Testing of polysaccharide thermal insulations against fungi

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Performance of bio-based building materials

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This work discusses decay resistance of:

(1) the commercial thermal Cellulose Fibre Insulation containing boric acid in a function of the biocide and fire retardant (Climatizer Plus– CFI);

(2) three potential thermal insulations from polysaccharide wastes (Pulp and paper sludge – PPS).

Toxic chemical elements in the pulp and paper sludge – PPS

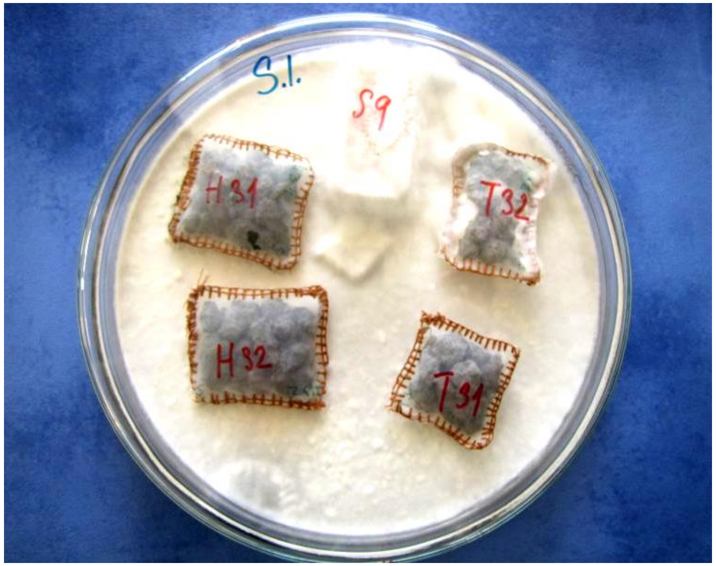
Type of PPS	Amount [mg.kg^{-1}]								
	As	Cd	Cr	Cu	Hg	Mo	Ni	Pb	Zn
PPS-1	7.9	2.8	8.7	85.0	0.3	2.8	2.8	15.0	182.0
PPS-2	14.7	0.5	15.4	56.9	0.8	3.5	2.4	5.2	77.8
PPS-3	1.0	0.5	8.9	17.1	0.7	6.4	4.2	8.4	25.6

Methodology of test against fungi

Biological resistance tests - sterile laboratory conditions.

Samples of fluffy insulations - sewn (polyethylene thread) - into polyethylene bags.

Bags - imposed into Petri dishes with agar-malt soil and fungal mycelia (EN 113),
- the dry rot fungus (*Serpula lacrymans* / Wulfen / J. Schrőt)
- the timber gill polypore (*Gloeophyllum trabeum* / Pers. / Murrill)



The bags opened - the insulations dried, cooled and weighed in oven dry state and the mass losses Δm determined.

$$\Delta m = [(m_0 - m_{0\text{-}F}) / m_0].100 \qquad (\%)$$

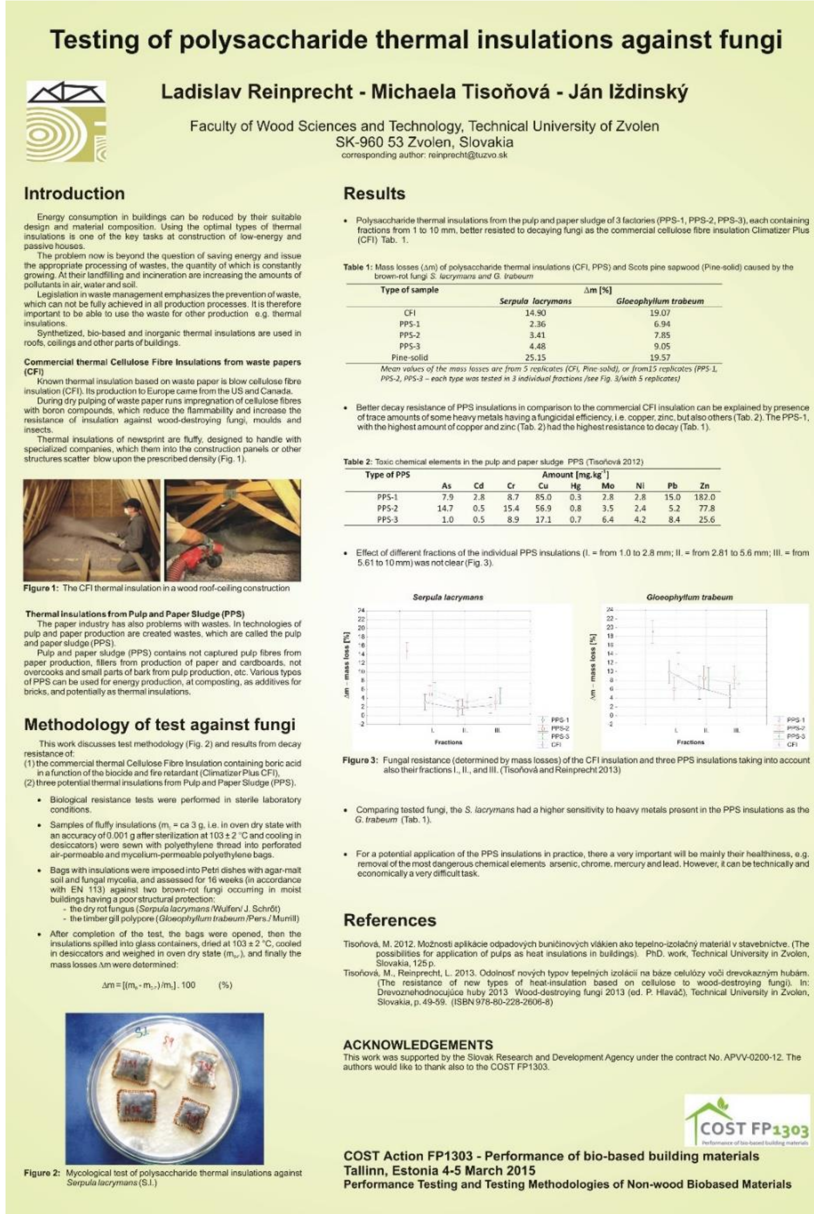
Mycological test of polysaccharide thermal insulations against *Serpulalacrymans (S.l.)*

Results

Polysaccharide thermal insulations from the pulp and paper sludge better resisted to decaying fungi as the commercial cellulose fibre insulation Climatizer Plus (CFI)

Type of sample	Δm - mass loss [%]	
	Serpula lacrymans	Gloeophyllum trabeum
CFI	14.90	19.07
PPS-1	2.36	6.94
PPS-2	3.41	7.85
PPS-3	4.48	9.05
Pine-solid	25.15	19.57

For a potential application of the PPS insulations in practice, there a very important will be mainly their healthiness, e.g. removal of the most dangerous chemical elements – arsenic, chrome, mercury and lead. However, it can be technically and economically a very difficult task.



Testing of polysaccharide thermal insulations against fungi

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Introduction

Energy consumption in buildings can be reduced by their suitable design and material composition. Using the optimal types of thermal insulations is one of the key tasks at construction of low-energy and passive houses.

The problem now is beyond the question of saving energy and issue the appropriate processing of wastes, the quantity of which is constantly growing. At their landfilling and incineration are increasing the amounts of pollutants in air, water and soil.

Legislation in waste management emphasizes the prevention of waste, which can not be fully achieved in all production processes. It is therefore important to be able to use the waste for other production e.g. thermal insulations.

Synthetized, bio-based and inorganic thermal insulations are used in roofs, ceilings and other parts of buildings.

Commercial thermal Cellulose Fibre Insulations from waste papers (CFI)

Known thermal insulation based on waste paper is blow cellulose fibre insulation (CFI). Its production to Europe came from the US and Canada.

During dry pulping of waste paper runs impregnation of cellulose fibres with boron compounds, which reduce the flammability and increase the resistance of insulation against wood-destroying fungi, moulds and insects.

Thermal insulations of newsprint are fluffy, designed to handle with specialized companies, which them into the construction panels or other structures scatter blow upon the prescribed density (Fig. 1).

Figure 1: The CFI thermal insulation in a wood roof-ceiling construction

Thermal insulations from Pulp and Paper Sludge (PPS)

The paper industry has also problems with wastes. In technologies of pulp and paper production are created wastes, which are called the pulp and paper sludge (PPS).

Pulp and paper sludge (PPS) contains not captured pulp fibres from paper production, fillers from production of paper and cardboards, not overcooks and small parts of bark from pulp production, etc. Various types of PPS can be used for energy production, at composting, as additives for bricks, and potentially as thermal insulations.

Methodology of test against fungi

This work discusses test methodology (Fig. 2) and results from decay resistance of:
(1) the commercial thermal Cellulose Fibre Insulation containing boric acid in a function of the biocide and fire retardant (Climatizer Plus CFI),
(2) three potential thermal insulations from Pulp and Paper Sludge (PPS).

- Biological resistance tests were performed in sterile laboratory conditions.
- Samples of fluffy insulations (m_i = ca 3 g, i.e. in oven dry state with an accuracy of 0.001 g after sterilization at 103 ± 2 °C and cooling in desiccators) were sewn with polyethylene thread into perforated air-permeable and mycelium-permeable polyethylene bags.
- Bags with insulations were imposed into Petri dishes with agar-malt soil and fungal mycelia, and assessed for 16 weeks (in accordance with EN 113) against two brown-rot fungi occurring in moist buildings having a poor structural protection:
  - the dry rot fungus (*Serpula lacrymans* /Wulfen/ J. Schröt)
  - the timber gill polypore (*Gloeophyllum trabeum* /Pers./ Murill)
- After completion of the test, the bags were opened, then the insulations spilled into glass containers, dried at 103 ± 2 °C, cooled in desiccators and weighed in oven dry state ($m_{0,F}$), and finally the mass losses Δm were determined:

$$\Delta m = [(m_0 - m_{0,F})/m_0] \cdot 100 \qquad (\%)$$

Figure 2: Mycological test of polysaccharide thermal insulations against *Serpula lacrymans* (S.l.)

Results

- Polysaccharide thermal insulations from the pulp and paper sludge of 3 factories (PPS-1, PPS-2, PPS-3), each containing fractions from 1 to 10 mm, better resisted to decaying fungi as the commercial cellulose fibre insulation Climatizer Plus (CFI) Tab. 1.

Table 1: Mass losses (Δm) of polysaccharide thermal insulations (CFI, PPS) and Scots pine sapwood (Pine-solid) caused by the brown-rot fungi *S. lacrymans* and *G. trabeum*

Type of sample	Δm [%]	
	Serpula lacrymans	*Gloeophyllum trabeum*
CFI	14.90	19.07
PPS-1	2.36	6.94
PPS-2	3.41	7.85
PPS-3	4.48	9.05
Pine-solid	25.15	19.57

Mean values of the mass losses are from 5 replicates (CFI, Pine-solid), or from15 replicates (PPS-1, PPS-2, PPS-3 – each type was tested in 3 individual fractions /see Fig. 3/with 5 replicates)

- Better decay resistance of PPS insulations in comparison to the commercial CFI insulation can be explained by presence of trace amounts of some heavy metals having a fungicidal efficiency, i.e. copper, zinc, but also others (Tab. 2). The PPS-1, with the highest amount of copper and zinc (Tab. 2) had the highest resistance to decay (Tab. 1).

Table 2: Toxic chemical elements in the pulp and paper sludge PPS (Tisoňová 2012)

Type of PPS	Amount [$mg.kg^{-1}$]								
	As	Cd	Cr	Cu	Hg	Mo	Ni	Pb	Zn
PPS-1	7.9	2.8	8.7	85.0	0.3	2.8	2.8	15.0	182.0
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PPS-3	1.0	0.5	8.9	17.1	0.7	6.4	4.2	8.4	25.6

- Effect of different fractions of the individual PPS insulations (I. = from 1.0 to 2.8 mm; II. = from 2.81 to 5.6 mm; III. = from 5.61 to 10 mm) was not clear (Fig. 3).

Figure 3: Fungal resistance (determined by mass losses) of the CFI insulation and three PPS insulations taking into account also their fractions I., II., and III. (Tisoňová and Reinprecht 2013)

- Comparing tested fungi, the *S. lacrymans* had a higher sensitivity to heavy metals present in the PPS insulations as the *G. trabeum* (Tab. 1).
- For a potential application of the PPS insulations in practice, there a very important will be mainly their healthiness, e.g. removal of the most dangerous chemical elements arsenic, chrome, mercury and lead. However, it can be technically and economically a very difficult task.

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