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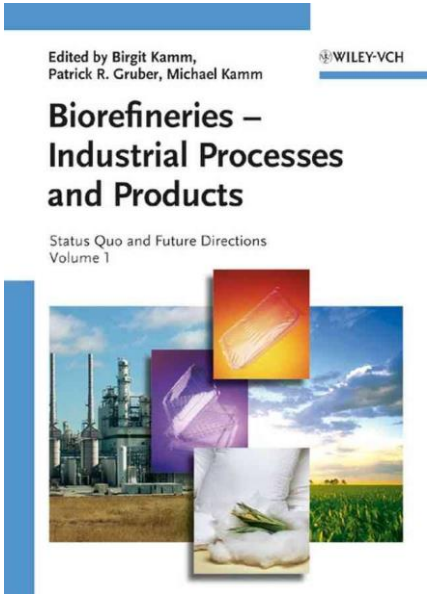
Bioraffineriekonzepte und zugehörige Produkte

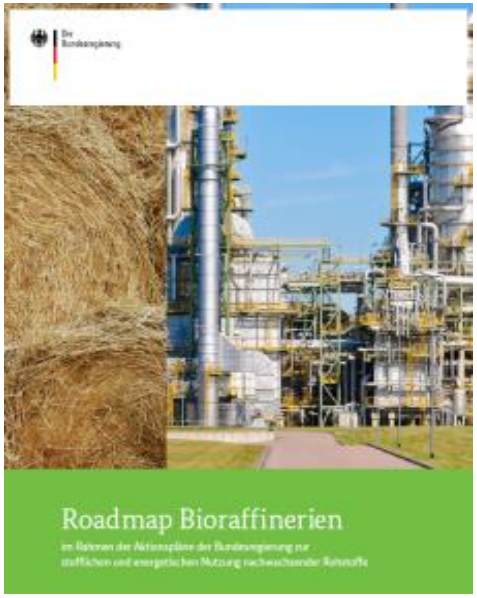
Margit Schulze

Hochschule Bonn-Rhein Sieg, Department of Natural Sciences, 53359 Rheinbach

Münster ▪ NRW-GI FG Ressourcen ▪ November 12, 2019



2002 joint venture **Cargill Dow LLC**
PLA plant in Blair/Nebraska



Roadmap Biorefinery 2012
The German Government

Joint European Biorefinery Vision 2012
HORIZON 2020

2010 Policy of the Chemical Industry
VCI, DECHEMA, DGMK, GDCh

2011: Together for Sustainability http://tfs-initiative.com/

Purpose: "to develop & implement a **global audit program** to assess and improve **sustainability practices** within the supply chains of the chemical industry."

TOGETHER FOR SUSTAINABILITY

AkzoNobel, ARKEMA, BASF We create chemistry, BAYER, BOREALIS Keep Discovering, BRENNTAG, CLARIANT, covestro, DSM, DUPONT, EASTMAN, EVONIK POWER TO CREATE, Henkel, ICL, IFF, LANXESS, MERCK, SANOFI, SOLVAY asking more from chemistry, syngenta, The Biofore Company UPM, WACKER, WANHUA

BRUSSELS— June 5, 2019.

General Assembly of TfS
Election of the new President
Bertrand Conquéret, Henkel,
(2019-21)

2013

CHEMIE³
DIE NACHHALTIGKEITSINITIATIVE
DER DEUTSCHEN CHEMIE

VERBAND DER CHEMISCHEN INDUSTRIE e.V. VCI

Industriegewerkschaft Bergbau, Chemie, Energie IGBCE

BAVC Die ChemieArbeitgeber

*Mit ihrer **Initiative Chemie³** wollen die Allianzpartner von Chemie³, VCI, IG BCE und BAVC, Nachhaltigkeit als Leitbild in der chemischen Industrie verankern.*

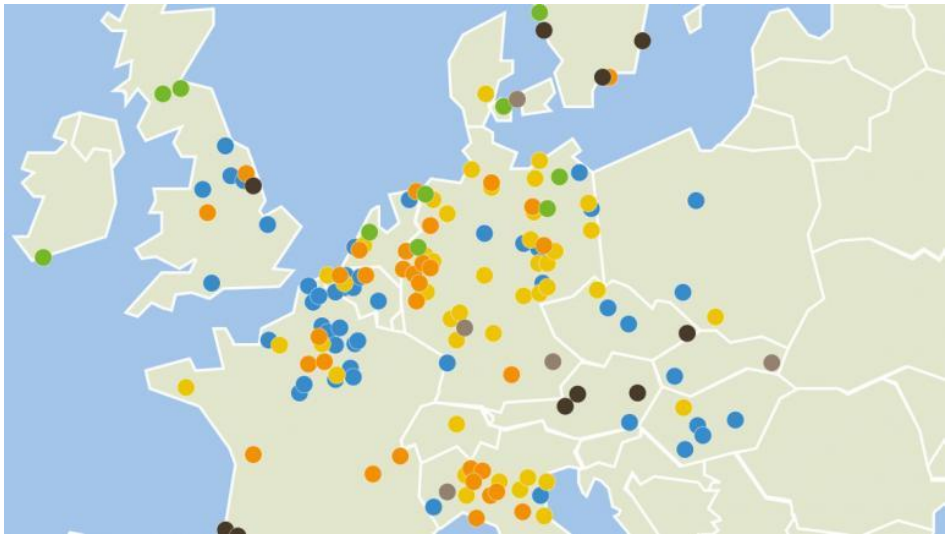
Dazu hat Chemie³ zwölf „Leitlinien zur Nachhaltigkeit für die chemische Industrie in Deutschland“ erarbeitet und unterstützt ihre Mitglieder bei deren Anwendung im Unternehmensalltag.

2017 **ZENTRUM FÜR NACHHALTIGE CHEMIE** ISC3
Bundesumweltministerium und Bundesumweltamt

ISC3
International Sustainable
Chemistry Collaborative Centre

Bioraffinery Categories regarding feedstock and final products

63 **Sugar and starch**-based refineries (bioethanol, secondary products)
64 **Oil and fat**-based refineries (biodiesel)
54 **Oil and fat**-based refineries (oleochemicals, detergents, lubricants)
25 **Wood**-based refineries (excluding paper/pulp prodction)
13 **Waste**-based refineries (e.g. wood chips, straw)



2017-12-04: Nova Institute Wuppertal
Biorefineries in Europe:
https://biooekonomie.de/nachrichten/wo-europa-bioraffinerien-stehen

Biorefineries in Germany:

https://biooekonomie.de/nachrichten/wo-europa-bioraffinerien-stehen

- **Sugar/starch biorefinery**: cereal crops/sugar beet / Südzucker/ CropEnergies in **Zeitz** (Saxony-Anhalt)
https://www.industriepark-zeitz.de/en/businesses/industrial-services/bioraffinerie-elsteraue-gmbh/

- **Wood-based lignocellulosic biorefinery:** LCF / DECHEMA , Fraunhofer CBP / **Leuna** (Saxony-Anhalt)
https://www.cbp.fraunhofer.de/de/forschung/projekte/projekte_rohstoffaufbereitung/lignocellulose-bioraffinerie.html

- **Lignocellulosic biorefinery:** straw / Süd-Chemie company in Munich and **Straubing** (Bavaria)
https://www.clariant.com/en/Company/Contacts-and-Locations/Locations/Europe

BIOÖKONOMIE.DE

Startseite > Printer-friendly > Clariant baut große Bioraffinerie in Rumänien

Sprache Deutsch
02.11.2017

Clariant baut große Bioraffinerie in Rumänien

Das Schweizer Spezialchemieunternehmen Clariant errichtet in Rumänien eine Bioraffinerie für die industrielle Großproduktion von Ethanol aus Pflanzenresten.

Am 31. Oktober hat der Clariant-Verwaltungsrat die Investition in eine neue kommerzielle Großanlage zur Produktion von Cellulose-Ethanol aus Pflanzenreststoffen bekanntgegeben. Zur Anwendung kommt hier die von Clariant entwickelte sunliquid-Technologie. Dieses Verfahren testet Clariant bereits seit fünf Jahren in einer Demonstrationsanlage im bayerischen Straubing [1]. Die neue Anlage mit einer jährlichen Produktionskapazität von 50.000 Tonnen wird im Südwesten Rumäniens errichtet. Die Einrichtung soll als Referenzanlage die Wettbewerbsfähigkeit und Nachhaltigkeit der sunliquid-Technologie im kommerziellen Maßstab unter Beweis stellen.

ATB Pilot plant for the production of lactic acid
(Foto: ATB)

Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB) Potsdam

- Pilot plant designed as an industrial demonstration plant with limited production capacity
- Major product **lactic acid** (up to 10 tons/year)

Objectives:

- Sample provision for industry and research
- Feasibility of bioconversion products
- Data collection for further scale-up

Contact: Dr. Joachim Venus
www.atb-potsdam.de

Biorefinery Feedstock, Platform and Products

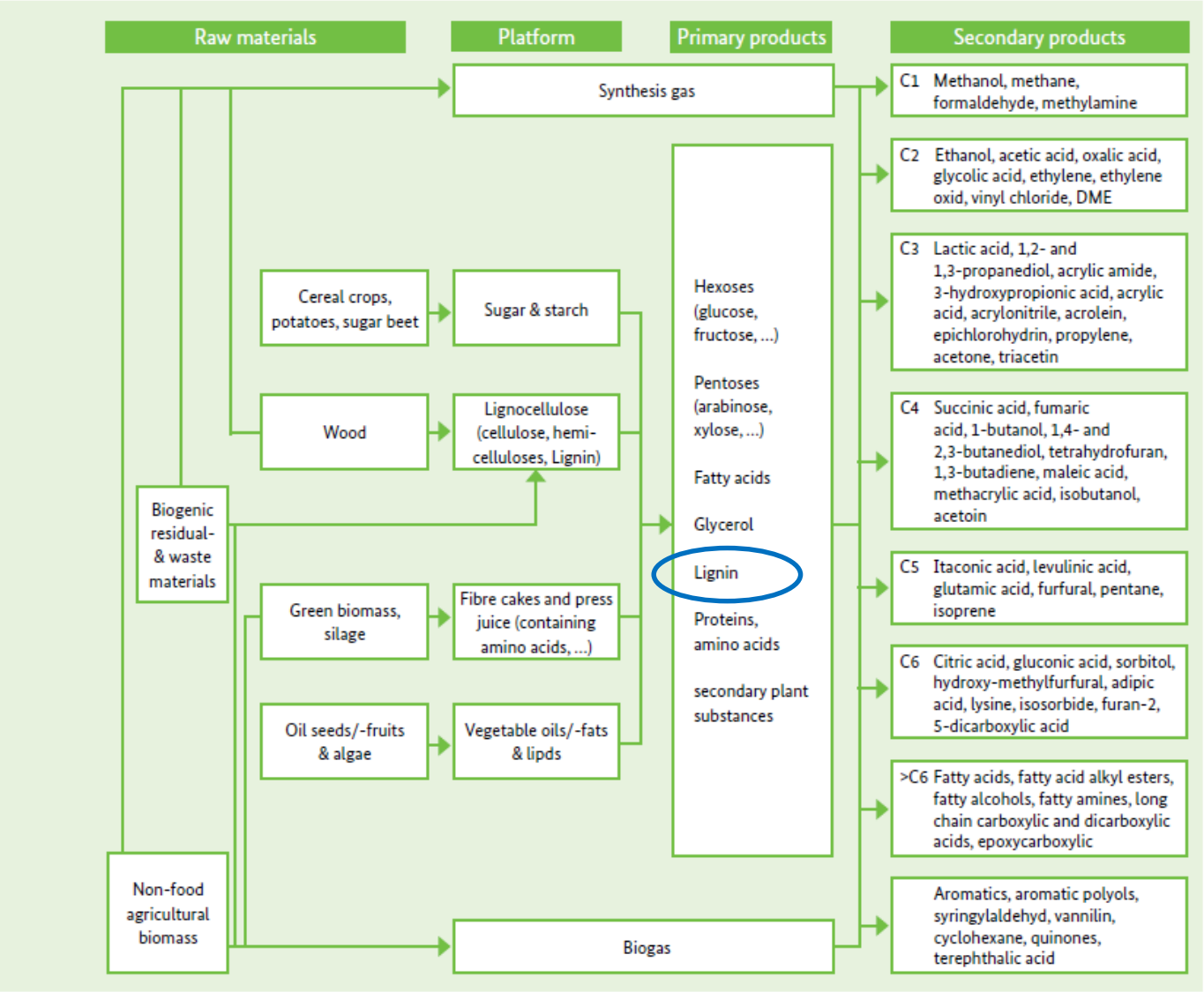
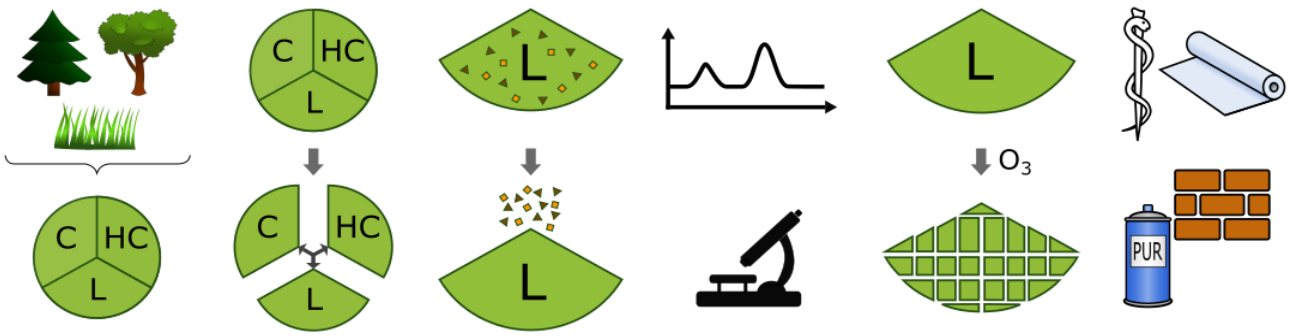


Figure 33: Products from biorefineries (selection)

Lignocellulose Feedstock (LCF) – a Renewable Resource for Energy and Material Development

Cellulose (C), Hemicellulose (HC), Lignin (L)



Biomass ▪ **Pulping** ▪ **Purification** ▪ **Analysis** ▪ **Modification** ▪ **Application**

- Wood
- Grass

- Kraft
- Organosolv

- SEC, NMR
- SAXS/WAXS, CT-EM

- Demethylation
- Depolymerisation

El Khaldi-Hansen *et al.* (**2016**) In: **Analytical Techniques and Methods for Biomass**.Springer.
Alzagameem et al. (**2018**) In: **Biomass and Green Chemistry**. Springer
Alzagameem *et al.* (**2019**). *Appl. Sciences*, MDPI

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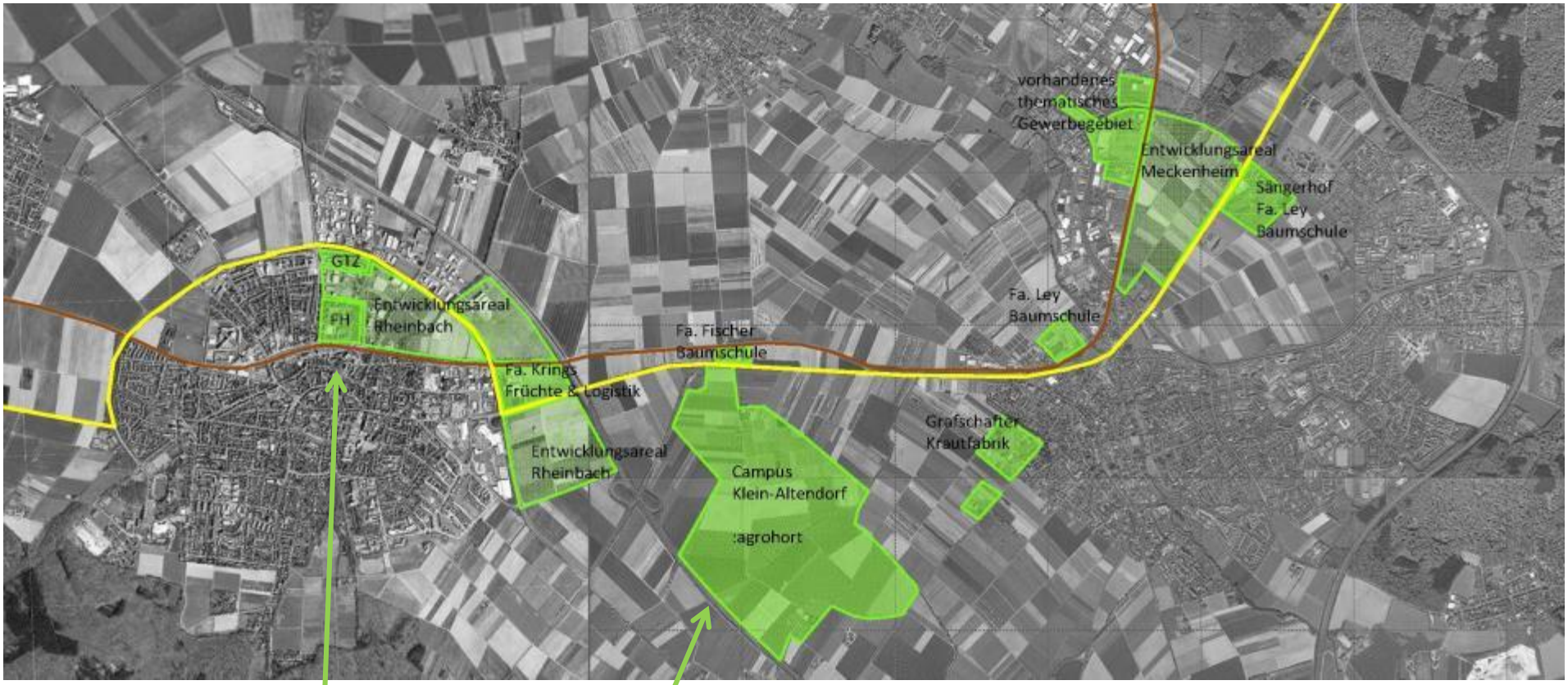
***bio innovation park* Rheinland**



H-BRS and **University Bonn/Campus Klein-Altendorf** (180 ha)
City of **Rheinbach**

Nov 28, 2019: ab 8:30 Uhr Unternehmer-Frühstück
am Campus Rheinbach

Renewable Resources at Campus Klein-Altendorf

Miscanthus x giganteus

Paulownia tomentosa

Silphium perfoliatum

Lignocellulose Feedstock

Company	Pulping Process	Capacity (t/a)
Alfeld (SAPPI)	Mg sulfite	130.000
Ehingen (SAPPI)	Mg sulfite	130.000
Mannheim (SCA)	Mg sulfite	220.000
Stockstadt (SAPPI)	Mg sulfite	140.000
Blankenstein (Mercer)	**Kraft**	**300.000**
Stendal (Mercer)	**Kraft**	**600.000**



- Global annual availability ca. 70 Mio t
- Annual growth rate of 2 % until 2023.
- Increasing total market size: US$ 904 Mio in 2017 to US$ 1021 Mio in 2023.

Benchmark: energetic use of blak liquor.

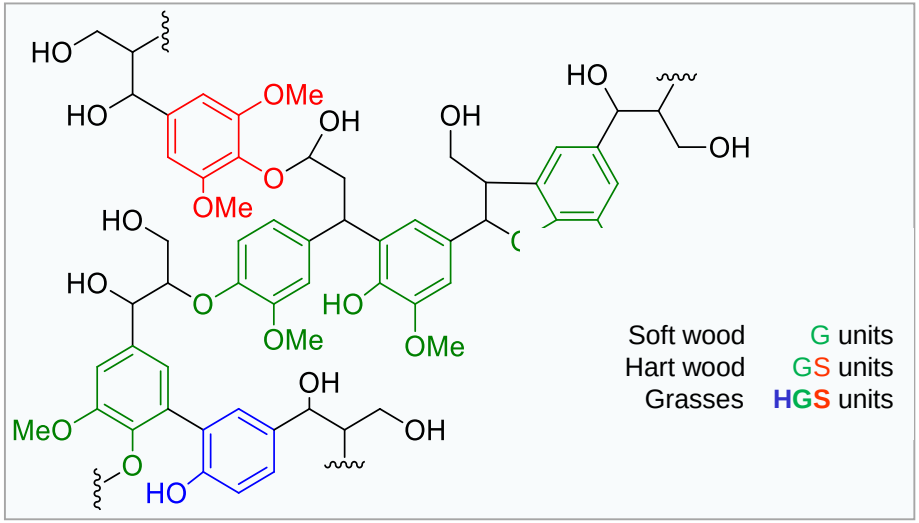
Lignin Market - Forecasts from 2018 to 2023. ID: 4479455. Report February 2018.

Lignin Composition & 3D Structure

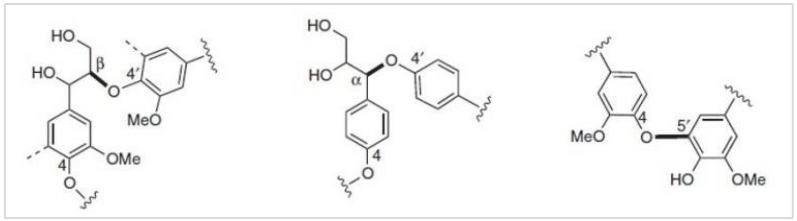
Approaches in lignin research

1. **Exploitation of unmodified lignin**
   and improve access to functional group
   (via optimizing the isolation process)

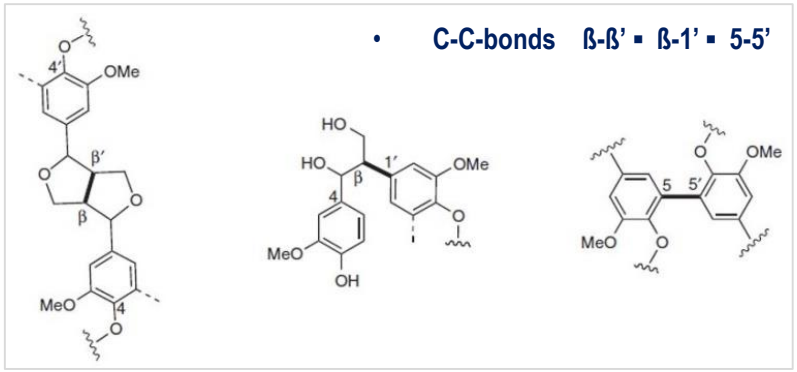
2. **Chemical modification of lignin**
   functionalization versus depolymerization



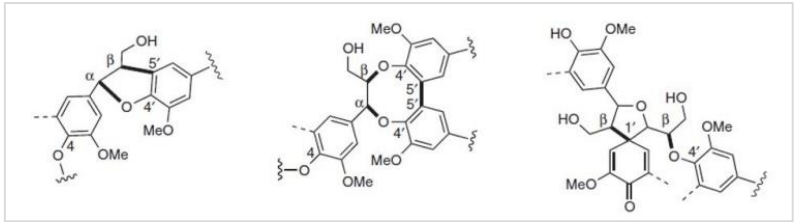
- ether bonds ß-O-4' ▪ α-O-4' ▪ 4-O-5'



- C-C-bonds ß-ß' ▪ ß-1' ▪ 5-5'



- more complex linkages



Alzagameem A *et al.* (**2018**) Molecules 23, 2664.
doi:10.3390/molecules23102664

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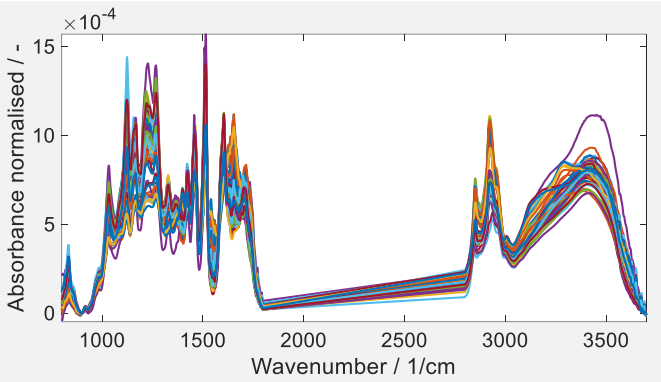
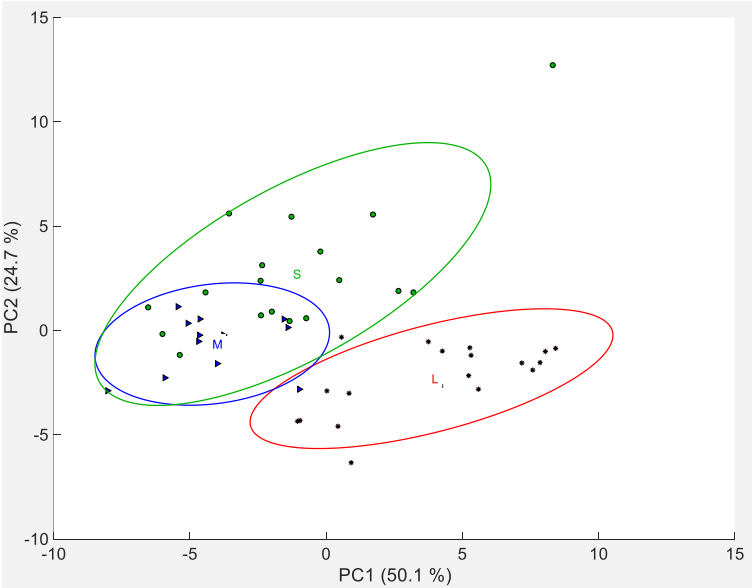
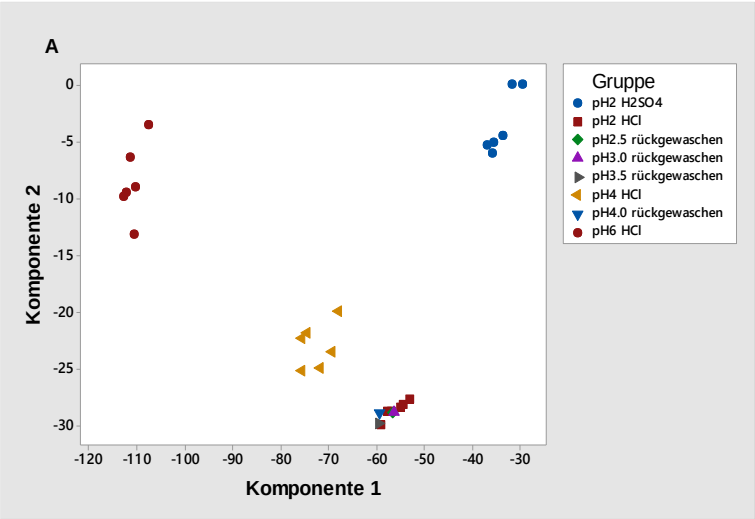
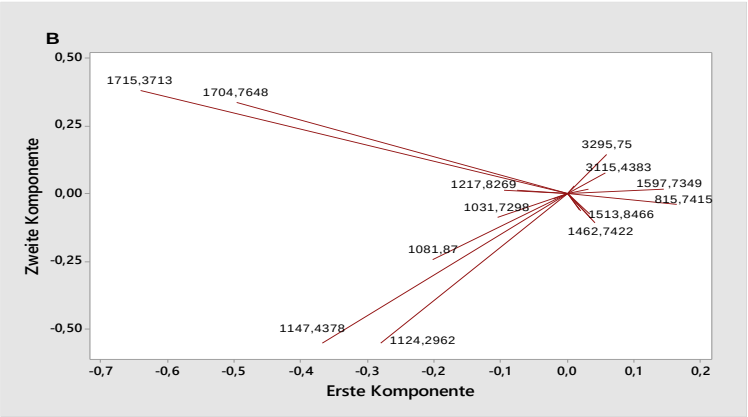
LCF Analysis and Quality Control





PCA plot: 95 % confidence intervals. Leaf lignins (L) *versus* stem lignins (S). Mixture lignins (M) behave like stem lignins (S).





Monakhova *et al.* (**2018**) *J Pharm Biomed Anal*. 149, 128-132.
Bergs et al. (**2019**) *Int. J. Mol.* Sci. 20, 1200.

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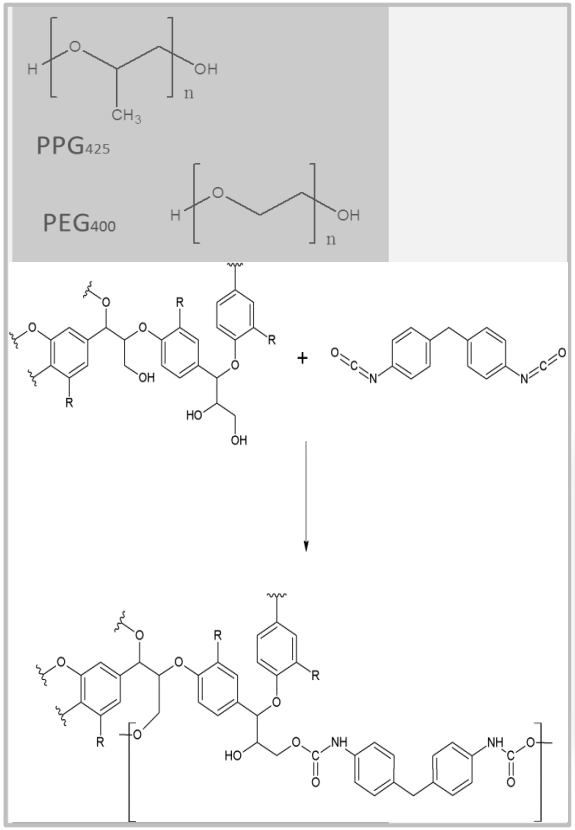
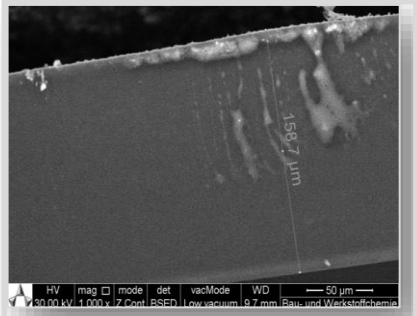
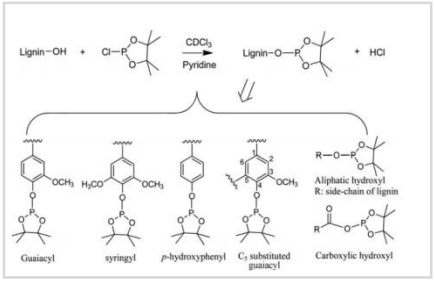
Lignin-based Polyurethanes

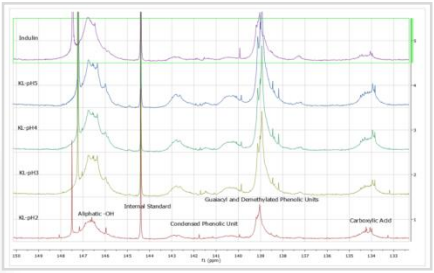


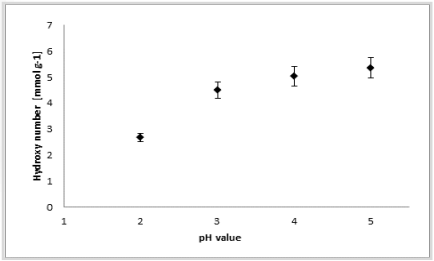
homogeneous ▪ transparent
flexible spin coat films

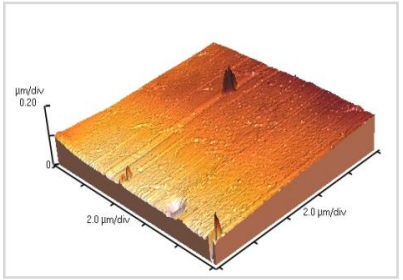


SEM average thickness 160 µm









color modification: ink/carbon

lignin content increase up to 80 %

Klein *et al.* (**2018**).
Manuscript ID: RA-ART-10-2018-008579.

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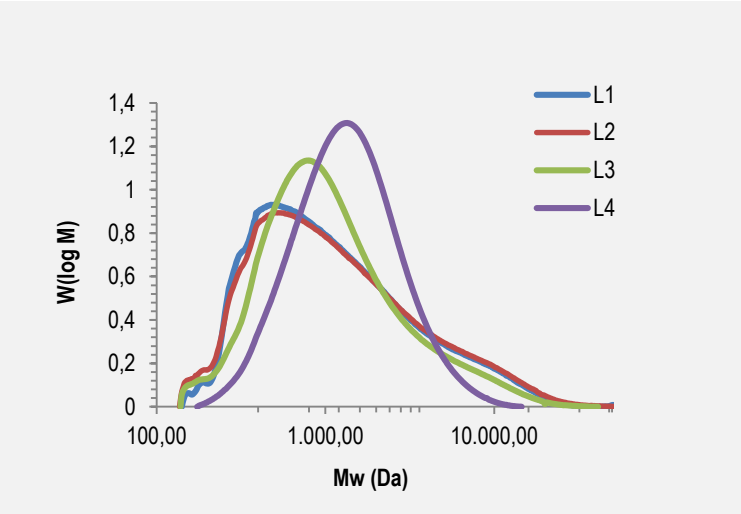
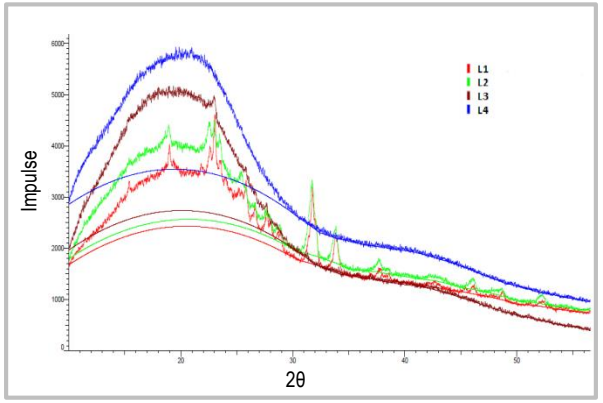
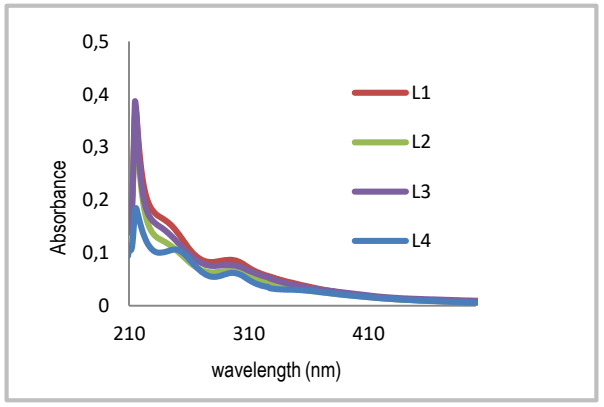
Lignin Antioxidant Activity



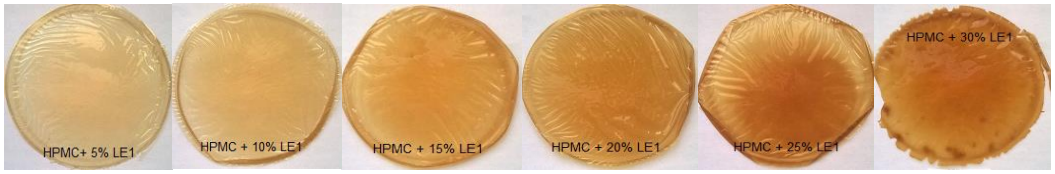
Fraction	PD
L1	2.9
L2	3.2
L3	2.4
L4	1.6





DPPH Inhibitions / Total Phenolic Content (TPC): kraft *versus* organosolv lignins (beech, spruce/pine.

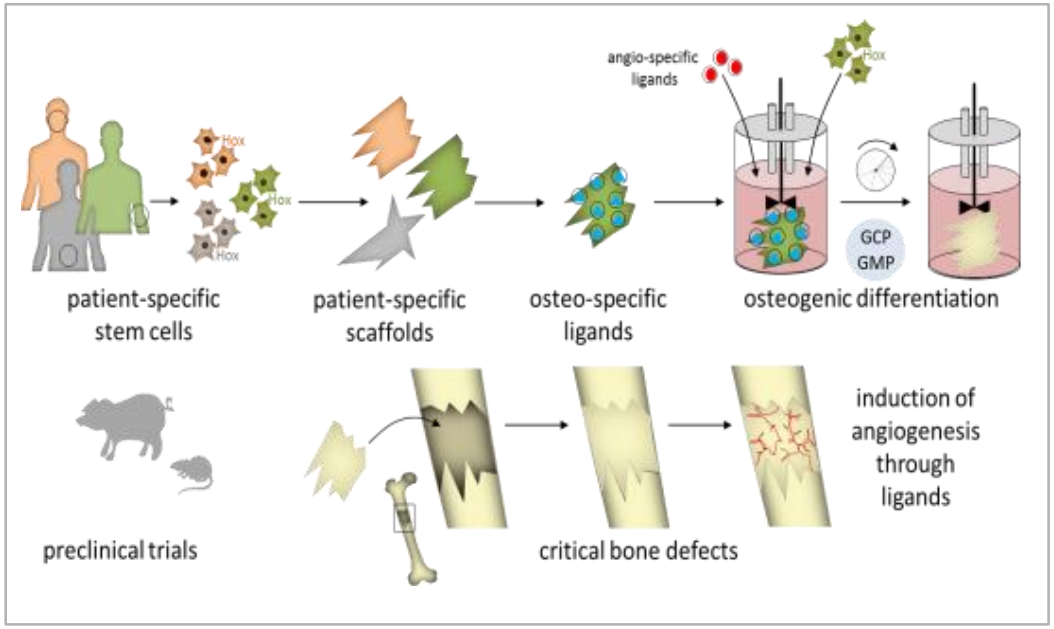
	L1	L2	L3	L4	DL	OLSW	Lit. [30]
DPPH inhibition (%)	65.1 ± 3.7	66.8 ± 6.6	62.2 ± 9.5	68.2 ± 3.6	64 ± 2.6	42 ± 1.9	54.76
TPC (%)	30 ± 1.2	26.8 ± 0.5	33.5 ± 0.9	35 ± 1.0	33.3 ± 1.6	34.1 ± 1.0	29.61

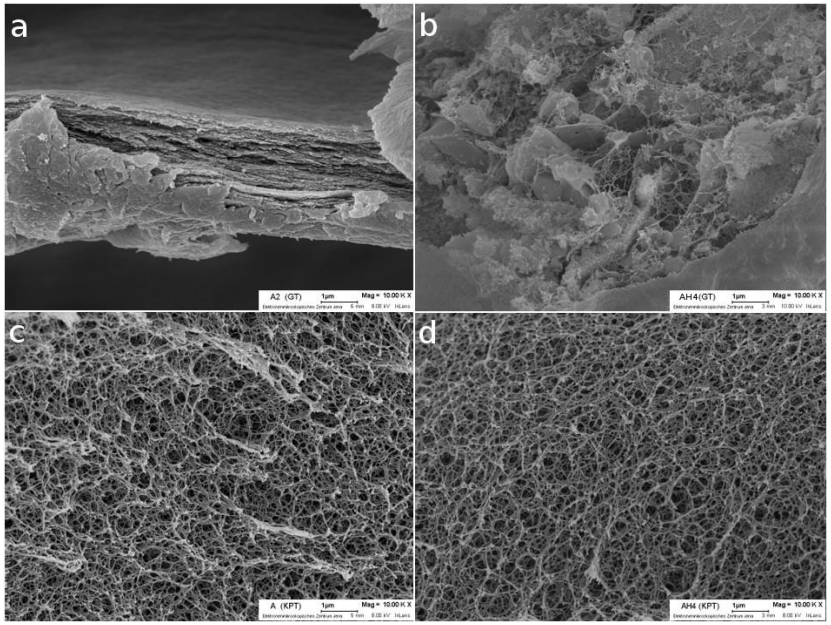


Lignin-based films with hydroxypropyl methylcellulose (HPMC)
From left to right 5, 10, 15, 20, 25 and 30 weight % lignin

Alzagameem *et al.* (**2018**), Molecules 23:2664.
doi:10.3390/molecules23102664.

LCF/Polysaccharides Used in Biomedicine





Schulze & Tobiasch (**2012**). In: **Tissue Engineering** III. Springer.
Leiendecker *et al.* (**2016**) **Curr Stem Cells Res Therapy** 12:103-123.
Ottensmeyer et al. (**2018**) *Int. J. Mol. Sciences* 19, 306.
Götz et al. (**2019**) *Pharmaceutics* 11, 117.

Witzler *et al.* ACS Spring Meeting, April, **2019**.
Witzler *et al.* (**2019**) *Int. J. Mol. Science*, 20(14, 3565.

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Biobased Polymers for Construction and Packaging

- **Lignin-based Polymers for Construction Applictions,** BMBF IngenieurNachwuchs (2014-2018)
  University Bonn, DLR Köln, Henkel Düsseldorf
  - Dr. Basma El Khaldi-Hansen (BTU Cottbus, 10.03.2015)
  - Dr. Michel Bergs (University Bonn, 20.12.2018)
  - Abla Alzagameem (BTU Cottbus, Thesis submitted)
  - Stephanie Klein (TU Darmstadt)

- **Biobased Materials** EFRE Program EU/NRW (2017-2020)
  University Bonn / CKA, >25 regional SME
  - Jessica Rumpf (University Bonn)

- **LCF and Biopolymer Analysis Using Chemometrics**, BMBF FHprofUnt (2019-2022)
  TU Darmstadt / Helmholtz Geesthacht, Spectral Service AG, Uni Wellington/NZ
  - Xuan-Tung Do (TU Darmstadt)
  - Rene Burger (TU Darmstadt)

- *Submitted to* BMEL/FNR: **LCF for Packaging Applications**
- *Submitted to* DFG: **Application methodology of machine learning and quantum computing tools in analysis and structure elucidation of LCF**

Biocompatible Polymers for Drug Release and Tissue Regeneration

- **Personalised Cell-based Implantates for Bone Defects of Critical Size** BMBF (2015-2019)
- **TestMedgO** NRW Zeit für Forschung (2017-2020)
  Universities Jena, Düsseldorf, Heidelberg, Münster, botiss biomaterials (straumann group)
  - Markus Witzler (University Jena)

- **Hybrid-Materials for Bone Regeneration** BMBF (2019-22)
  Universities Jena, Bonn and Bochum, Artoss GmbH, Spectral Service AG
  - Dominik Büchner (University Jena)

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Europäischer Fonds für regionale Entwicklung

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Prof. Dr. Thomas Heinze, Uni Jena
Prof. Dr. Bernd Diehl
Prof. Dr. Yulia Monakhova

Prof. Dr. Edda Tobiasch (HBRS)
Prof. Dr. Steffen Witzleben (HBRS)

Postdoc ▪ PhDs
Dr. Basma Hansen
Dr. Michel Bergs
Abla Alzagameem
Stephanie Klein
Xuan Tung Do
Jessica Rumpf
Markus Witzler
Dominik Büchner

Students ▪ Scholars
Sandra Brück
Sönke Martienßen
Linda Wiedemann

Christopher Konow, U.S.
Michael Larkins, U.S.
Maddie Picket, U.S.

DAAD RISE

Ministerium für Innovation, Wissenschaft und Forschung des Landes Nordrhein-Westfalen

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FKZ: 54669218 ▪ BMBF-AIF ▪ FKZ: 1720X06
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