Circular and Biobased Performance Materials Symposium
19 June 2019, Wageningen, The Netherlands

Session: Using biobased sources for new chemicals and materials
Presentation by: Richard Gosselink, *Wageningen FBR*

Title: **Lignin use in bio-asphalt**

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Curriculum:
Dr. Richard Gosselink started his career in 1990 in Wageningen. He has a chemistry background and holds his PhD at Wageningen University on lignin valorisation. Currently, he is senior scientist and expertiseleader biopolymer functionalisation & characterisation at the Wageningen Food & Biobased Research contract research organisation. He coordinates lignocellulosic biorefinery and lignin chemistry & application research. In these R&D projects sustainable and cost effective technologies are developed together with industrial stakeholders within the biobased and circular economy. From 2018 he chairs an European network on lignin: CA17128 LignoCOST (www.lignocost.eu).

Abstract:
Lignin is a large side stream generated at the pulp&paper and biorefinery industry. Lignin is mainly used as energy source and for the recovery of chemicals. However, due to its aromatic structure and intrinsic binder, UV stability and antioxidant functionality, lignin can be used for a variety of products. Therefore more and more industries see now the opportunities of lignin production and use in added value applications beyond its energy value.
As the asphalt industry is expecting scarcity of bitumen and quality changes and is looking for sustainable solutions, lignin can potentially substitute bitumen as asphalt binder. This large market can absorb large quantities of lignin when successful. This presentation will give the results of a joint research development from lab to demonstration scale using lignins for the substitution of bitumen. Finally, examples of lignin based roads in The Netherlands are given.

Lignin use in bio-asphalt

CBPM symposium, Wageningen

19 June 2019

Dr. Richard Gosselink

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Outline

- Lignin
- Asphalt binders

- Production and availability of lignin
- The road from lab to demonstration scale
  - Bio-asphalt demonstration road in Zeeland
  - Demonstration cycling path @ Wageningen campus
- Sustainability aspects
- Future perspective

Wageningen Food & Biobased Research

Applied research for sustainable innovations

- In-depth knowledge of the entire agri-food chain
- Market oriented R&D approach
- Multi-disciplinairy applied R&D project teams; 250 employees
- Up-scaling: from lab to pilot
- Connection with the University of Wageningen

Sustainable Food Chains

Biobased Products

Healthy & Delicious Foods

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Research programmes

- Postharvest quality
- Food waste prevention & utilisation
- Food innovations for responsible choices
- Smart customised nutrition & health
- Protein for life
- Biobased chemicals & fuels
- Renewable materials
- Biorefinery

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Developed products

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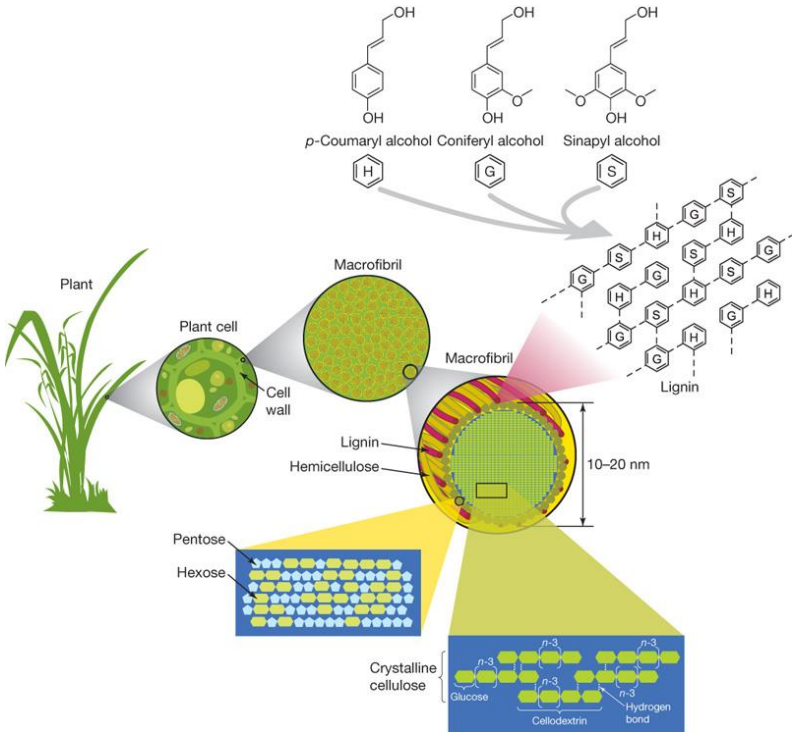
Lignocellulose

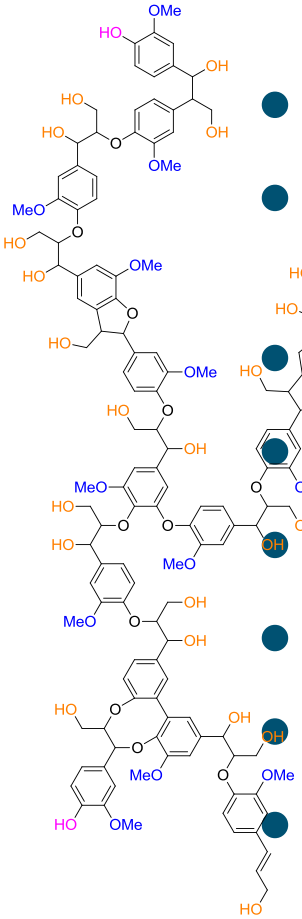


Rubin, 2008

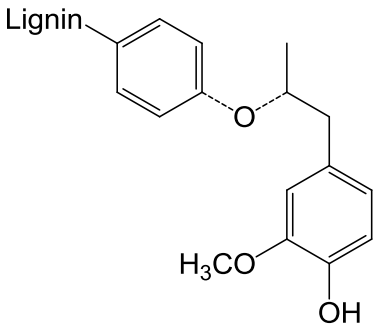
Biomass	Lignin content (%)
Wood	20-30
Straw, hemp, flax, miscanthus, bagasse	15-25
Digestate	5-25
Grass	5-15
Coconut husk	30-50
Wood bark	20-30

What is lignin and why interesting?

- Lignin = 15-25% of lignocellulosic biomass



- Biobased
- Large side stream of paper & pulp industry and biofuel industry (>>50 M tonnes/y)
- Mainly used as energy source
- Natural binder
- Water resistent
- Aromatic ringstructure
- UV stabiliser
- Resembles products derived from fossil resources



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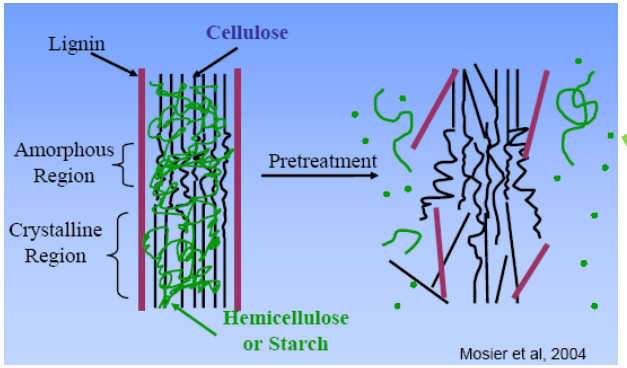
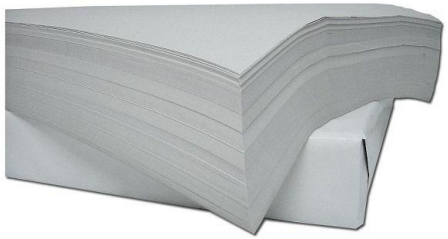
Production of lignin

Pulping / fractionation



Cellulose



Paper, textiles or biofuel (bioethanol)

Lignin

Materials, fuels and chemicals

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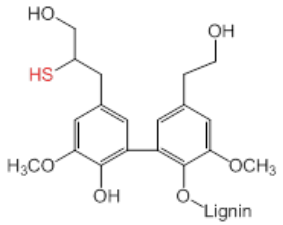
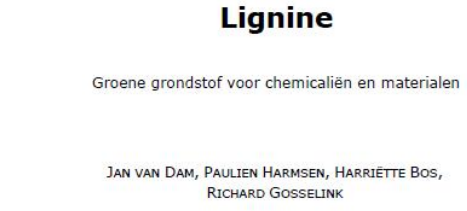
Technical lignin availability (dry ton/y)

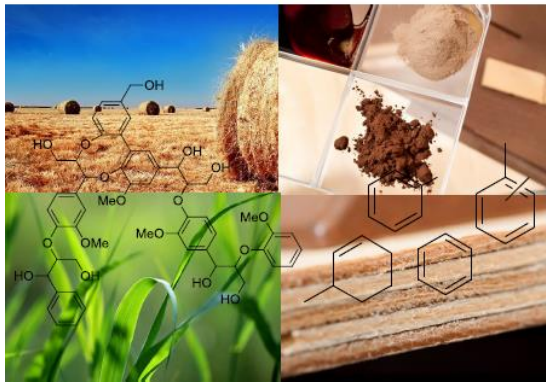
- Pulp & Paper industry
  - 1 M ton lignosulphonates
  - >100 kton kraft lignins
  - 5-10 kton soda sulphur-free lignins



Kraft lignin

- Biomass conversion (Biorefinery)
  - Sulphur-free lignins, several pilot/demo initiatives
    - Acid hydrolysis lignins
    - Steam explosion
    - Organosolv lignins





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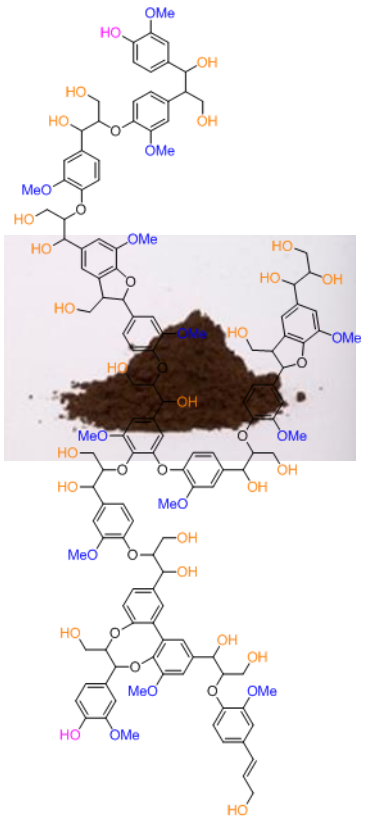
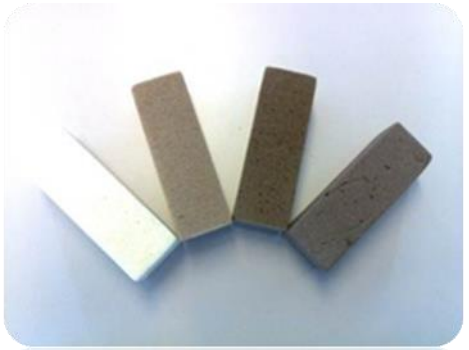
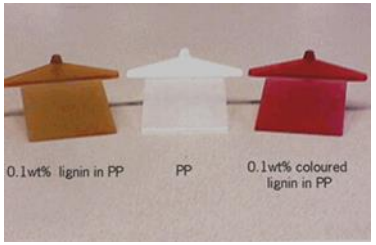
Lignin research @ WFBR

Lignin analytics ---- conversion, fractionation ---------- application development







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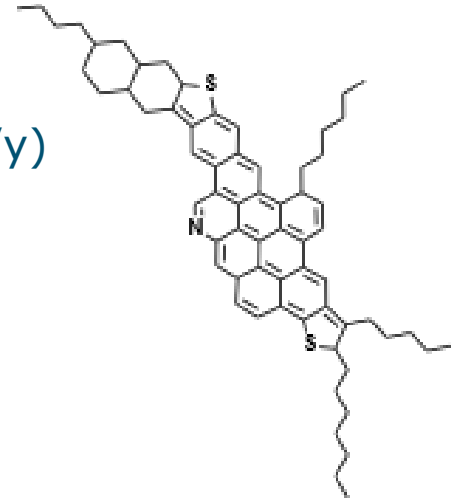
Bitumen

- Binder in asphalt
- Visceus complex fraction derived from crude fossil oil
- Distillation fraction
- Hydrophobic
- High carbon content
- Recyclable



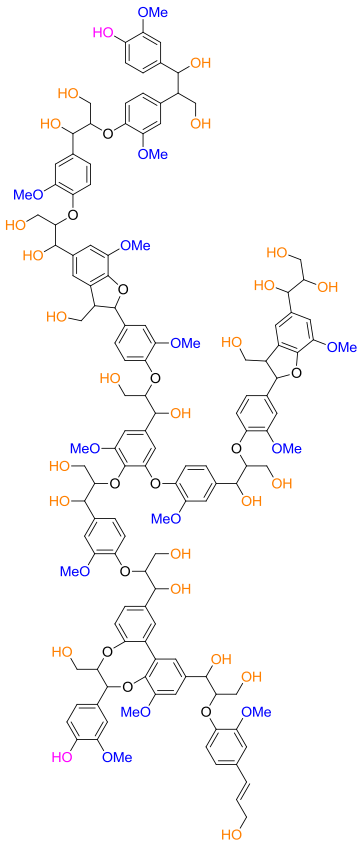
- Bitumen consumption (in NL 350 kton/y ; in EU 20 Mton/y)
- Prices varies (300 – 500 € / ton)
- Variation in quality
    - BUT WE NEED GOOD QUALITY ROADS

Drivers for lignin as bitumen substitute

- Solution for scarcity of bitumen in near future
- A way to guarantee the binder quality
- Substitution of fossil resource
- Adding extra functionality to asphalt
- Longer lifetime results in less maintenance (business case!)

Lignin as bitumen substitute

- Lignine is natural binder
- Brown / black powder
- Relatively hydrophobic
- High carbon content (2/3 C; 1/3 O)
- Thermoplastic biopolymer (Tg ≈ 100-150°C)
- UV-stabiliser
- Substitute larger fractions in bitumen



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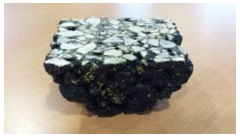
Road from lab to demonstration

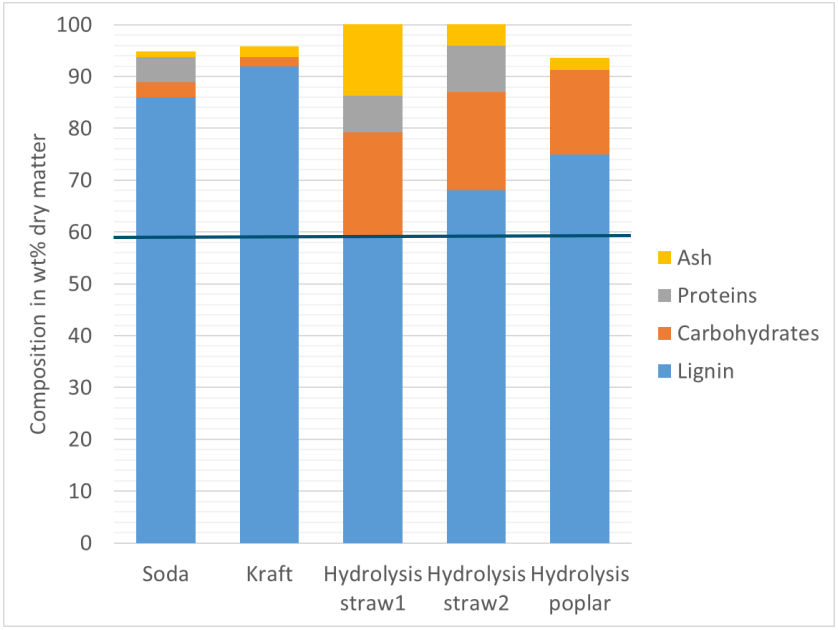
- Literature and patents showed lignin and bitumen can be mixed
- Selection of lignin with suitable properties
- Need for dry lignin powder
- Link lignin properties to asphalt binder properties
- Lignin-bitumen binder processable at lower temperature (vegetable oil)
- Labscale tests
- Pilot tests (1 m^2)

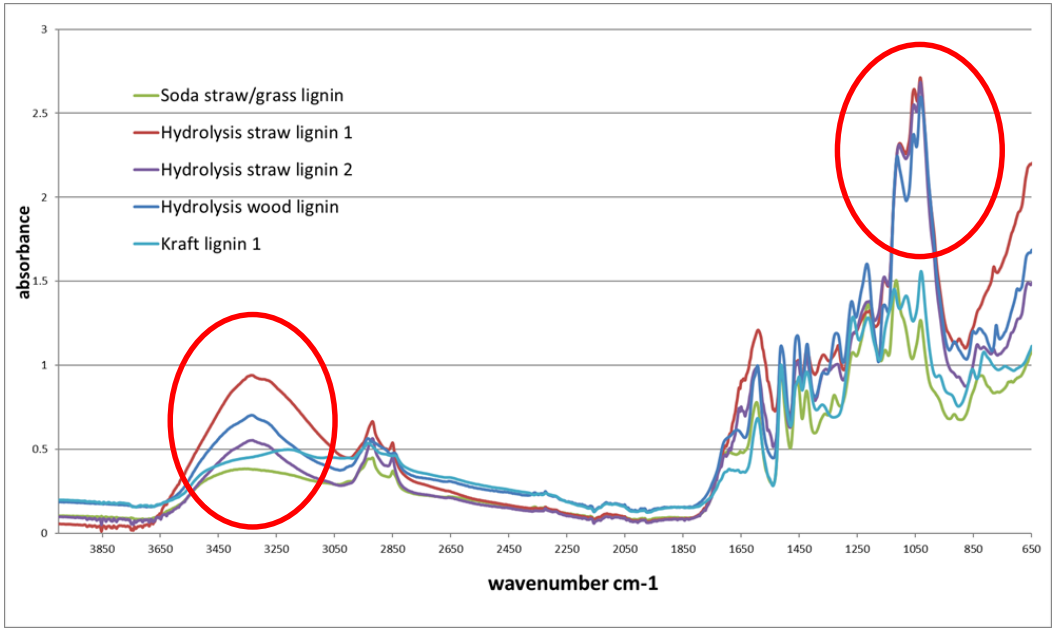


- Demo tests (10 m^2)
- Demonstration roads

Selection of suitable lignin

- Large number of technical lignins tested
  - Pulp & paper industry
  - Biorefinery industry (cellulosic ethanol, biochemicals)





Fast screening tool FT-IR

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Gosselink R.J.A., Landa P., Lignin-based bio-asphalt, WO2019/092278

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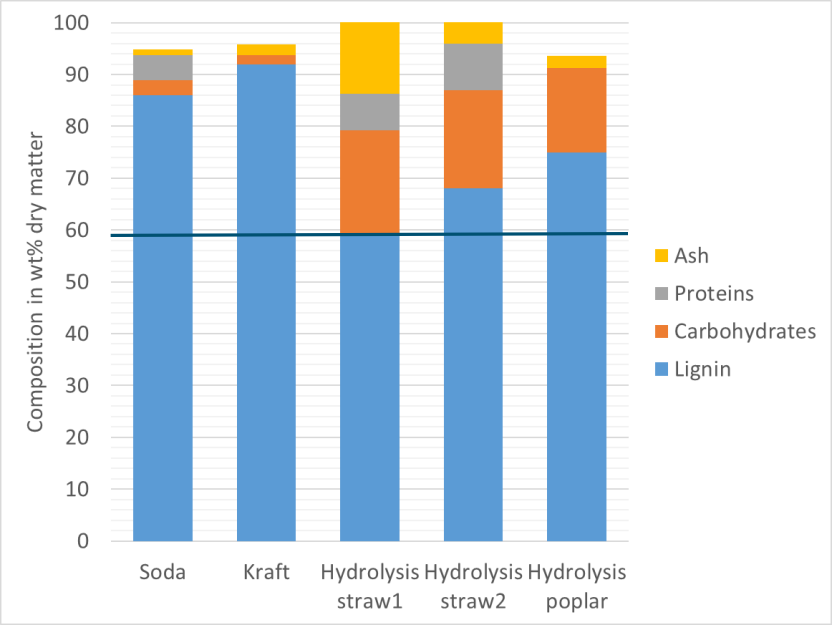

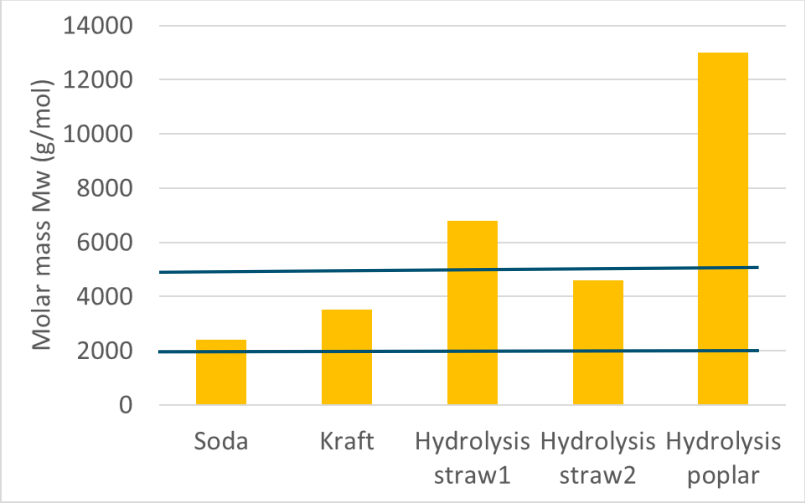

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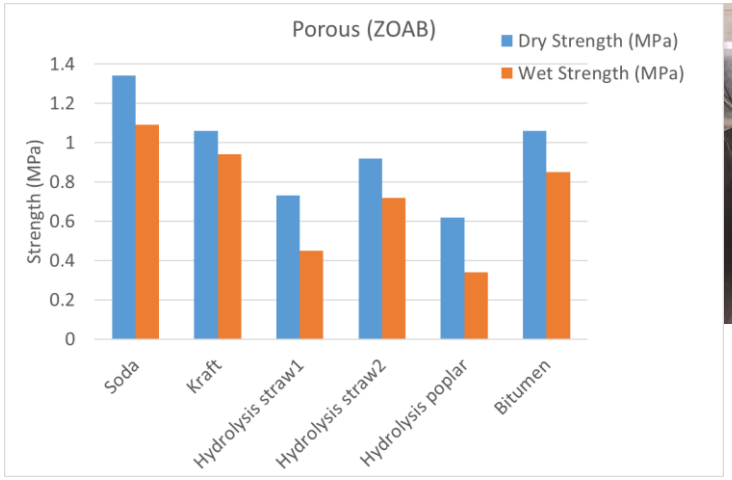
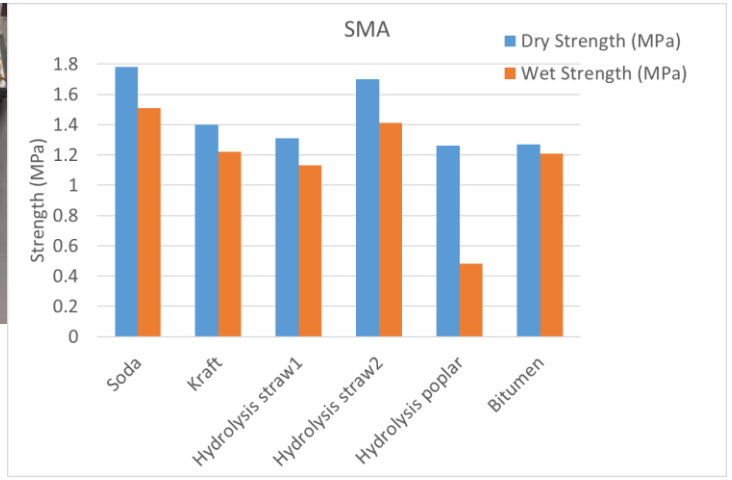
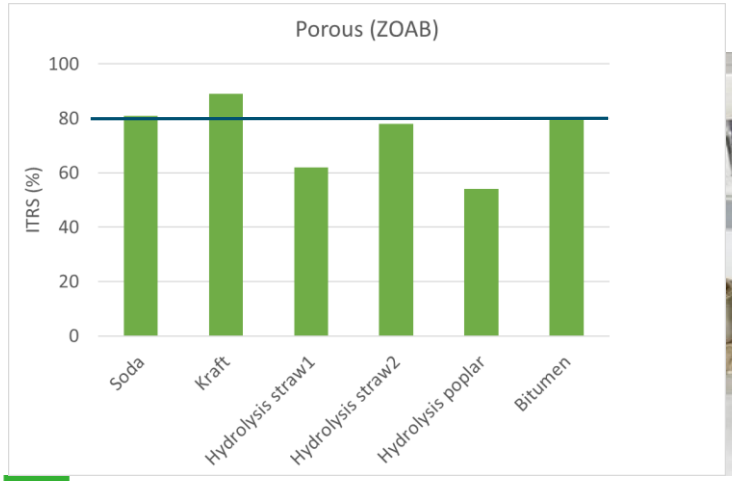
Labscale bio-asphalt tests

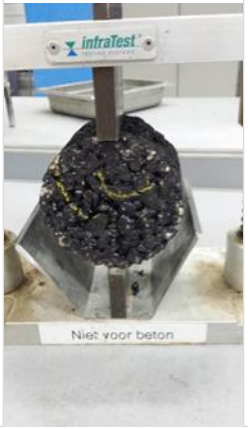
- Porous asphalt (ZOAB)

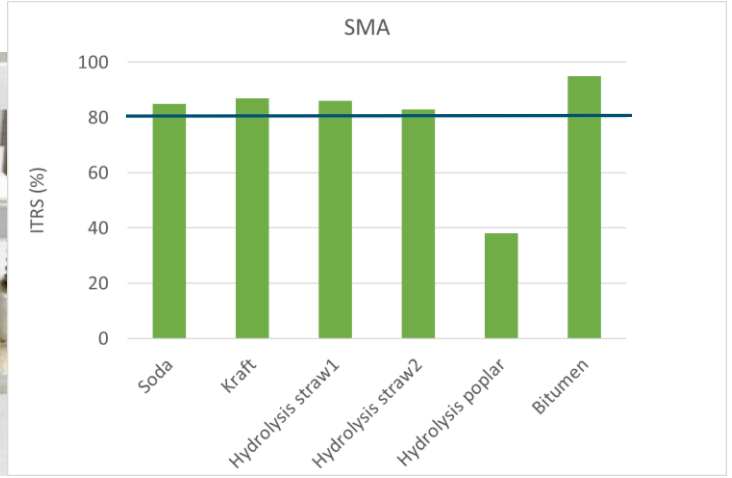
Stone mastic asphalt (SMA)











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Labscale bio-asphalt tests

- Some lignin-rich streams fails as asphalt binder

Labscale bio-asphalt tests

- Stiffness and resistance to fatigue (4-points bending test)

	Hydrolysis lignin	Kraft lignin	Minimum requirement	Maximum requirement
Stiffness (MPa)	4441	6530	3600	11000
Fatigue resistance (Vermoeiing ε6)	107	124	>100	>130
Track formation Fc Max	<0,6	<0,2	0,2	4,0
Durability %	85	85	> 80	
Density (Kg/m^3)	2299	2355		

AC Surf. NEN-EN 12697-24/26

Demonstration Bio-asphalt in Zeeland

- 50% substitution of bitumen by soda lignin
- Manufacturing at lower temperature (130-140 °C, lower CO_2)
- Mixing lignin – bitumen – asphalt ingredients @ asphalt mill
- July 2015 1st lignin bio-asphalt road

- After 4 years lignin asphalt behaves very good!

Lignin based cycling path Wageningen

- 3 Lignin selected
  - Soda
  - Kraft
  - Hydrolysis lignin

Pavement
June 2017

- 1 km cycling path at Wageningen campus
  - 10 tonnes of lignin
  - Production at 140°C
  - 7 trucks equals 220 tonnes bio-asphalt
  - Top layers in separate sections

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Lignin based asphalt binder: functionality

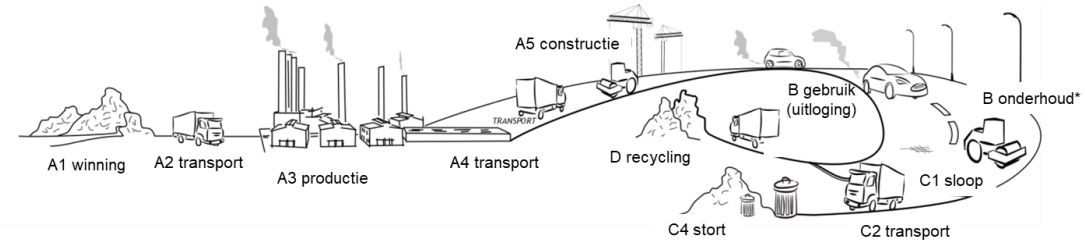
- Extra functionality for kraft lignin (first results)
    - Noise reduction -4.2 dB(A)
    - Rolling resistance -3.4%
    - Brake decelaration +0.8 m/s^2
- Substitution of polymer modified bitumen
- Enhancement of road lifetime

Gosselink R.J.A., Landa P., Lignin-based bio-asphalt, WO2019/092278

Lignin based asphalt binder

- Two technologies
  - Mixing @ asphalt mill (WFBR/AKC): 6 demonstration roads in NL
  - Blending lignin/bitumen binder (TNO/WFBR)

- Certification, LCA, MKI
  - Procurement / tender



- Our final goal: development of a bitumen-free asphalt binder
  - Lignin modification, other Biobased components

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Gosselink, R.J.A., P. Landa, Lignin-based bio-asphalt, WO2019/092278
Slaghek, T., D. van Vliet et al., Bitumen composition, EP2 918 640 (2014)

Future perspectives

- Lignin is a promising raw material as asphalt binder
- Demonstration roads show good results
- Functional lifetime of the road is important
- Life cycle assessment data needed
- Recycling possibilities
- Substitution of polymer modified bitumen
- Bitumen-free asphalt binders

Acknowledgements

- AKC, H4A, Zeeland Seaports, Roelofs, ACOB, provence of Gelderland, Municipality of Wageningen, WUR, TNO

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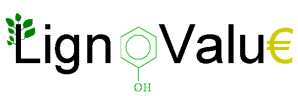
Wageningen UR Lignin Platform

- *Focus on lignin to bioaromatics + materials*
  - *Knowledge institutes + industrial partners*

- *EU projects:*
- *NL projects:*

BIOSYNERGY



LigniFAME

- *Industry sponsored projects: coatings, resins, life sciences, ...*
- *Networks:*

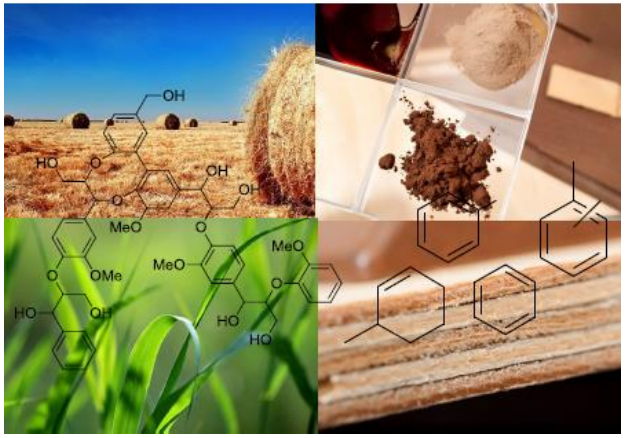
2018-2022

Thank you for your attention

Lignine

Groene grondstof voor chemicaliën en materialen

Jan van Dam, Paulien Harmsen, Harriëtte Bos,
Richard Gosselink



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