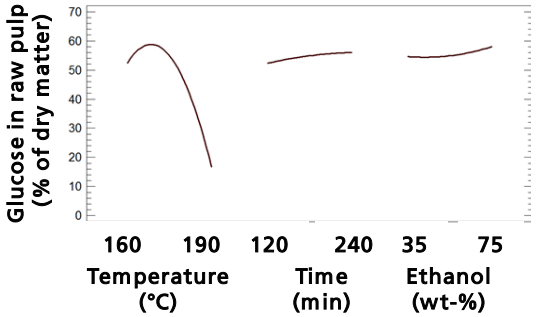


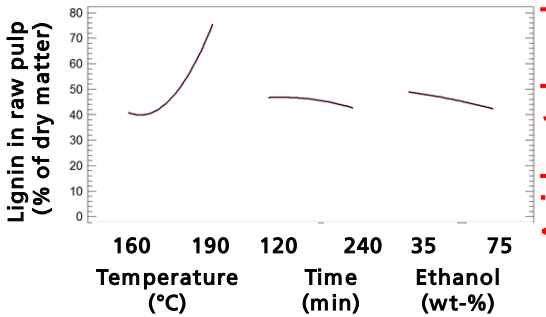


Auto-catalyzed cooking

Release of reducing sugars







Acid-catalyzed cooking

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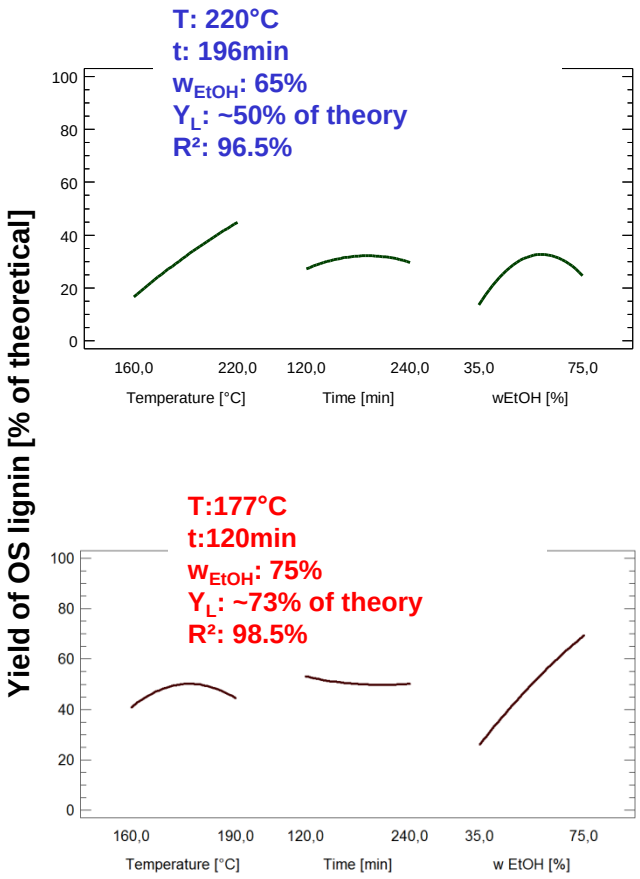
Integrated Bio refinery concepts as a crucial approach for economically reasonable bio-based production processes

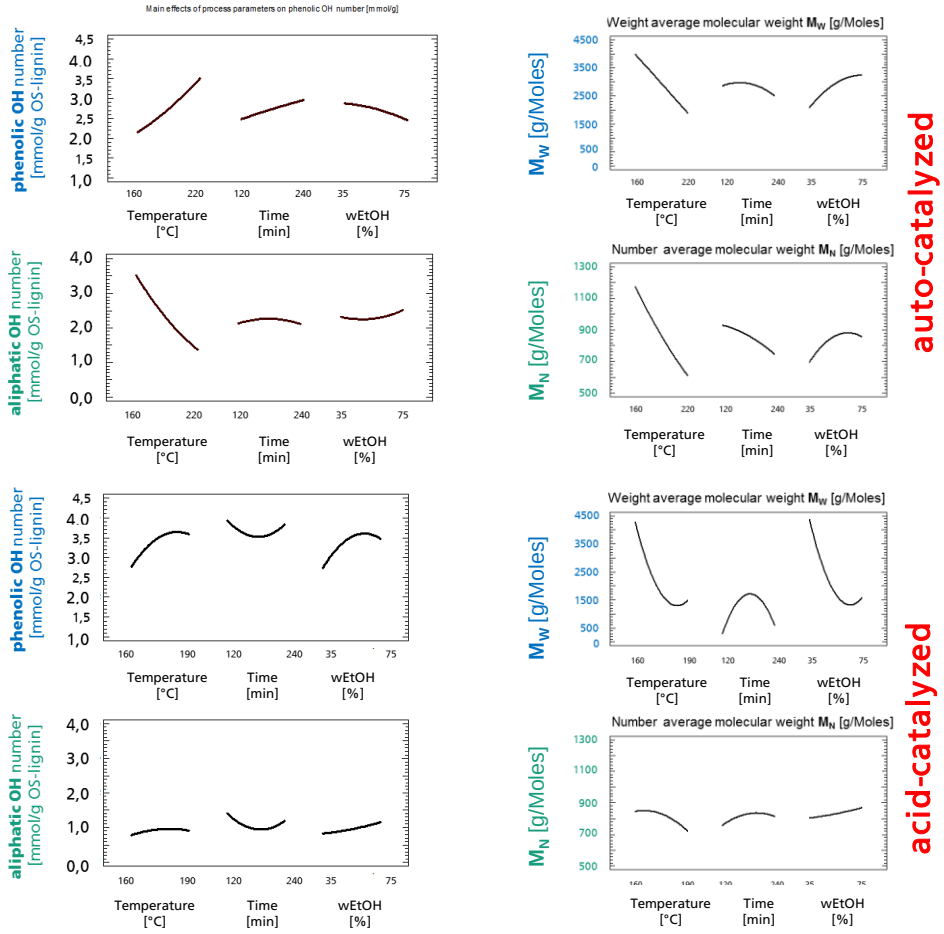
Characteristics of OS-lignin from recycled wood

Type

Yield: E/W-OrganoSolv-Lignins



Structural Features: E/W-OrganoSolv-Lignin



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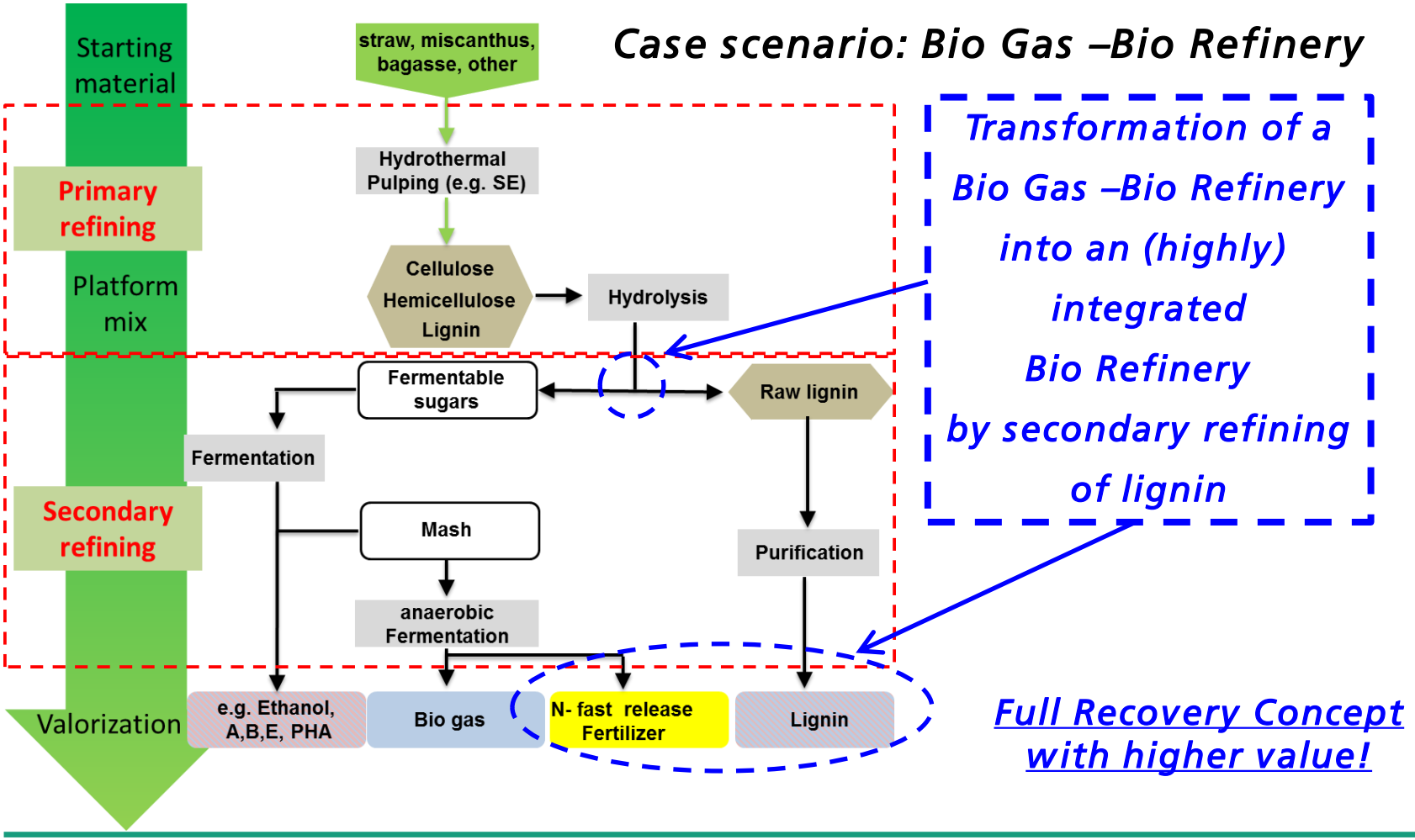
Integrated Bio Refinery concepts as a crucial approach for economically reasonable bio-based production processes

Example:

Case scenario: Bio Gas –Bio Refinery



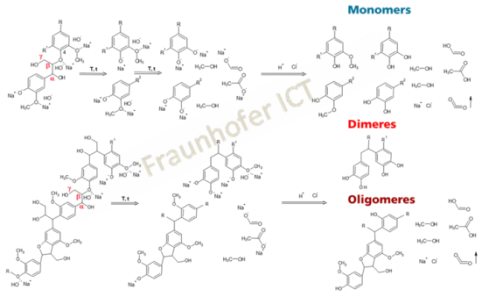
Lignin conversion into building blocks &/ or chemical conversion into Nitrogen – slow release fertilizer as part of the secondary refinery module – transfer of the biogas bio refinery into a (highly) integrated bio refinery

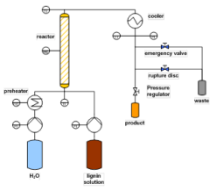
- **Chemical conversion of N- fast release fertilizer/Lignin mix into N- slow release fertilizer by an Ammonia/Lignin-oxidation process – Soil quality, Water quality- Environmental Impact**

- **Base catalyzed degradation**

Generation of oligomer building blocks & monomer oxy-aromatic compounds by Base Catalyzed Degradation of lignin

Base catalyzed degradation of lignin in continuously flow reactor





T: 250 to 350°C

t: 35 sec -15min or longer

p: 200 to 250bars

Lignin conc.: 10%

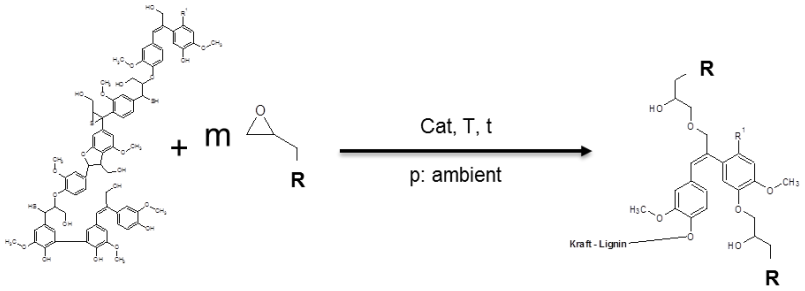
Catalysts: NaOH, KOH

Lignin types:

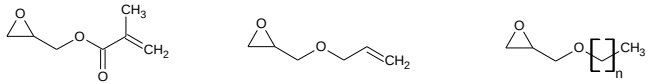
- Kraft-lignin
- OS-lignins
- Steam exploded lignin
- Lignin sulfonate

- **Grafting of new functional groups onto lignin**

Lignin functionalization - Catalyzed, region-selective opening of terminal epoxy-rings of 2,3-epoxy-1-propanol derivatives by phenolic OH-groups, in alkaline solution or in ethanol



Several derivatives are available for a tailored functionalization, e.g.



- **Application field: In both cases building blocks for material applications (epoxy, PU, glues, foams, composites)**

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POTENTIAL DECONSTRUCTION OF RECYCLED WOOD, STRUCTURAL FEATURES OF ISOLATED LIGNIN AND WAYS TO ACTIVATE IT FOR MATERIAL APPLICATIONS

Summary

- With global rising use of wood & other lignocelluloses in the future, the importance of efficient utilization of side streams (e.g. RW, agric. Residues) will increase,
- Recycling of waste wood by stronger sorting into Class AI in combination with the lignocellulose bio refinery concept supports the cascading use of wood in the future,
- A potential deconstruction process of recycled wood AI could be ethanol-based Organosolv cooking for the generation of well hydrolysable pulp and sulfur free lignin,
- Hydrolysable pulp can be utilized by biotechnological processes, generating platform chemicals and bio gas
- Several chemical modification processes are available &/or will be developed for the utilization of functionalized/ activated lignin in material applications,
- Material applications could be PU-foams, casting resins, epoxy resins etc.
- A full recovery concept of side stream lignocellulose is possible in a (highly) intergrated bio refinery.

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Thank you for your attention!

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