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Estonian University of Life Sciences
Metsanduse ja inseneeria instituut
Institute of Forestry and Engineering

Biorefining – the Future of Biomass Valorisation

Timo Kikas

Professor

Chair of Biosystems Engineering

Institute of Forestry & Engineering

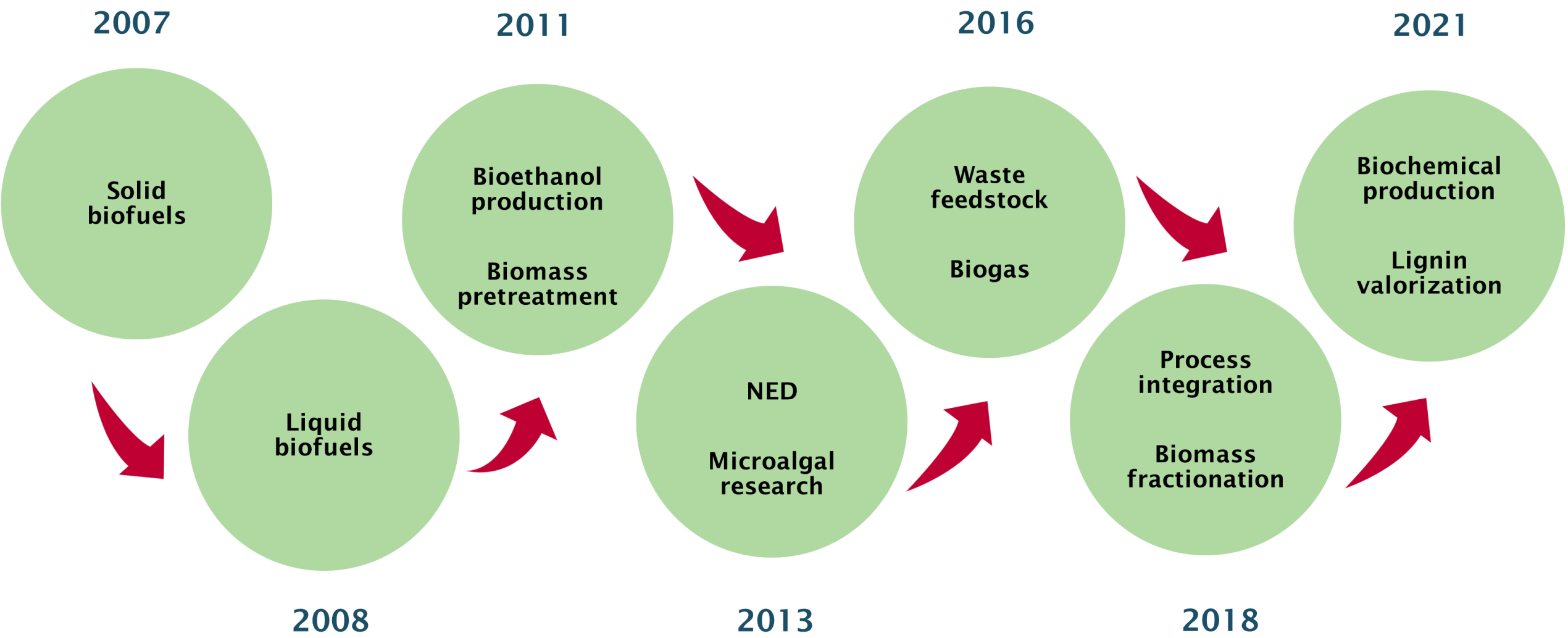
Estonian University of Life Sciences

Estonian University of Life Sciences

Estonian University of Life Sciences

- EMÜ - Leading institution in Estonia - biosciences, agriculture, forestry, and environmental sustainability.
- EMÜ ranks #54 in QS WUR Ranking By Subject 2024 in the field of “Agriculture and Forestry”.
- EMÜ’s mission aligns with Estonia's national strategy for sustainability and development of a bioeconomy.
- EMÜ focus - solving global challenges - research in renewable resources, biorefinery systems, and agriculture.

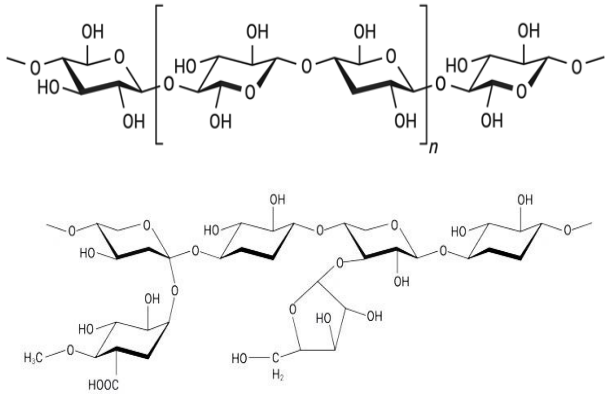
Chair of Biosystems Engineering (BSE): Research areas



Conventional lignocellulosic biorefineries

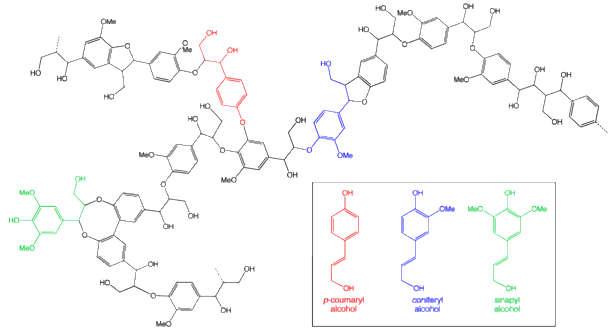
Virgin lignocellulosic biomass

Biorefinery

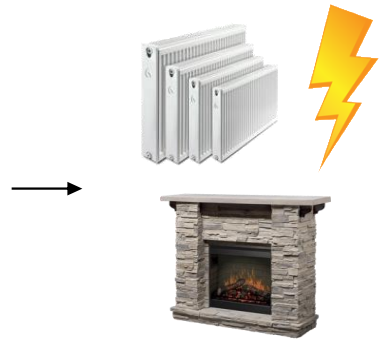


Cellulose and hemicellulose

Fuels, chemicals, and materials



Lignin



Heating and energy

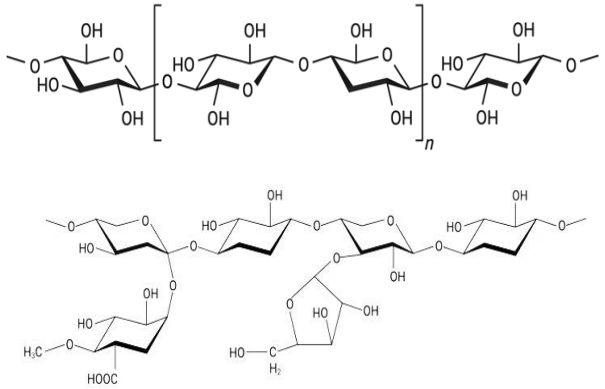
Forestry, agricultural, and associated industrial waste

Heating

Conventional lignocellulosic biorefineries

Virgin lignocellulosic biomass

Biorefinery

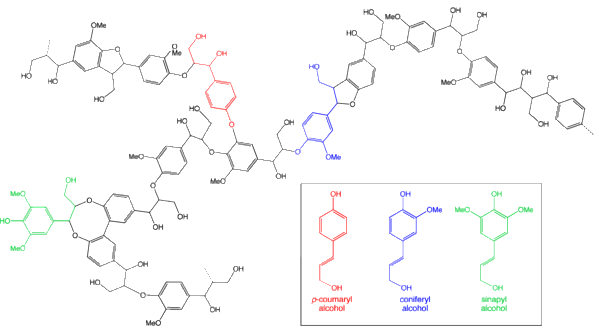


Cellulose and hemicellulose

Fuels, chemicals, and materials

Heating

Forestry, agricultural, and associated industrial waste



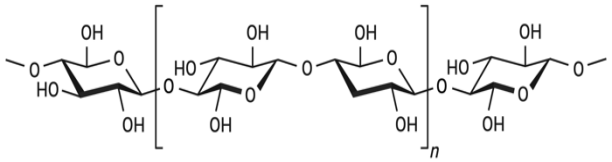
Lignin

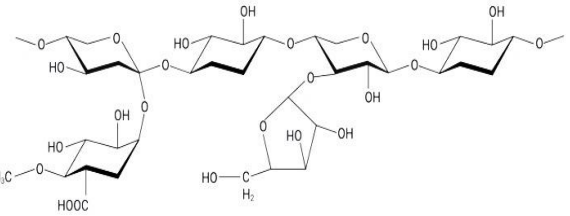
Heating and energy

Lignocellulosic biorefineries from waste biomass

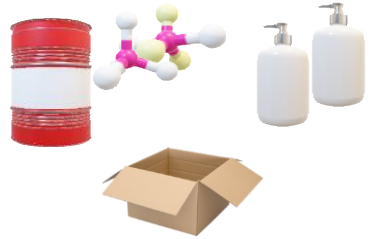
Forestry, agricultural, and associated industrial waste

Biorefinery

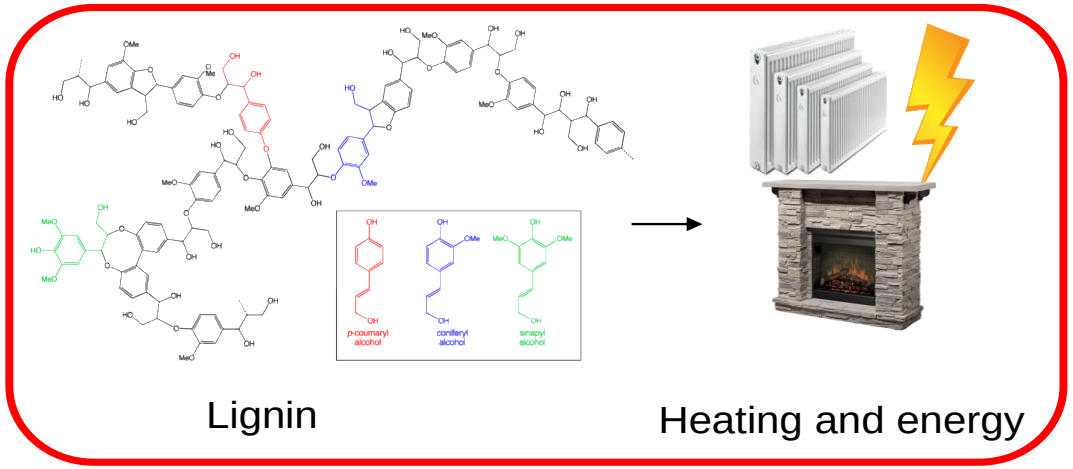




Cellulose and hemicellulose



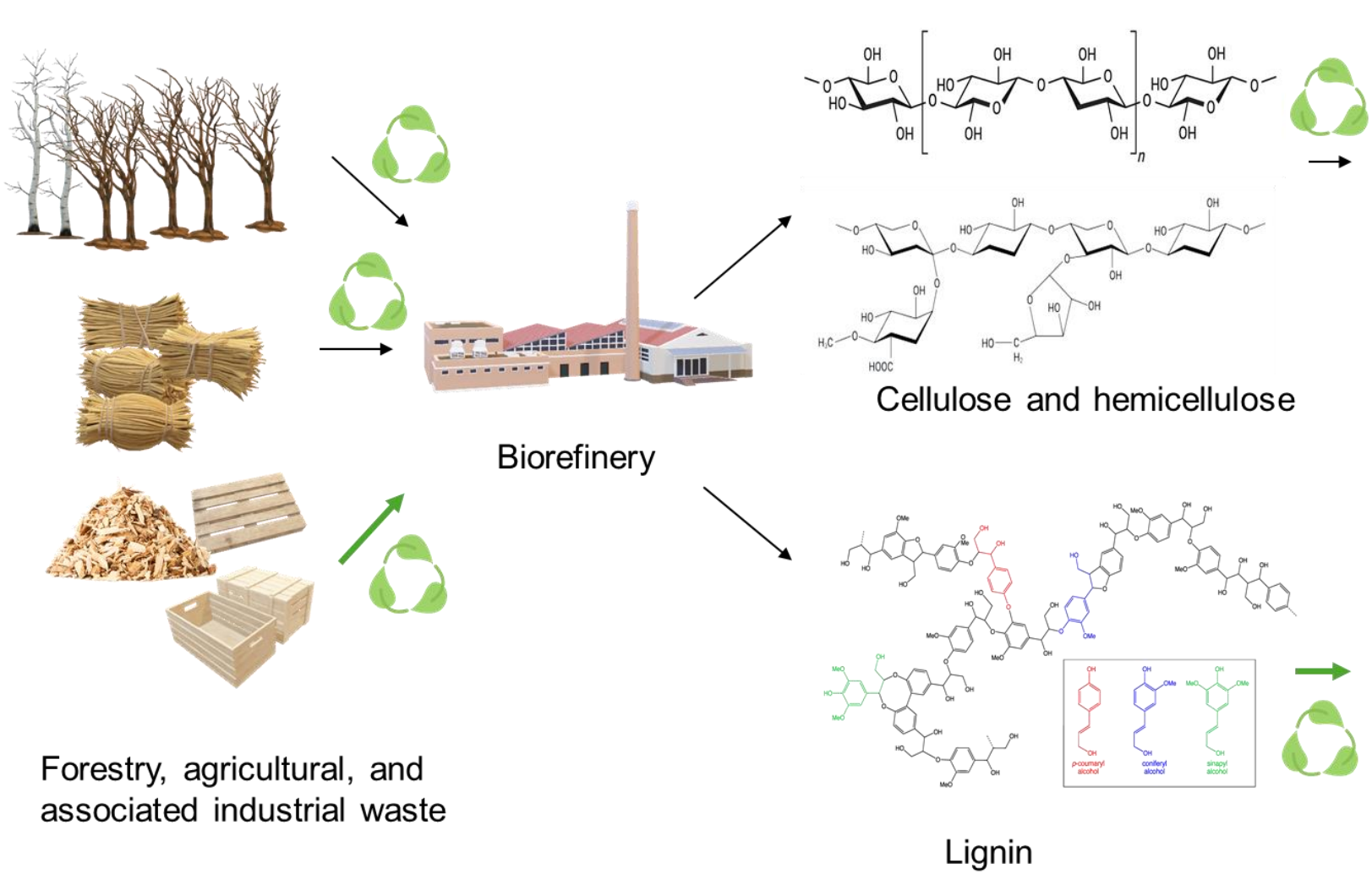
Fuels, chemicals, and materials



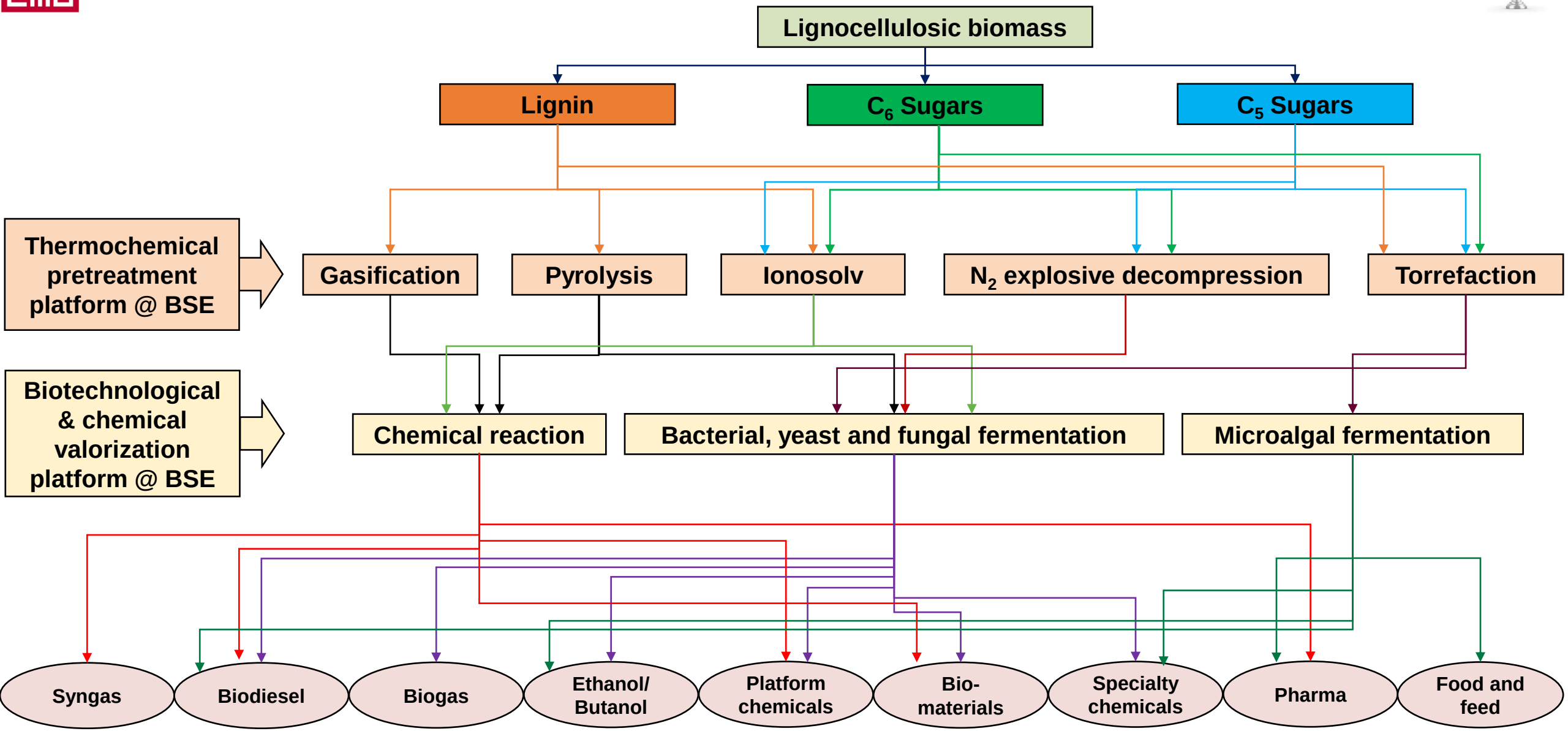
Lignin

Heating and energy

Group focus: Complete waste biomass valorization

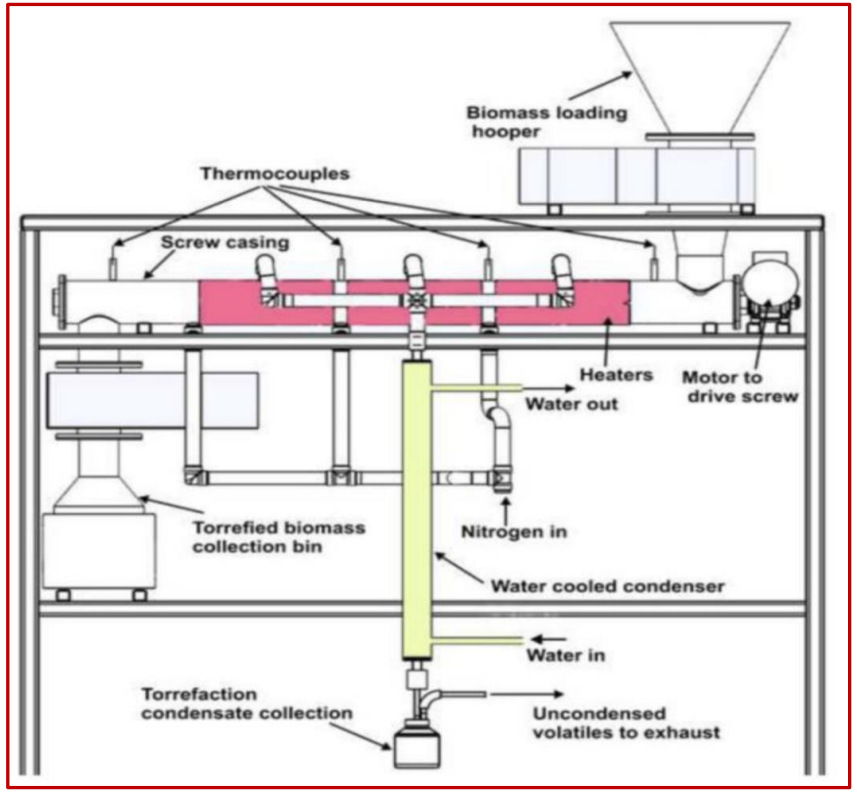


Biorefinery technology platform



Torrefaction
(Thermochemical pretreatment platform)

Torrefaction reactor



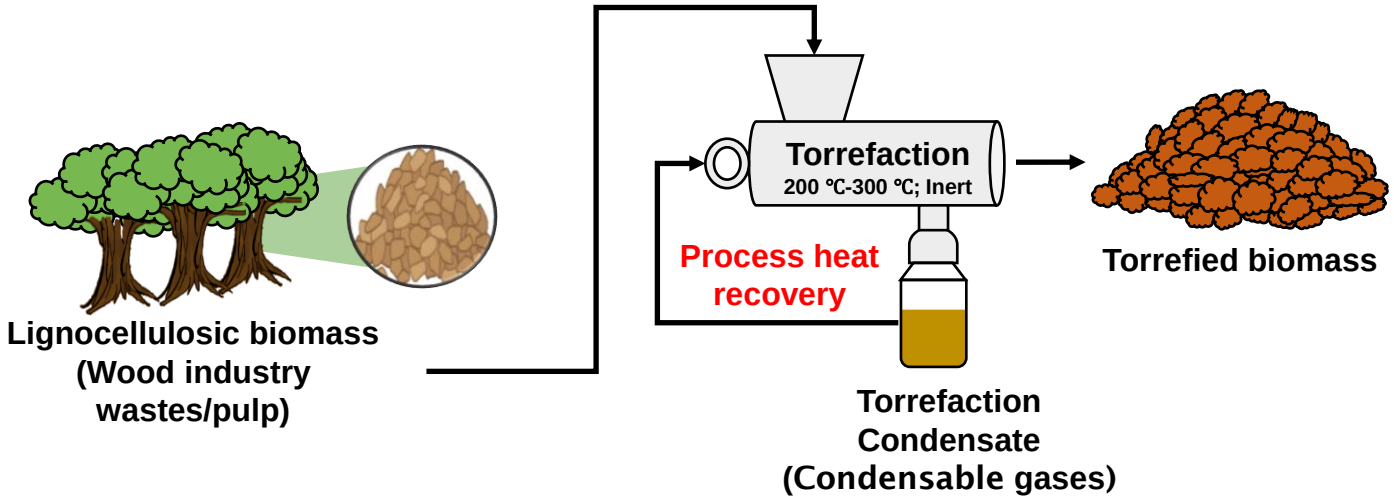
(Image: Cahyanti et al., 2021)

Selective hemicellulose removal

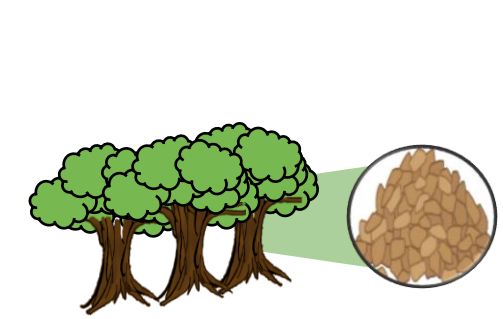
Low inhibitor concentration

Low grinding energy requirement

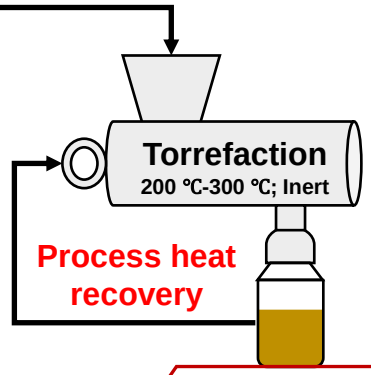
Biomass torrefaction product distribution

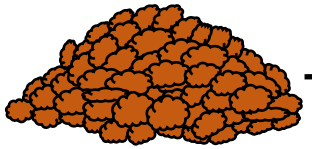


Biomass torrefaction product distribution



Lignocellulosic biomass
(Wood industry
wastes/pulp)





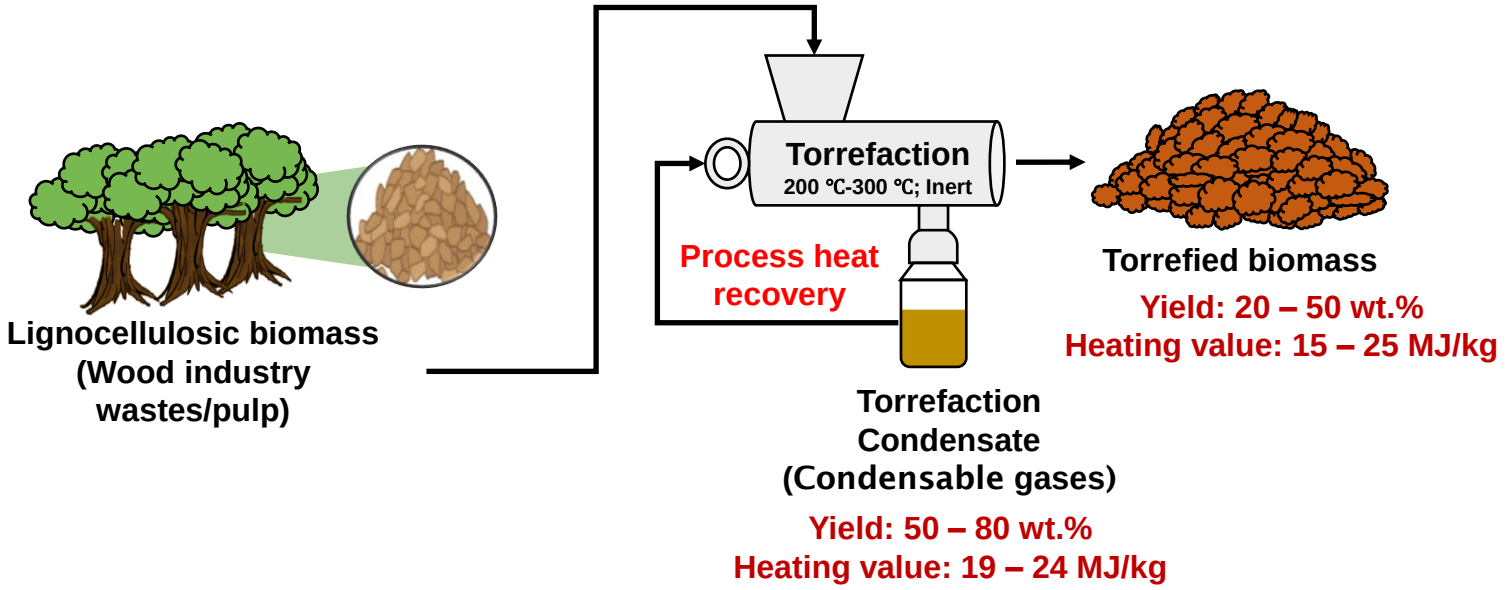
Torrefied biomass

Raw aspen biomass and aspen
biomass torrefied at 225 °C – 300 °C

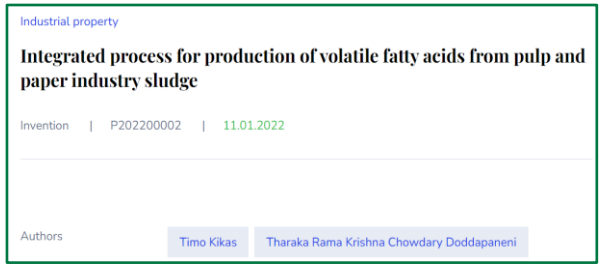
Torrefaction
Condensate
(Condensable gases)

Water (50%-80%)
Acetic acid (5%-8%)
Formic acid – (1%-2%)
Propionic acid
Lactic acid
Formaldehyde
Acetaldehyde
Furfural
5-Hydroxymethylfurfural
Methanol

Biomass torrefaction product distribution



Patents and publications


Industrial property

Integrated process for production of volatile fatty acids from pulp and paper industry sludge

Invention | P202200002 | 11.01.2022

Authors

Timo Kikas

Tharaka Rama Krishna Chowdary Doddapaneni


Bioresource Technology

Volume 301, April 2020, 122737

Review

Biomass torrefaction: An overview on process parameters, economic and environmental aspects and recent advancements

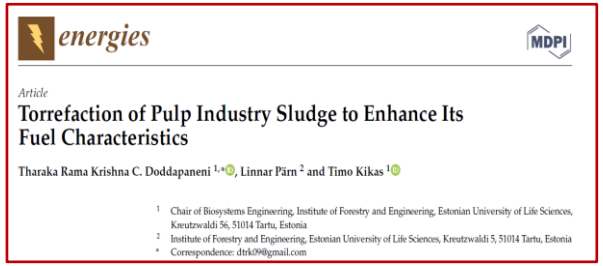
Margareta Novian Cahyanti, Tharaka Rama Krishna C. Doddapaneni, Timo Kikas


Chemical Engineering Journal Advances

Volume 14, 15 May 2023, 100463

Integrating torrefaction of pulp industry sludge with anaerobic digestion to produce bioenergy and biochemicals: Techno-economic and environmental feasibility analysis

Tharaka Rama Krishna C. Doddapaneni, Timo Kikas


energies

MDPI

Article

Torrefaction of Pulp Industry Sludge to Enhance Its Fuel Characteristics

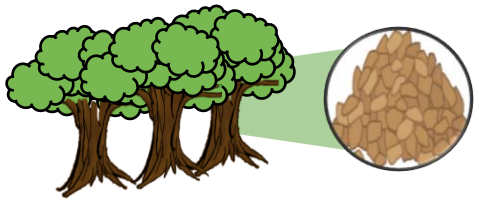
Tharaka Rama Krishna C. Doddapaneni [1,*], Linnar Pärn [2] and Timo Kikas [1]

[1] Chair of Biosystems Engineering, Institute of Forestry and Engineering, Estonian University of Life Sciences, Kreutzwaldi 56, 51014 Tartu, Estonia

[2] Institute of Forestry and Engineering, Estonian University of Life Sciences, Kreutzwaldi 5, 51014 Tartu, Estonia

* Correspondence: dtrk09@gmail.com

Advanced application of torrefaction products



Wood industry wastes

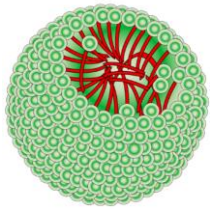
Torrefaction
200 ℃-300 ℃; Inert

Process heat recovery

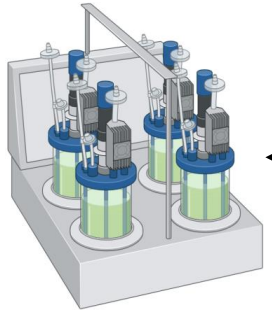
Torrefaction Condensate (Condensable gases)

Torrefied biomass

Microbial submerged fermentation



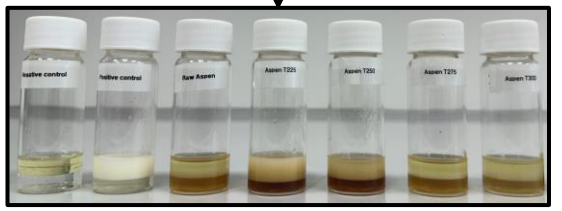
Biosurfactant production



Separation & purification

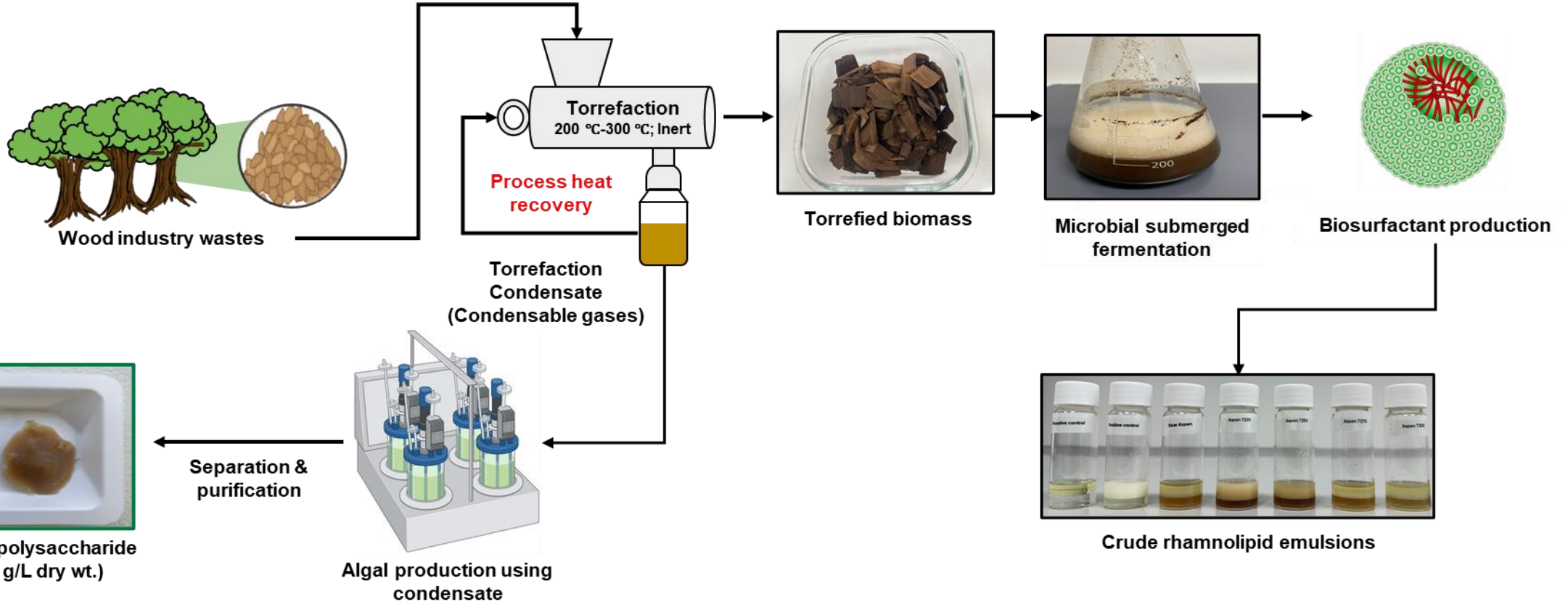
Algal exopolysaccharide (0.439 g/L dry wt.)

Algal cultivation using condensate



Crude rhamnolipid emulsions

Advanced application of torrefaction products



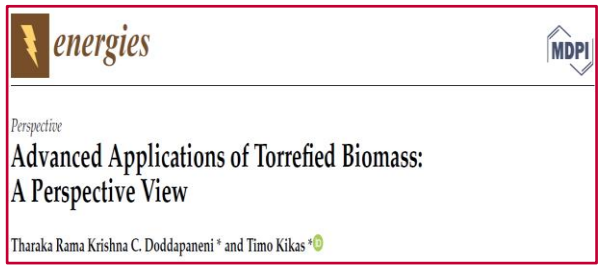
Patents and publications


Industrial property

Torrefaction based integrated process to produce surfactants and exopolysaccharides (EPS)

Invention | P202200006 | 20.04.2022

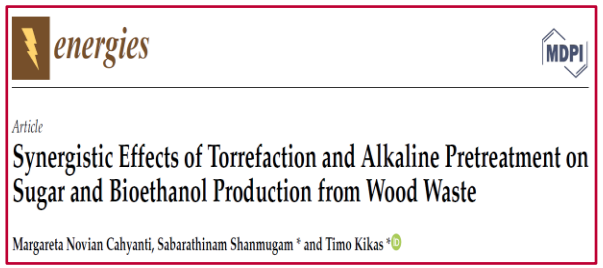
Authors Timo Kikas Tharaka Rama Krishna Chowdary Doddapaneni


energies MDPI

Perspective

Advanced Applications of Torrefied Biomass: A Perspective View

Tharaka Rama Krishna C. Doddapaneni * and Timo Kikas *


energies MDPI

Article

Synergistic Effects of Torrefaction and Alkaline Pretreatment on Sugar and Bioethanol Production from Wood Waste

Margareta Novian Cahyanti, Sabarathinam Shanmugam * and Timo Kikas *


ELSEVIER Environmental Research

Volume 251, Part 2, 15 June 2024, 118665

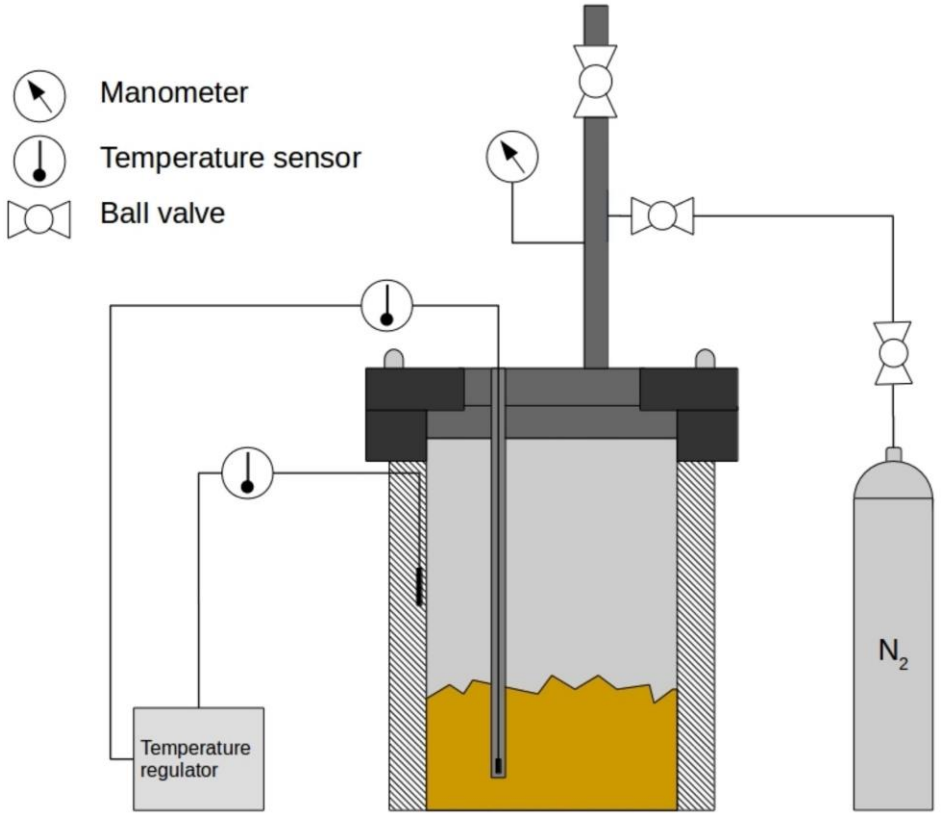
Review article

Common operational issues and possible solutions for sustainable biosurfactant production from lignocellulosic feedstock

Anjana Hari, Tharaka Rama Krishna C Doddapaneni, Timo Kikas

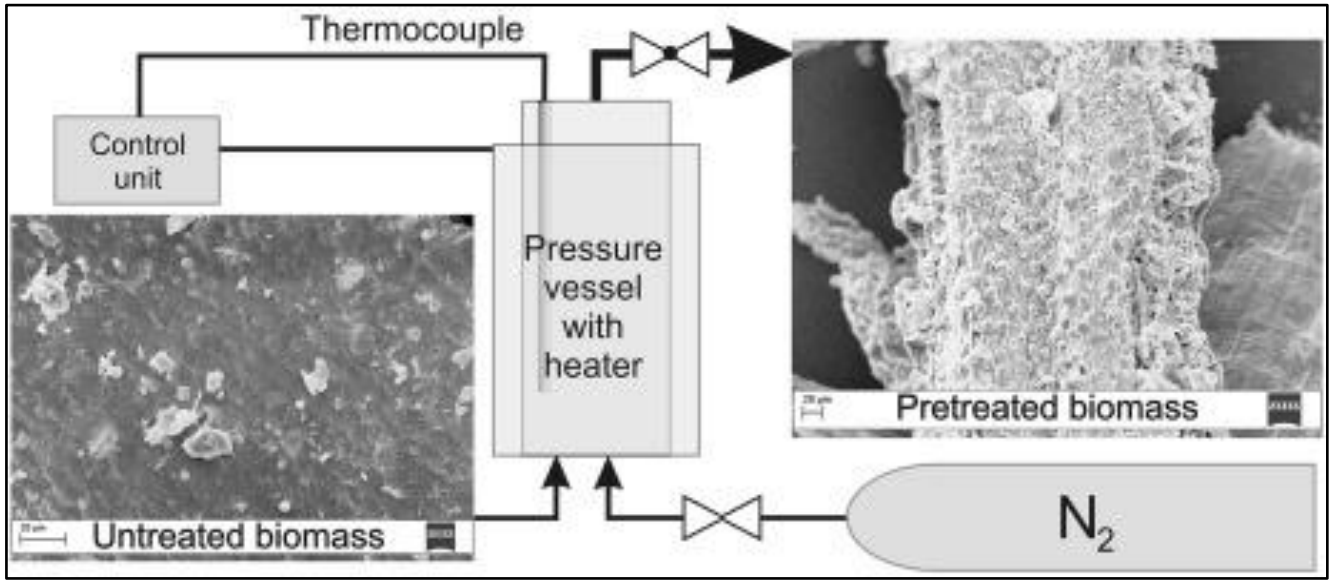
Nitrogen explosive decompression (NED)

NED reactor



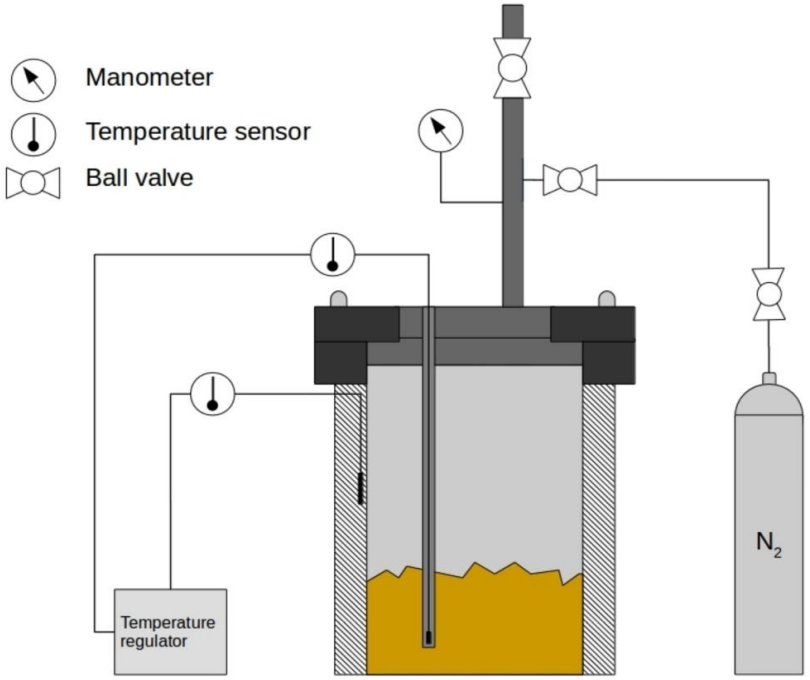
(Image: Sjulander and Kikas, 2022)

N_2 explosive decompression pretreatment of biomass



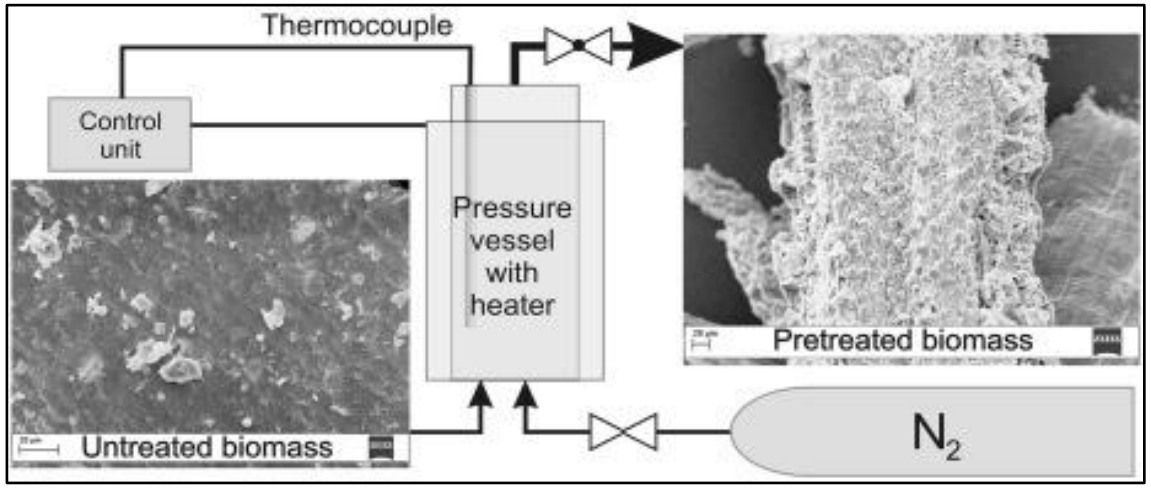
Nitrogen explosive decompression (NED)

NED reactor



(Image: Sjulander and Kikas, 2022)

N_2 explosive decompression pretreatment of biomass



Patents and publications


Industrial property

Nitrogen explosion pretreatment method for disruption of cellular structure of biomass

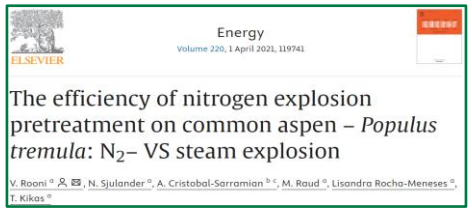
Invention | P201400050 | 30.12.2014

Authors: Timo Kikas, Merlin Raud, Marti Tutt, Jüri Olt


Energy
Volume 177, 15 June 2019, Pages 175-182

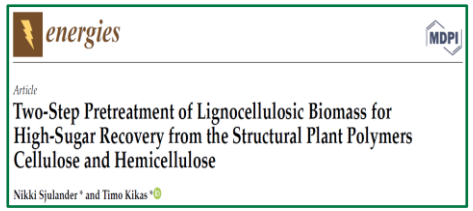
Nitrogen explosive decompression pre-treatment: An alternative to steam explosion

M. Raud, K. Krennhuber, A. Jäger, T. Kikas


Energy
Volume 220, 1 April 2021, 119741

The efficiency of nitrogen explosion pretreatment on common aspen – *Populus tremula*: N_2– VS steam explosion

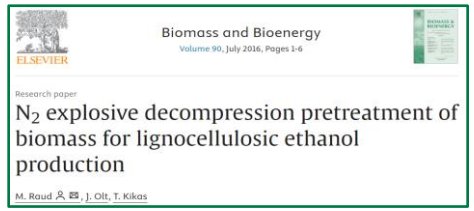
V. Rooni, N. Sjulander, A. Cristobal-Sarramian, M. Raud, Lisandra Rocha-Meneses, T. Kikas


energies

Article

Two-Step Pretreatment of Lignocellulosic Biomass for High-Sugar Recovery from the Structural Plant Polymers Cellulose and Hemicellulose

Nikki Sjulander and Timo Kikas

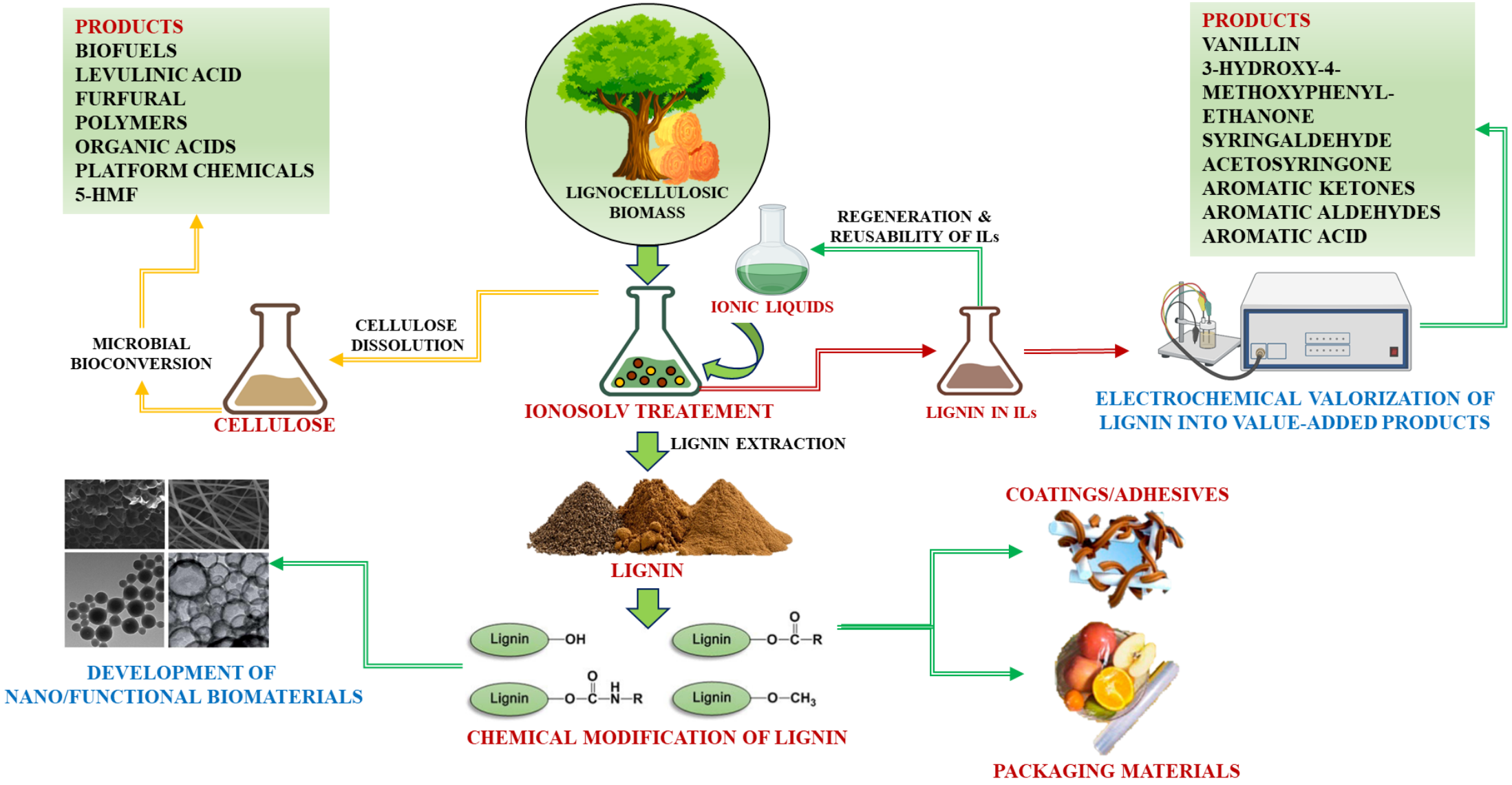

Biomass and Bioenergy
Volume 90, July 2016, Pages 1-6

Research paper

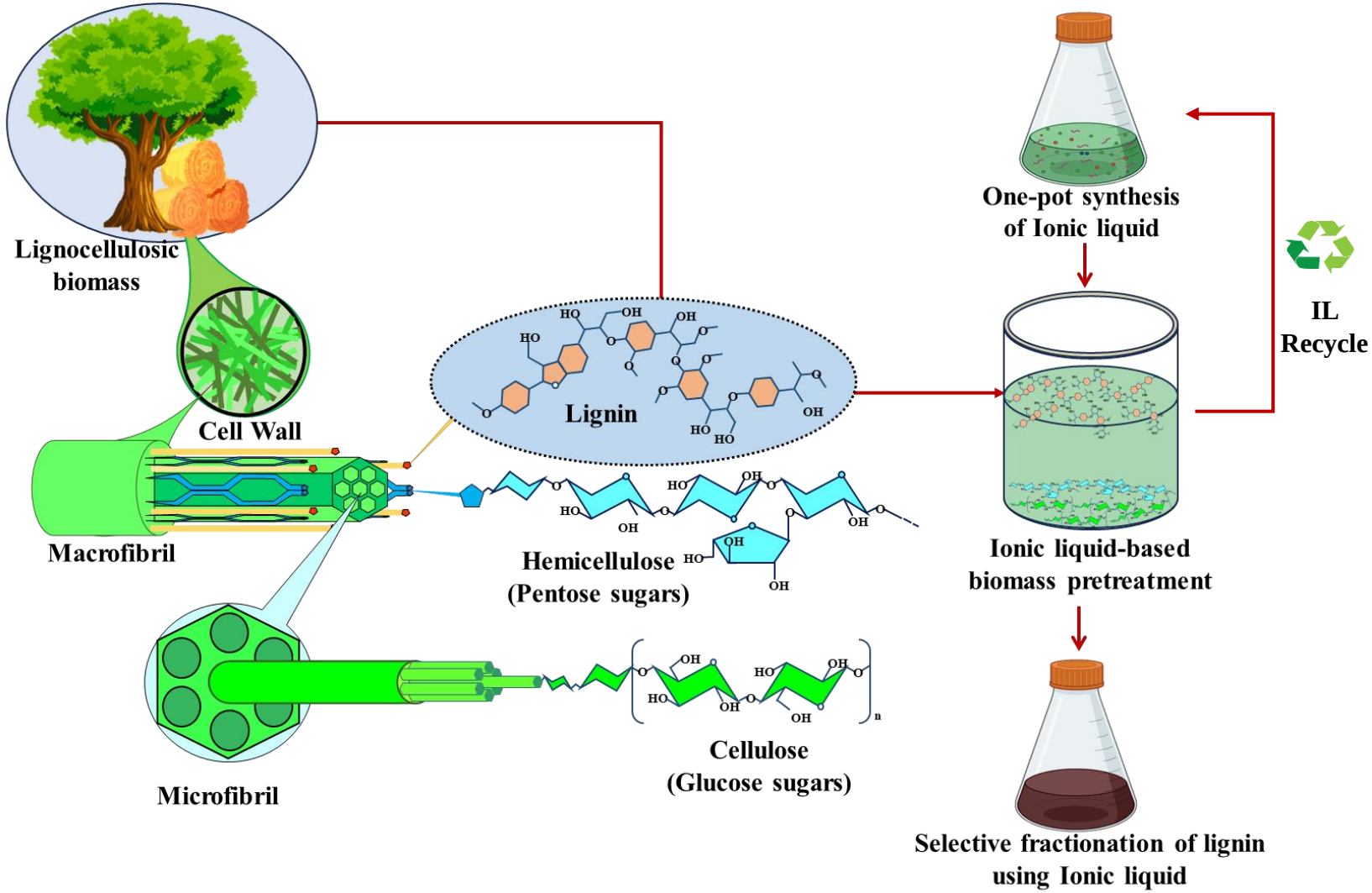
N_2 explosive decompression pretreatment of biomass for lignocellulosic ethanol production

M. Raud, J. Olt, T. Kikas

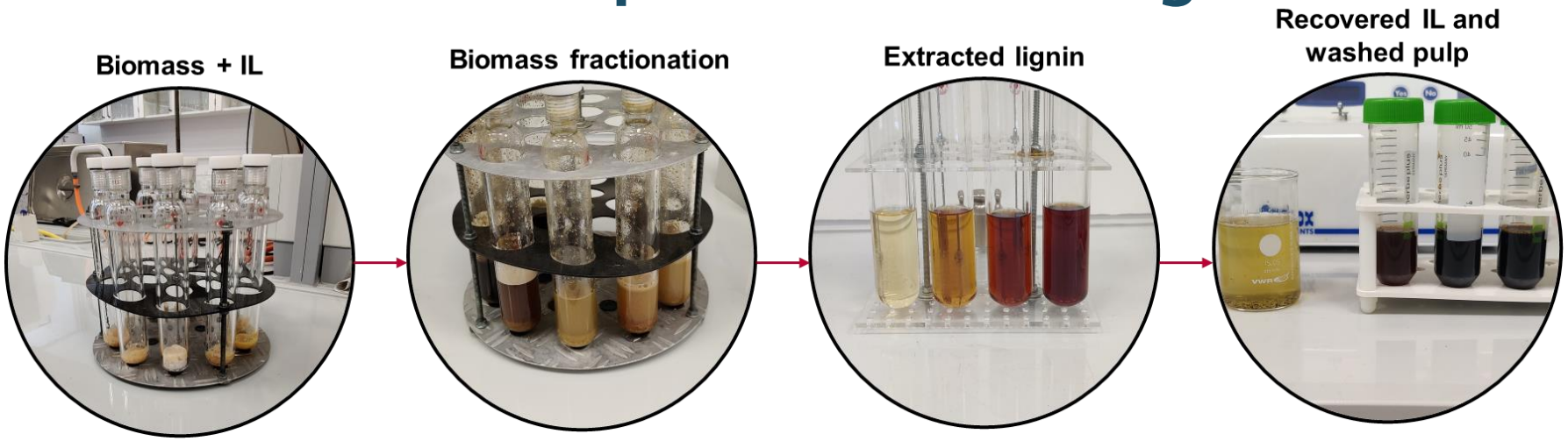
Ionic liquid based biorefinery approaches – Value-added products from lignin

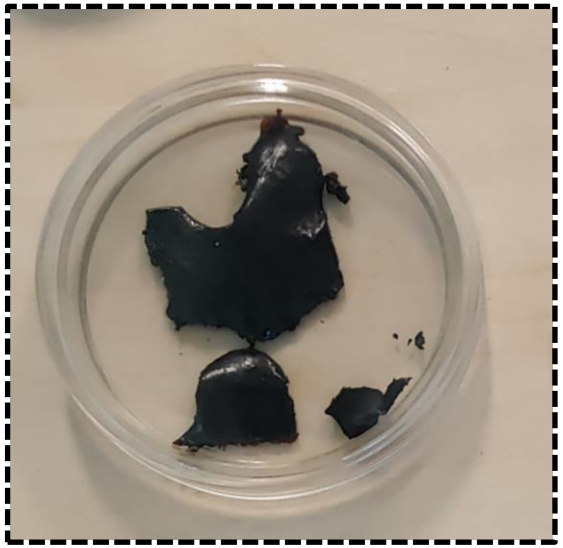


Ionic liquid based biorefinery approaches – Value-added products from lignin



Ionic liquid based biorefinery approaches – Value-added products from lignin

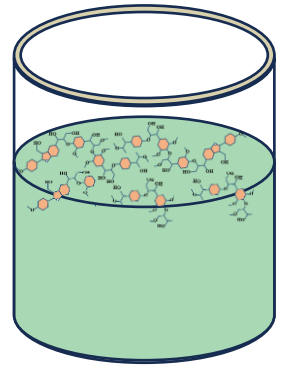




Lignin based plastic

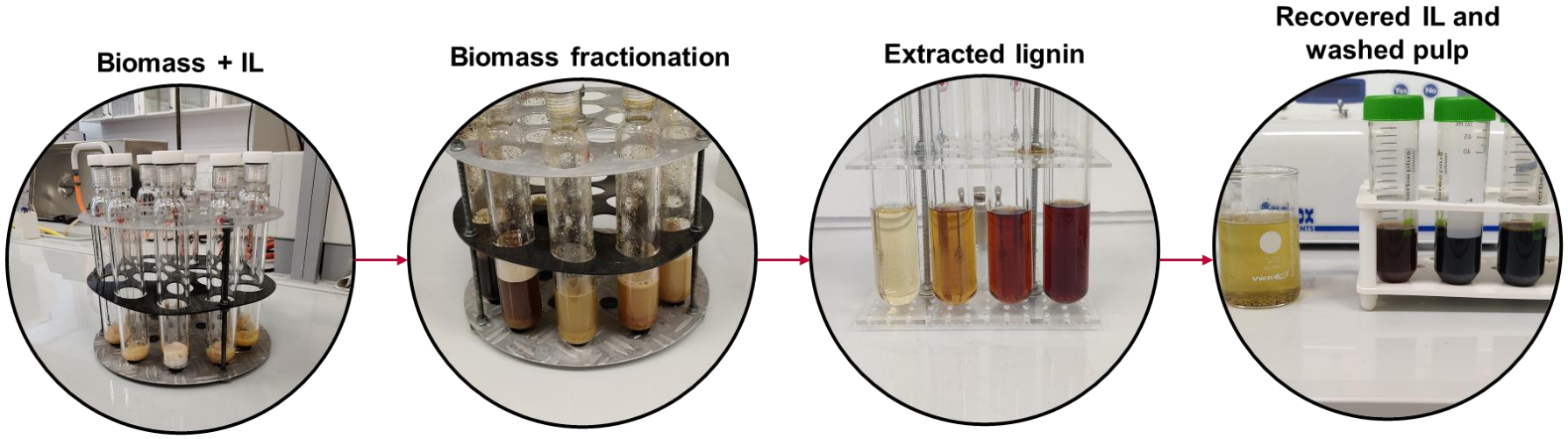
Lignin based resin

Monomers and oligomers



Lignin based value-added products

Ionic liquid based biorefinery approaches – Value-added products from lignin



Publications

polymers
MDPI
Article
Efficient Lignin Fractionation from Scots Pine (*Pinus sylvestris*) Using Ammonium-Based Protic Ionic Liquid: Process Optimization and Characterization of Recovered Lignin
Sharib Khan [1,†], Daniel Rauber [2,†], Sabarathinam Shanmugam [1,*,†], Christopher W. M. Kay [2,3], Alar Konist [4] and Timo Kikas [1,*]

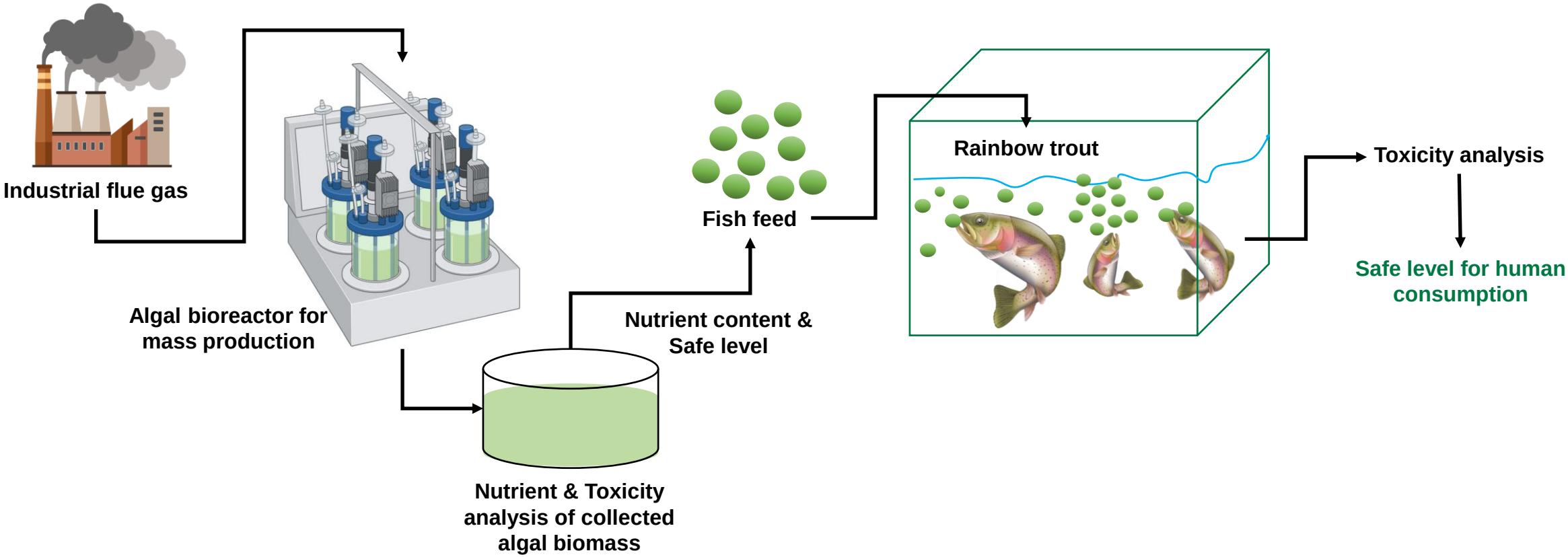
ELSEVIER
Chemosphere
Volume 290, March 2022, 133297
Extraction and isolation of lignin from ash tree (*Fraxinus exselsior*) with protic ionic liquids (PILs)
Isa Hasanov, Sabarathinam Shanmugam, Timo Kikas

energies
MDPI
Article
Enzymatic Conversion of Hydrolysis Lignin—A Potential Biorefinery Approach
Sharib Khan [1,*], Kait Kaarel Puss [2], Tiit Lukk [3], Mart Loog [2,4,*], Timo Kikas [1] and Siim Salmar [2,5]

energies
MDPI
Review
The Role of Ionic Liquids in the Lignin Separation from Lignocellulosic Biomass
Isa Hasanov, Merlin Raud * and Timo Kikas

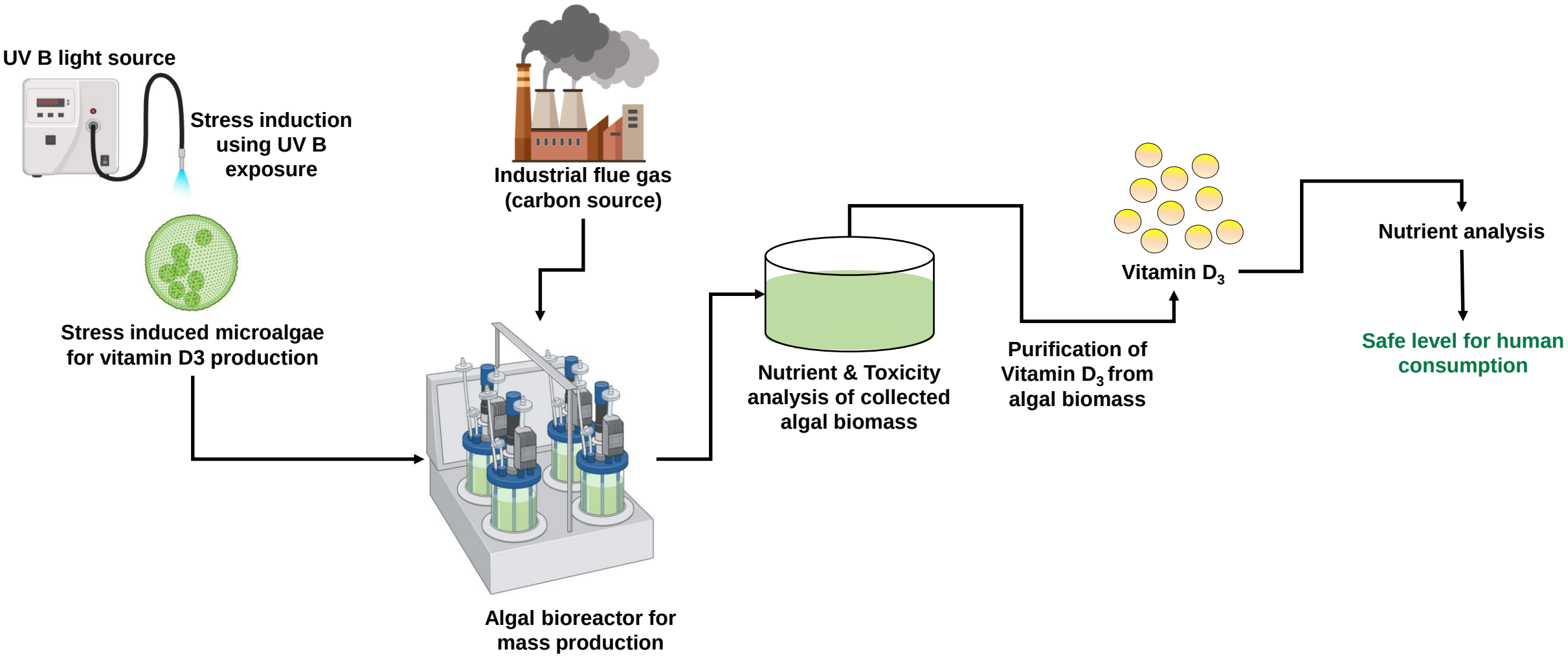
CO_2 sequestration using microalgae for value-added products

CO_2 absorbing algal biomass to fish feed



CO_2 sequestration using microalgae for value-added products

Enhanced Vitamin D_3 production from microalgae



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Team

Funding agencies

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The EEA and Norway Grants
Nordic Energy Research
Ministry of Environment, Estonia
Ministry of Education and Research, Estonia
Environmental Investment Center, Estonia
Estonian Science Foundation, Estonia

Email ID: Timo.Kikas@emu.ee

Eesti Maaülikool