Fraunhofer LBF

Roland Klein

—

OrganoPor
Flame retardant building insulation from agricultural residuals

OrganoPor - Motivation

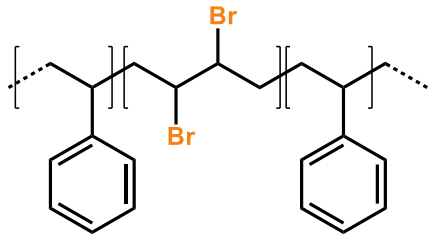
PS-foam building insulation (EPS, XPS) has outstanding properties

- low thermal conductivity
- low density
- In combination with polymer-FR: no flammability
- good compression strength
- very low price !!!
- good availability
- handling and integration in thermal insulation composite system established

However:

raw material is fossil-based

Polymeric flame retardant is brominated



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OrganoPor – The Idea

New bio-based materials for building insulation

- Innovative alternative to polystyrene foam
- Requirements
  - Sustainable
    - From renewable ressources
    - Low carbon footprint
    - No competition to food production
  - Competitive on the market
    - Acceptable price
    - Density, mechanics, thermal conductivity similar to PS
    - Processable as panel (no loose filler)
    - Flame retardant
- Additional advantage: high water vapour permeability

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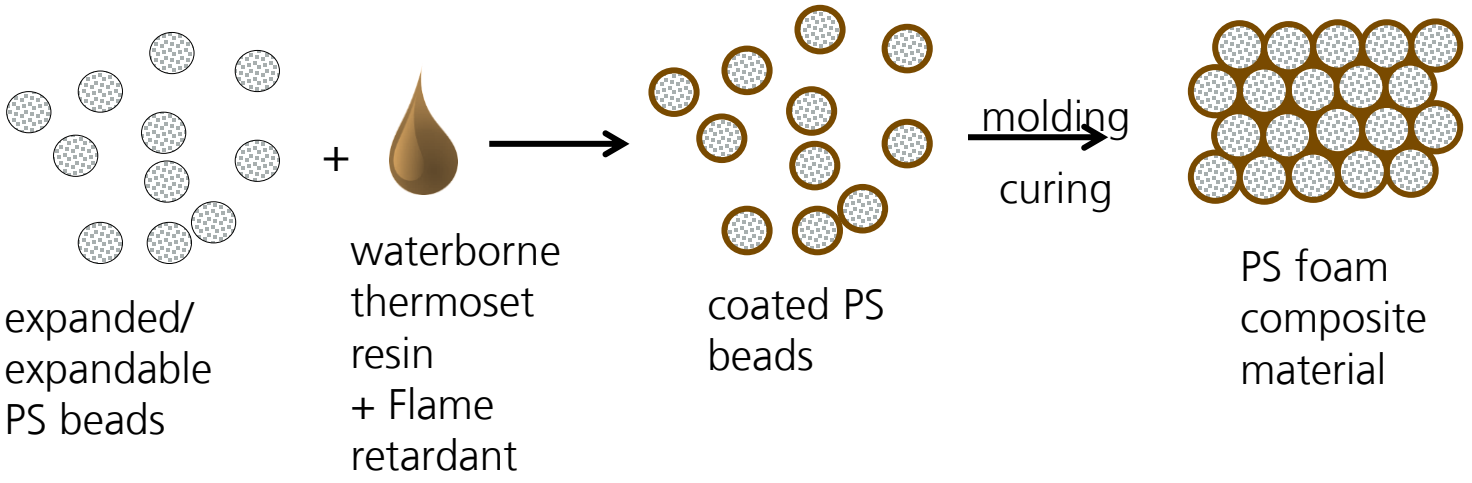
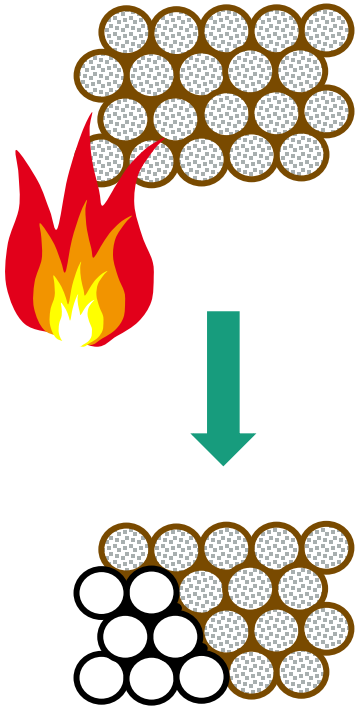
OrganoPor - Approach

New generation of PS foam composite material [1] as model for new products





Approach in OrganoPor-Project: Substitution of PS by agricultural residuals

[1] e.g.: WO 2014179842 A1, EP 3 333 216 A1, CN105482359

First Project OrganoPor

Funded by Federal Ministry of Agriculture, Food and Regional Identity

Demonstration of feasability

Used bio-based materials

- Cellulose (FLUPIS®, Thermofloc®)
- Starch foam (Flo Pak Bio®)
- **Expanded corc granuels**
- Expanded polylactic acid (EPLA)
- **Corn cob granules**
- Popcorn, puffed rice
- Sugar beet particles
- **Wheat straw**
- **Rapeseed straw**
- Flax straw
- Peanut shells
- Fruit pomace
- Rapeseed shells
- Wood fibers
- Bark

Suitable and used resins

- Not bio-based or degradable
  - Melamine-formaldehyde-resin (MF)
  - Acrylic resin (AcroDur® BASF)
- Partially bio-based
  - Phenol-formaldehyde-resin (PF) (21% Cardanol)
  - Epoxy resin (~56 % bio, Sicomin)
  - Tannin-urotropin-resin
    - Not commercially available
  - Lignin-Epoxy resin
    - Not commercially available
- **Lignin resin UPM**

With support from

Federal Ministry of Agriculture, Food and Regional Identity

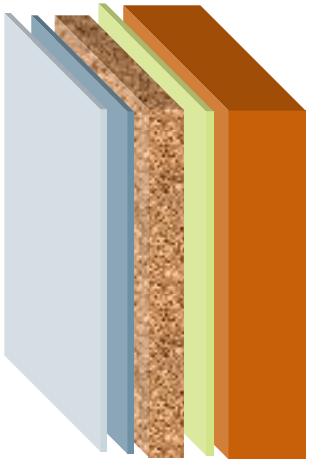
by decision of the German Bundestag

FNR
Fachagentur Nachwachsende Rohstoffe e.V.

Interest of several companies to transfer the result to an industrial process → new project, funded by ministry for economic affairs

Second Project OrganoPor: Optimization and Scale-up

Funded by ministry for Economic Affairs and Energy



UPM Biochemicals GmbH
Development / optimization of lignin-based resin binder

J. Rettenmaier & Söhne GmbH + Co KG
Biogenic residuals from agriculture and forestry / grinding

JOMA Dämmstoffwerk GmbH
Production of insulation panels
Planning of production plant

Baumit GmbH
Development of adopted thermal insulation composite system
Testing handling of panels

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Selection / evaluation of biogenic residuals
Reduction of bulk density
interactions
Raw materials ↔ resins ↔ flame retardants

development of panels in lab scale
testing fire behavior

preparation
small scale samples

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

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Availability of raw materials – Example: corn cob granules

Corn cobs

Application

- Granules for animal bedding
- Substitute for barbecue char coal

→ **Harvesting technology available**

Availability

- Corn: 400.000 ha
- Area yield: 10 t/ha
- Cob fraction: 20 %

→ **800.000 t/a**

- Targeted density: 120 kg/m³
- therfrom 90 kg/m³ corn cob fraction

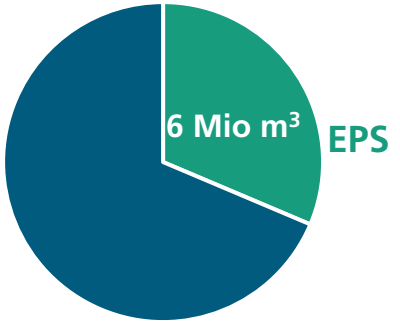
→ **9 Mio m³/a > EPS-market**

Building insulation market in Germany

18,4 Mio m³ / a [1)]

Market share EPS: ca. 32% [2)]

→ **ca. 6 Mio m³ EPS / a**



1) https://solidbau.at/news/daemmstoffmarkt-2024-stark-geschrumpft/
2) https://www.energie-experten.org/bauen-und-sanieren/daemmung/daemmstoffe

Availability of raw materials – Example: cereal straw

Cereal straw

Availability in Germany

- 30 Mio t / a:
- 66% collectable
- 4,8 Mio t for animal bedding
- → potentially available for technical applications: 15 Mio t (minus locally variable fractions for humus replication)
  - Depending on region 27 – 43 %
  - According to used model: **8 – 13 Mio t**

→ sufficient, to substitute all insulation materials in Germany

Source:
Schriftenreihe des BMU-Förderprogramms
„Energetische Biomassenutzung“
Band 2, Basisinformationen für eine nachhaltige Nutzung
landwirtschaftlicher Reststoffe zur Bioenergiebereitstellung 2011

Building insulation market in Germany

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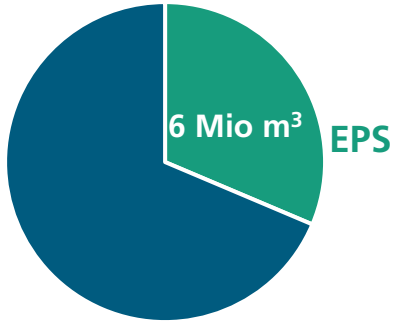
Market share EPS: ca. 32% [2)]

→ ca. 6 Mio m^3 EPS / a



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Availability of raw materials – Example: rape seed straw

Rape seed straw

No study availabe, similar to cereal straw

→ Transfer of some assumptions to rape seed straw: Availability 7,5 Mio t / a (BMU 2011; FNR 2015)

- 66% collectable
- Usage as animal bedding is negligible
- → technchal potencial: 5 Mio t
- minus 50% for humus replication
- **2,5 Mio t potencially for OrganoPor available**
- With a estimated (high) density of 200 kg / m³ (there of 150 kg / m³ rape seed straw, others are resin and flame retardant)

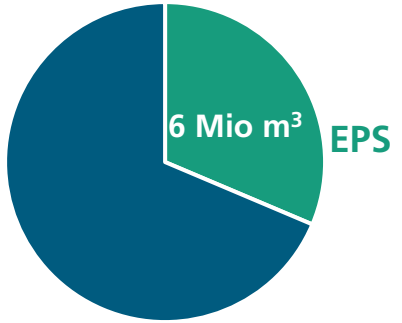
→16 Mio m³ OrganoPor-Panels from rape seed straw possible

Building insulation market in Germany

18,4 Mio m³ / a [1)]

Market share EPS: ca. 32% [2)]

→ ca. 6 Mio m³ EPS / a



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Reduction fo bulk density; Example: corn cob granules

Issue

Bulk density of animal bedding: ca. 400 kg/m³
→ Too high as raw material for insulation panels

Objective in Project

Reduction of bulk denity

- Identification of grinding process
- Extraction of soluble fractions maintaining the volume

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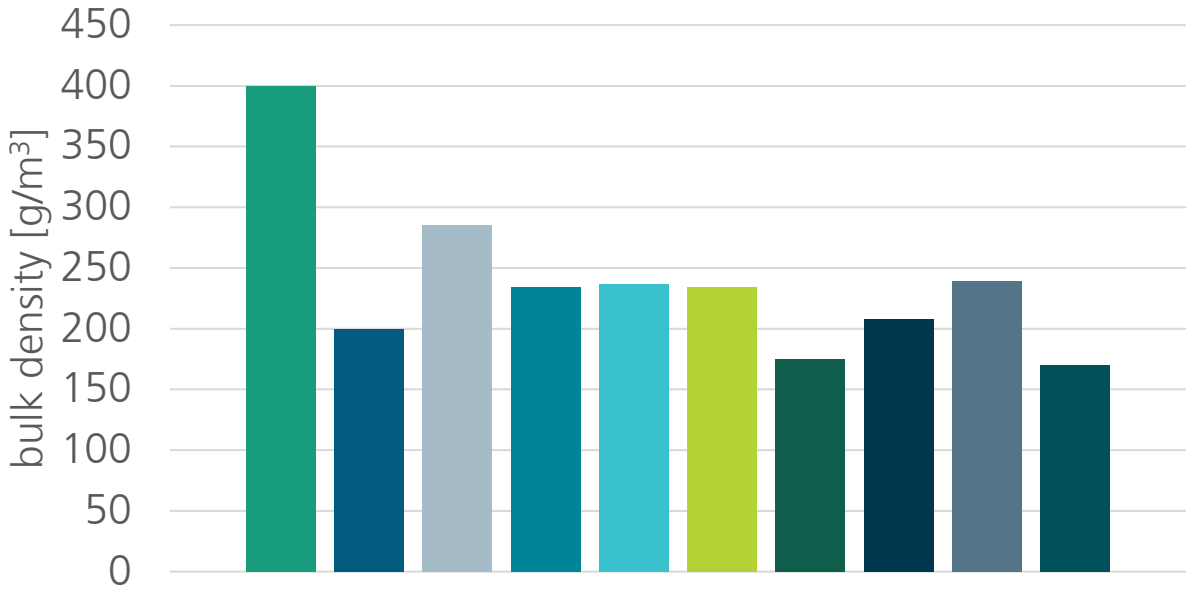

- different shredding and cutting methods lowered the bulk density.

Reduction fo bulk density; Example: corn cob granules

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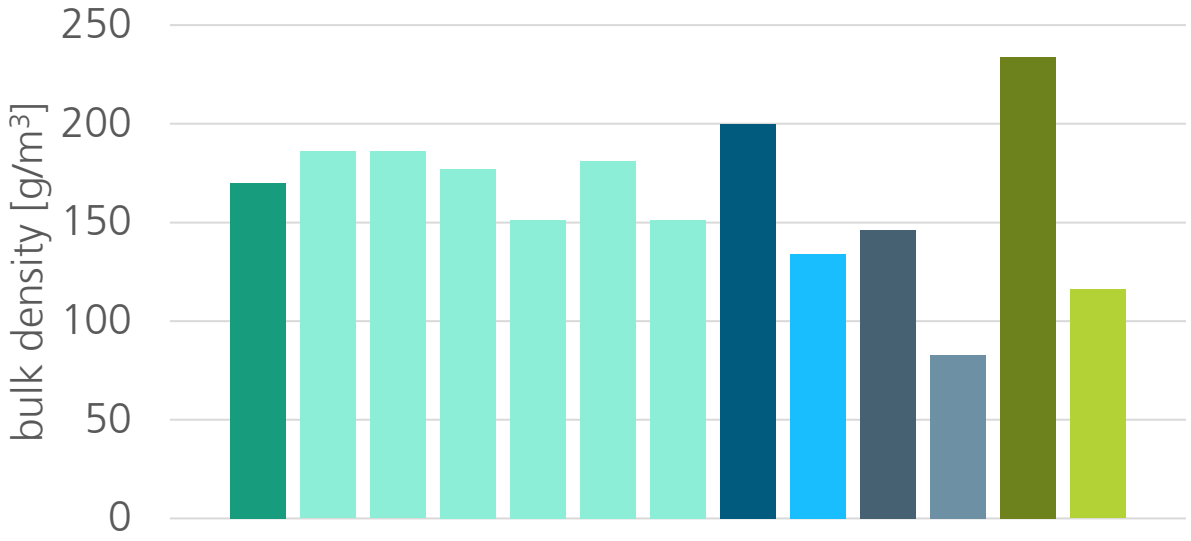


- Additional extraction protocols showed varying degrees of success

Preparation of panels in lab scale

sizing

Horizontal blade mixer

molding

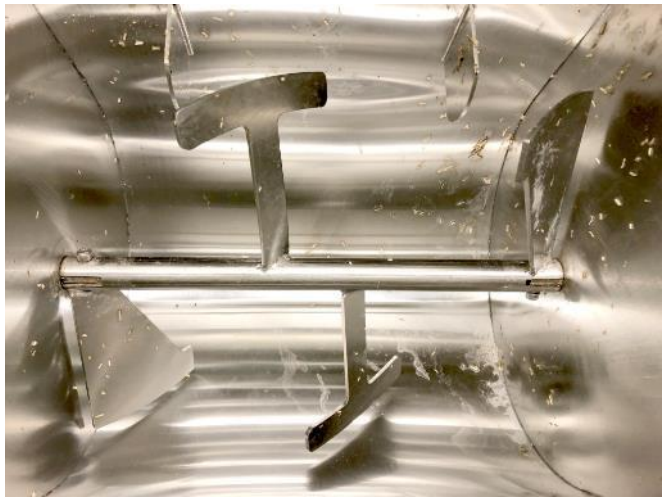
400 x 400 x 80 mm

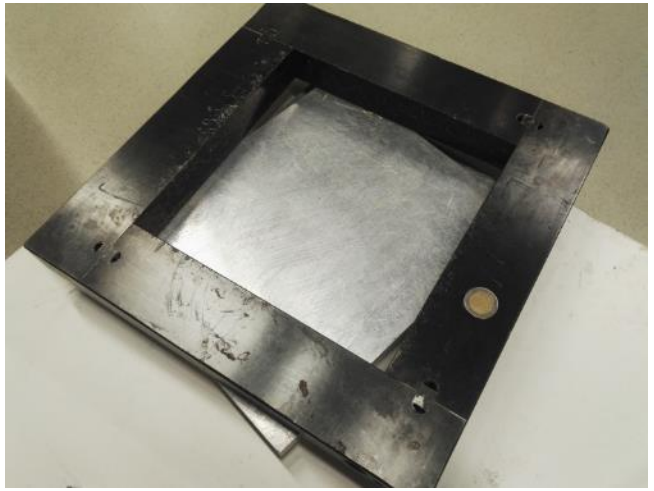
Mold for hot press

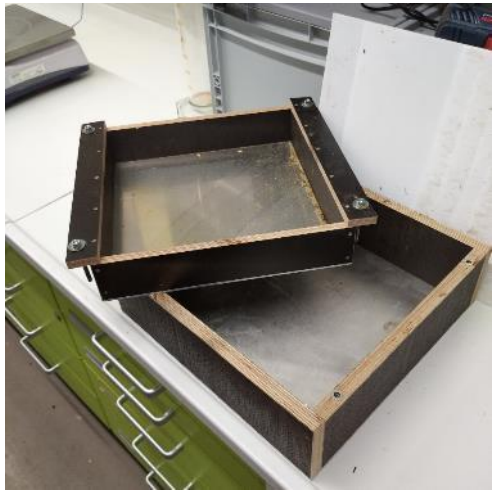
Mold for oven curing

curing

insulation panels







Characterization of panels

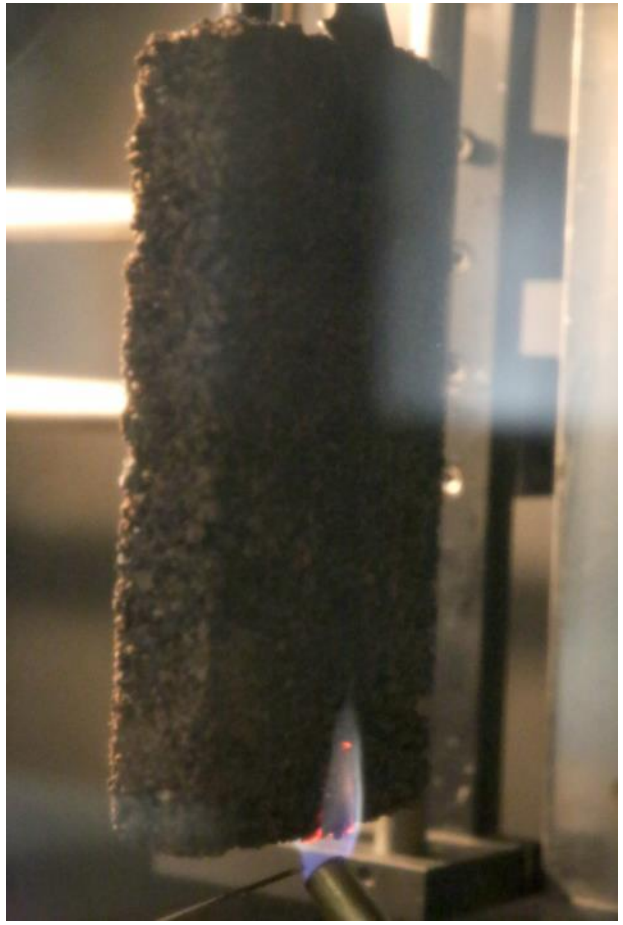
Flammability

During and after exposure to fire according to
DIN EN 13501 / EN ISO 11952-2:

- Marking at 15 cm not reached
- Self extinguishing after removal of flame
- No afterglow

- With this test: max. building material class E (normally flammable) can be reached

- For higher classification: SBI-Test (EN 13823) with larger panels needed



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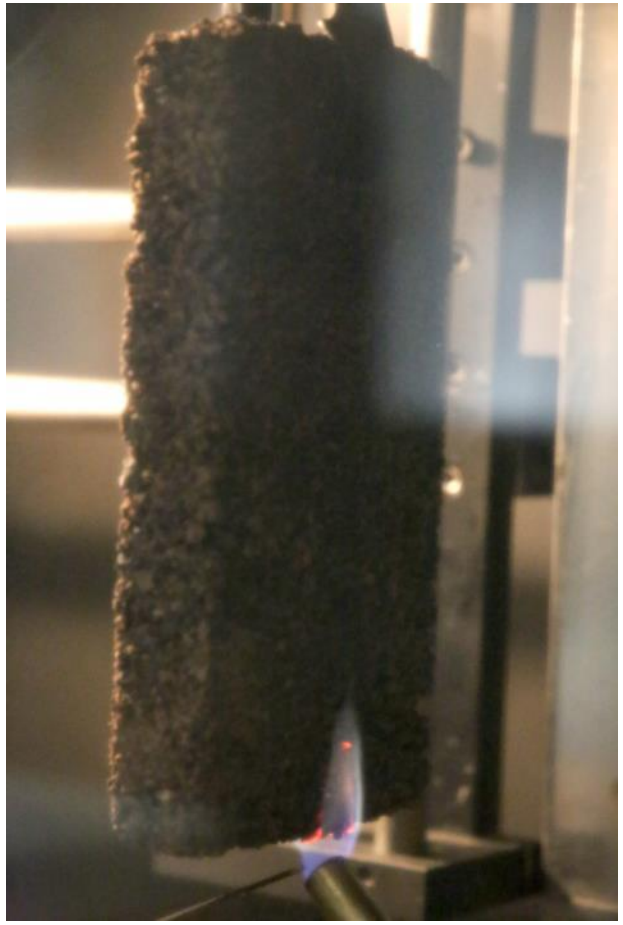
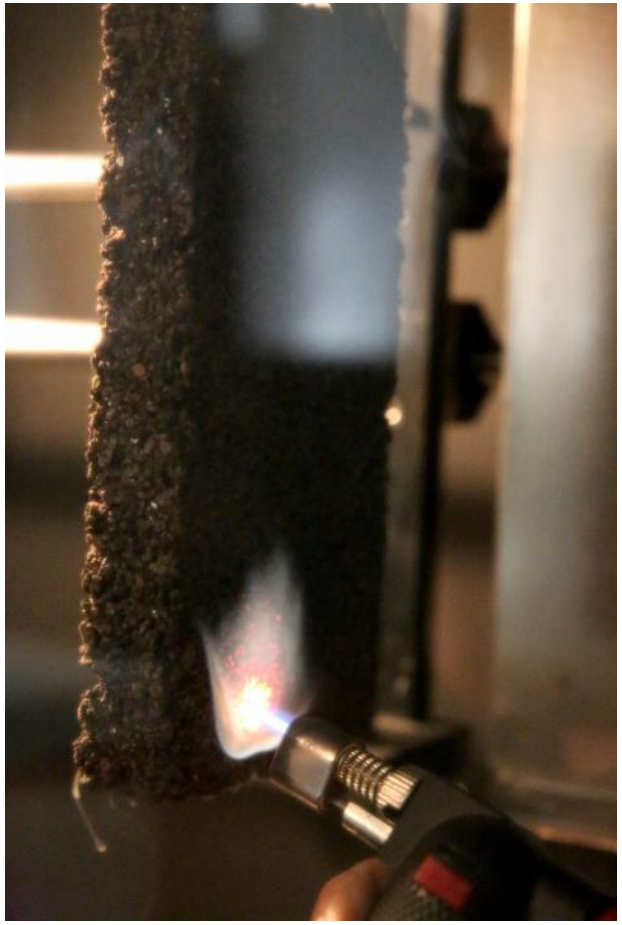
- **Preliminary studies with blowtorch: not burning**





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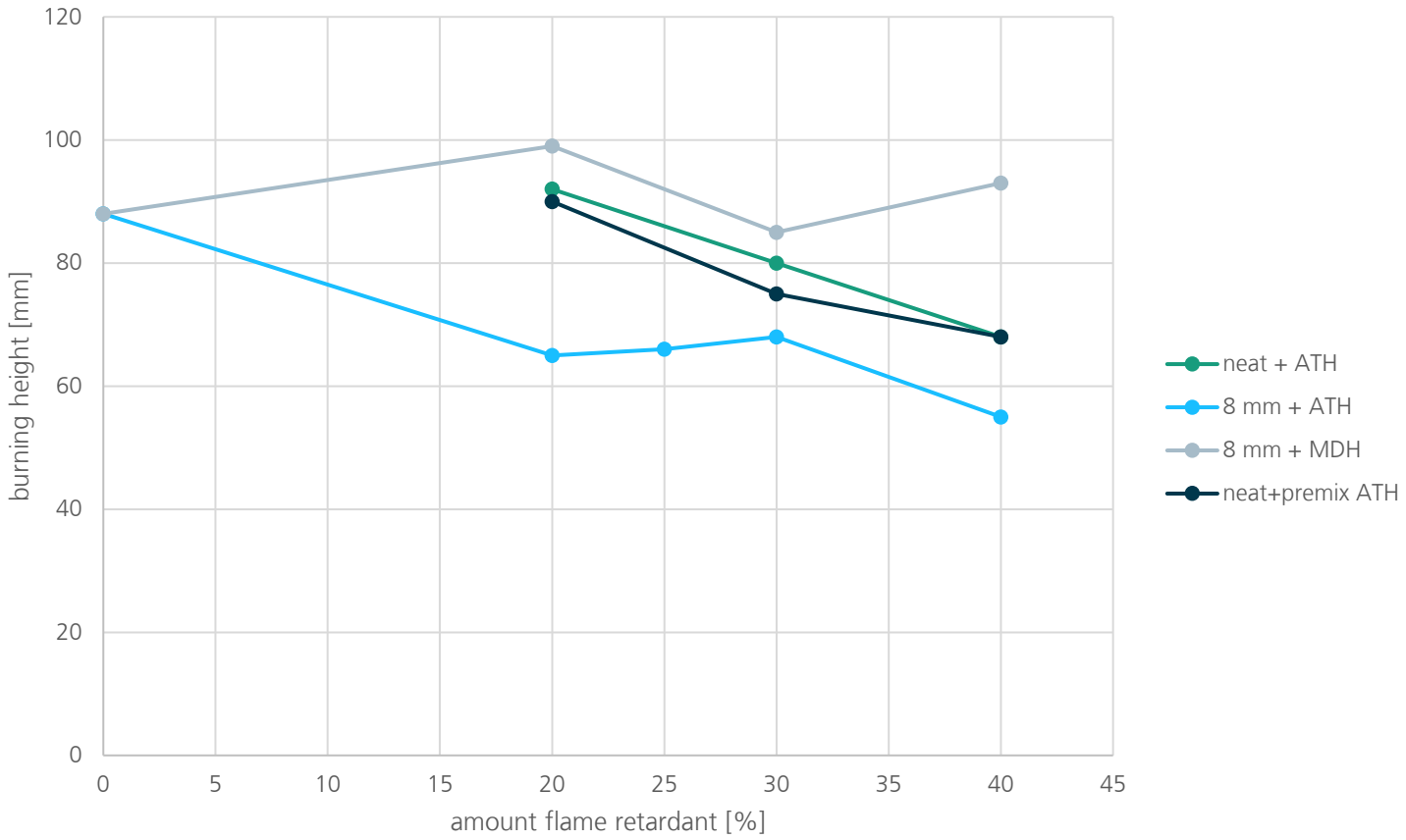
Flammability Test– Influence of different flame retardant and concentration



- Composits made of rapseed straw were tested.
- Flame retardant used: magnesium hydroxide (MDH) and aluminium hydroxide (ATH).

Characterization of panels

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Comparison: commercially available wood fiber insulation boards

Scale-up of panel manufacturing

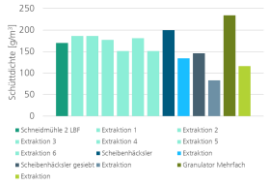
Preparation of panels at project partner

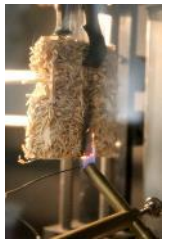
Size: 100 x 50 x 8 cm

Intergration in thermal insulation composite system

Summary

- Selection of suitable biogenic raw materials concerning availability and price successfull
- Reduction of bulk density is possible by selected grinding processes in combination with extractions
- Preparation of panels in lab-scale possible → next step: scale-up
- Low flammability
- Further optimizations of formulations and processes needed
- → looking for partners for milling/grinding and panel manufacturing





Follow-up Project: OrganoMurus

Substitute for drywall panel (gypsum cardboard)

ZUKUNFT BAU
FÖRDERN FORSCHEN ENTWICKELN

Started in Nov 2025

Partner:

technische universität dortmund

Goals

- Substitute for drywall panel (gypsum cardboard) in interior construction
- comparable practical construction properties in terms of processing, moisture resistance, dimensions, and stability
- 100% biogenic material base from agricultural side streams and residual flows & bio-based binder (lignin-based resin)
- Recyclable, or at least reusable
- Sustainability assessment

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