

Bio-asphalt: towards 100% fossil-free asphalt binders resulting in
30-60% reduction of the total CO₂ emission for the Dutch asphalt sector

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Wageningen Food & Biobased Research

Applied research for sustainable innovations

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



Sustainable Food Chains



Biobased Products



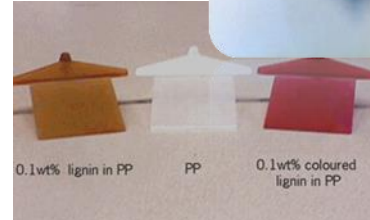
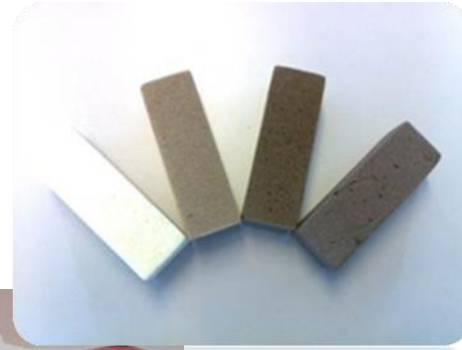
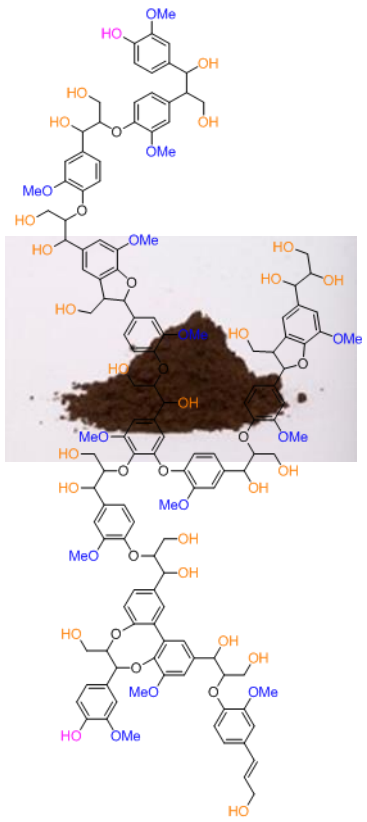
Healthy & Delicious Foods

Biobased Products Innovation Plant

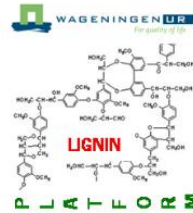


Lignin research @ WFBR

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



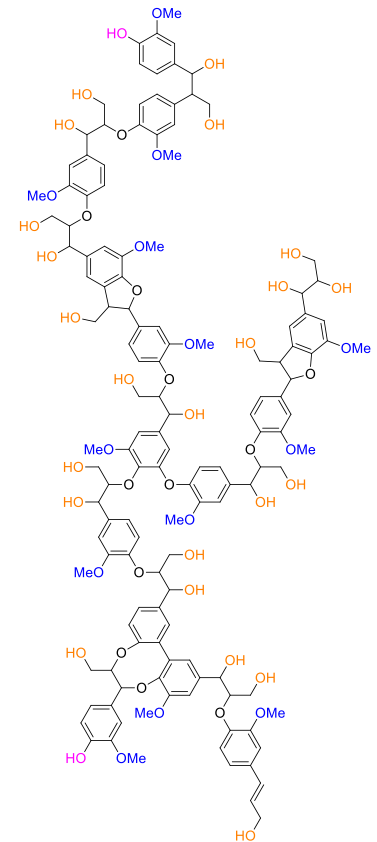
Lignin networks and projects



Chaplin consortium NL

Lignin as bitumen substitute

- Lignin is natural binder
- Brown / black powder
- Relatively hydrophobic
- High carbon content (2/3 C; 1/3 O)
- Thermoplastic biopolymer ($T_g \approx 100-150^\circ\text{C}$)
- UV-stabiliser
- Substitute larger fractions in bitumen



The concept of biobased asphalt

Bitumen

Coarse aggregates

Fine aggregates

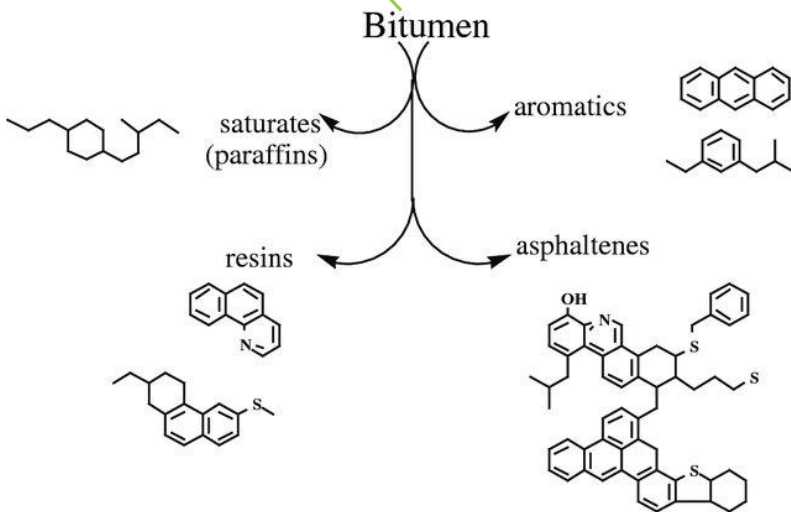
Filler

Asphalt



**Bitumen volume Europe:
12 million tons/year**

Two biobased asphalt technologies



Partial replacement of bitumen
by lignin (up to 50%)

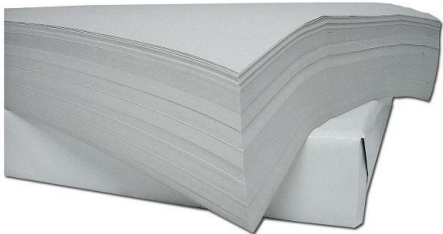
Full replacement of bitumen by
biobased components, including
lignin (100% biobased)

Production of lignin

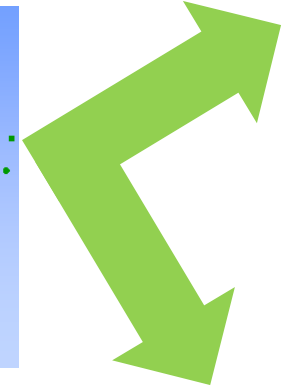
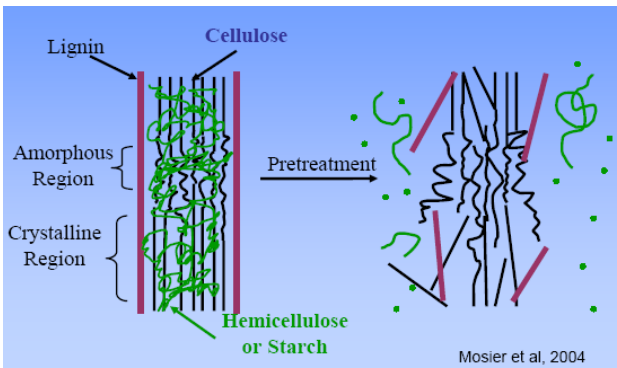


Pulping /
fractionation

Cellulose



Paper, textiles or
biofuel (bioethanol)

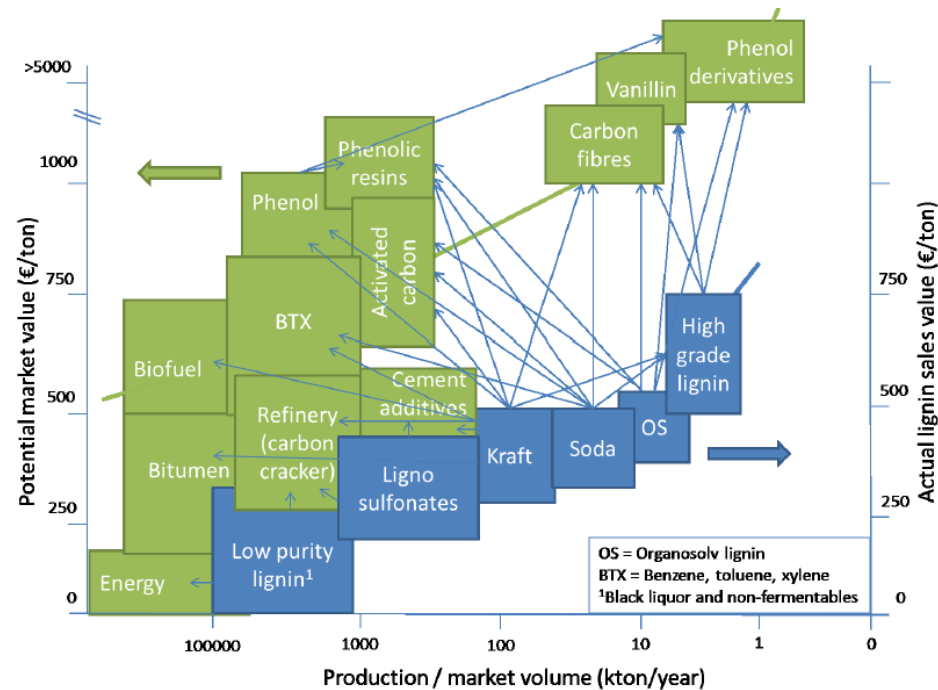


Lignin = large side
stream!!
>>100 Mton/y



Materials, fuels and chemicals

Lignin applications and market volume



- Bitumen relatively low-value, but high volume market
- WfBR lignin asphalt technology nevertheless enables direct introduction of lignin in existing asphalt plants without significant additional investment, making it easy to introduce in the market

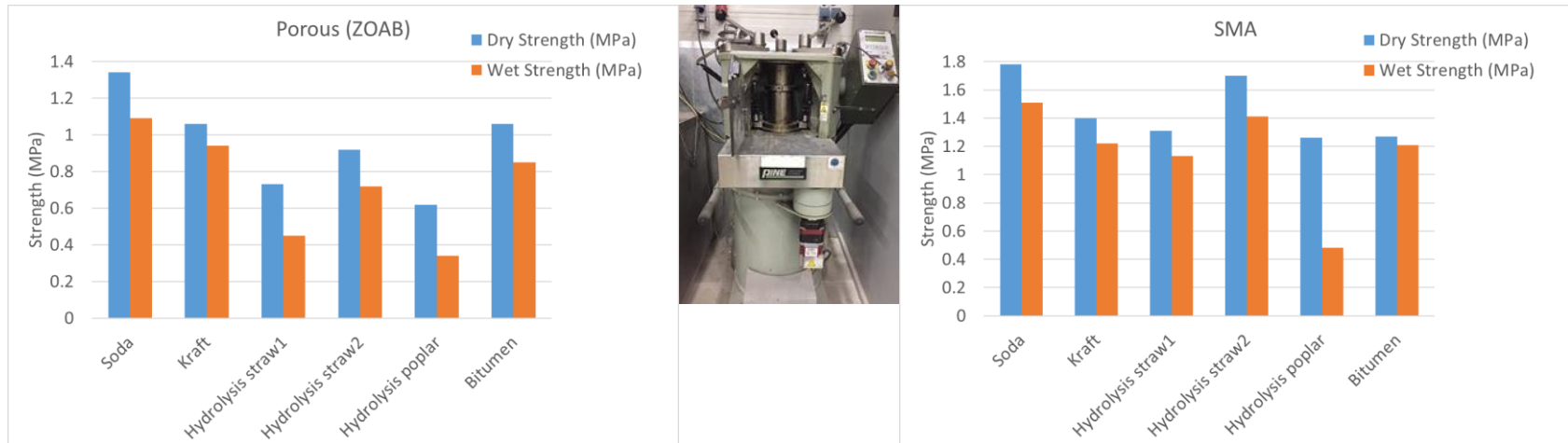
Drivers for lignin as bitumen substitute

- Lignin is a natural binder, UV stabiliser, resembles molecules in fossil bitumen
- Solution for scarcity of bitumen in near future (300,000 ton/y in NL)
- A way to guarantee the binder quality
- Substitution of fossil resource
- Long storage of biogenic carbon in roads (140,000 km in NL)
- 35-70% reduction of CO₂ emissions (Moretti *et al.* 2022)
- 30-60% reduction of CO₂ emissions for the Dutch asphalt sector (550 kt CO₂/y) → Large impact worldwide!!



Type of lignins and performance in asphalt

- Large number of technical lignins tested from Pulp & paper industry, but also from biorefinery industry (cellulosic ethanol, biochemicals)
- Tests on in porous asphalt (ZOAB) and Stone Mastic Asphalt (SMA) of Soda, Kraft and Hydrolysis lignin



	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		

Main milestones achieved so far

- Two patents* which show that lignin and bitumen can be mixed up to 50wt%
 - Patents granted in various countries, incl. Europe
- Demonstration roads in The Netherlands (>30 in total) 2015 - 2023



- 50% biobased asphalt → more data → validation → mainstream
- Demonstration roads outside The Netherlands usually by third parties with lower replacement rates (10-20% lignin).

Test sections so far (SMA)

Location	Name	Road type	Length (m)	Lignin used	Substitution (%)	Year of installation
Sas van Gent	Wervenweg	Industrial	70	soda	50	2015
Terneuzen	Europaweg	Provencial	400	kraft	45	2016
Terneuzen	Finlandweg	Industrial	100	kraft	45	2017
Wageningen	Bornsesteeg	Cycling path	1000	soda, kraft, hydrolysis	45	2017
Beek en Donk	N 272	Regional	2500	kraft	32	2017
Oostburg	Rondweg	Provincial	1000	kraft	45	2018
Vlissingen	Schotlandweg	Industrial	500	kraft	45	2018
Vlissingen	IJslandweg	Industrial	400	kraft	45	2018
Zevenaar	Witte Kruis	Cycling path	500	soda	50	2018
Gent (B)	Industrieterrein	Industrial	200	kraft	45	2018
Goes	Joachimkade	Industrial	300	kraft	45	2019
Vlissingen	Frankrijkweg	Cycling path	300	kraft	45	2019
Vlissingen	Oostenrijkweg	Industrial	250	kraft	50	2019
Sluiskil	Piet Heinstraat	Village	150	kraft	50	2019
Ijzendijke	Turkeijeweg	Provinciaal	800	kraft	50	2019
Vlissingen	Maltaweg	Industrial, 3 layers!	486	kraft	35/35/50	2020
Overijssel	N765 (Kampen)	Provincial	300	kraft	30	2020
Vlissingen	Frankrijkweg	Cycling path	163	kraft	40	2020
Vlissingen	Oostenrijkweg	Industrial	562	kraft	50	2020
Vlissingen	Europaweg	Cycling path	1169	kraft	40	2020
Vlissingen	Engelandweg	Industrial	137	kraft	50	2020
Sluiskil	Industrieweg	Provincial	588	kraft	50	2020

SMA, AC bind,
AC base

Activities 2020-2022 (CHAPLIN projects)

- Realisation of 6 demonstration roads
- AC 11 Surf mixtures with 30% RAP; lignin in new binder
- 1 road in October 2020 with 3 layers bio-asphalt
 - Top layer, bind and base layers
- Lengths 300-600 meters each
- Kraft lignin as bitumen replacement, but also biorefinery lignin from Avantium
- On lab scale, recycling of lignin based asphalt (removed from older road paved in 2015) was successfully tested



State of play

Applications in various countries

- Demo roads 
- Under negotiation 



The business case for (lignin-based) bio-bitumen

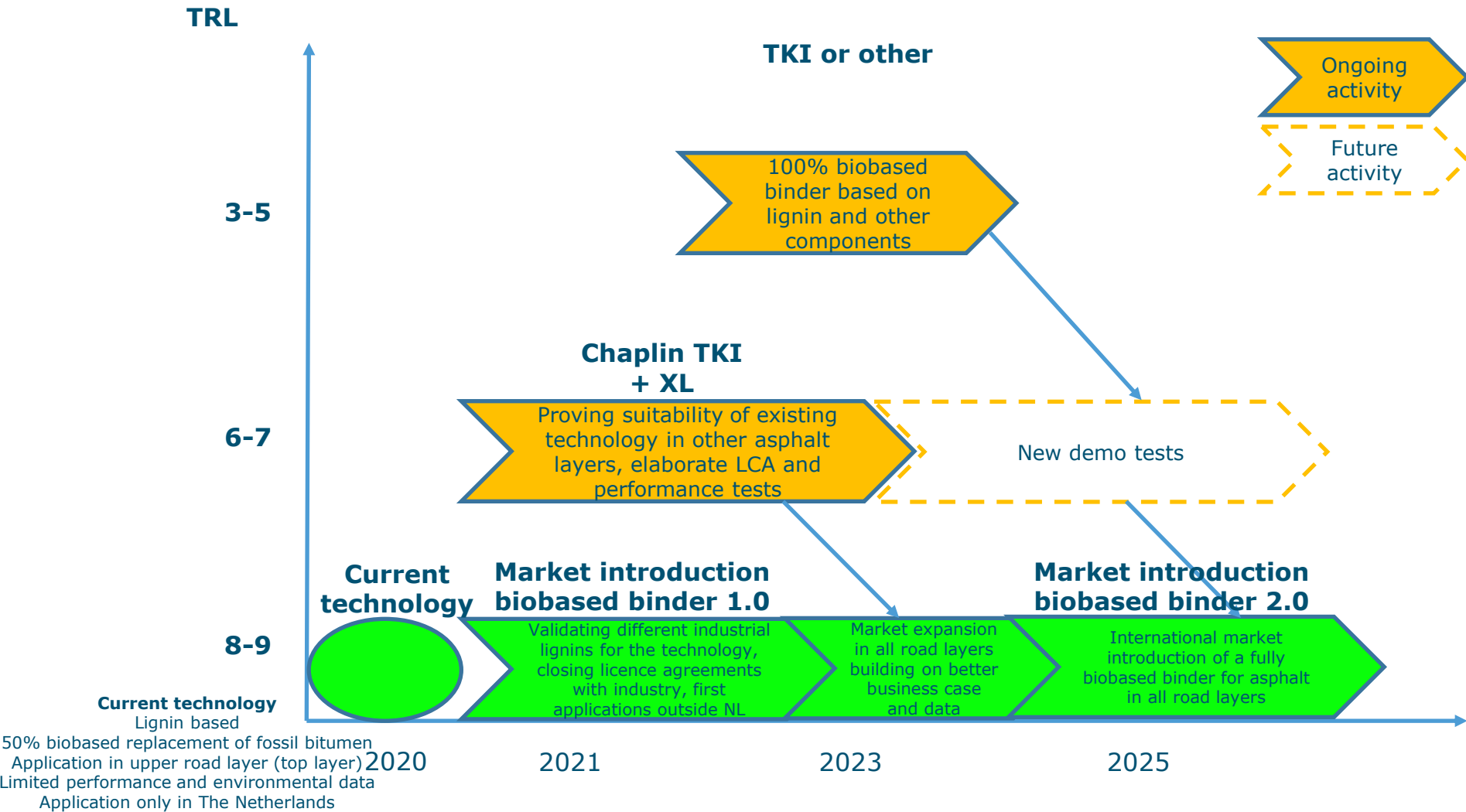
■ Large market:

- Current application in roads where local authorities demand more sustainable biobased materials (even at higher price)
- Bitumen is a huge market (in EU 11 Mton/y; WW 90 Mton/y)
- Fairly low price of bitumen (300 – 500 € / ton), but lignin can act as direct drop-in for biobitumen as soon as price approximates bitumen price
- Additional functionality of lignin binder compared to fossil bitumen can offset any price disadvantages (e.g. polymer modified bitumen)

■ Added value:

- Biobased content with lower CO₂-footprint is of added value to many municipalities, regions and national authorities responsible for road construction and maintenance
- Valorisation of lignin generates extra income to the producer

Our roadmap for a biobased binder for asphalt



Thank you for your attention

Lignine

Groene grondstof voor chemicaliën en materialen

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