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Fungus and fire resistance of insulation mats based on water glass bonded non-textile flax fibres

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Materials and methods Field retted flax crop were processed to fine non-textile fibres as specified elsewhere (Grohe 2003) and the material employed for the manufacturing of insulation mats. Water glass was applied as an adhesive and a solution prepared by adding 50 vol.% water to the received viscous water glass (Betol 39T1, 36 wt.% solids in water, Woellner Silikat GmbH, Ludwigshafen, Germany;) leading to 18 wt.% solids in water (pH∼11). An aqueous borate solution of 14 wt.% boric acid and 10 wt.% sodium hydroxide (33 wt.% NaOH solution) was mixed, giving 24 wt.% solids in water (ph∼13). Thus, the mixture contains a fraction of ∼21.6 wt.% of the flame retardant and fungicide Borax ($Na_2B_4O_7{\cdot}10\ H_2O$). The $B(OH)_3$-solids and the NaOH-solution were received as technical grade by Zschimmer und Schwarz, Lahnstein, Germany. Insulation mats were fabricated via a pilot plant, as described by Grohe 2003. During the process flax fleeces were sprayed either with (A) water glass or with (B) water glass and subsequently with the boric compound. Some insulation mats were fabricated by primarily spraying them with (C) boron-solution followed by another cycle comprised the spraying of water glass and boric compound. Test-series were carried out (Bundesanstalt für Materialforschung und -prüfung, Berlin, Germany) to investigate the biological resistance of insulation mats fabricated via the production runs (A), (B) and (C) (see Table 1). Thereby, five samples (90 × 90 × 40–55 mm) of each production run were exposed to pure cultures of the wood destroying fungal species *Aspergillus niger, Aspergillus terreus, Aureobasidium pullulans, Paecilornyces variotii, Penicillium funiculosum, Penicillium ochro-chloron, Scopulariopsis brevicaulis and Trichoderma viride* and the degree of fungal attack verified, according to DIN IEC 68-2-10. To investigate the fire properties of insulation mats five samples of the series (B) were tested according to DIN 4102-1 (FIW—München, München, Germany).

Results and discussion The results in Table 1 indicate that only the samples of production run (C) fulfill the accreditation criteria (0 or 1 for all samples; DIN IEC 68). For the different behavior of the samples (A), (B) and (C) to fungal attack three influencing factors have to be considered.

1. The boron-compound is not efficient enough.
2. The covering-grade of the fibre materials by inorganic solids varies in a wide range.
3. The mats and, in particular, the fibre material were already contaminated by fungi.

As the biological resistance of the samples increases in the order of the series (B), (A) and (C) and, moreover, the samples (A) are free of boron (see Table 1) the fungicide boron cannot have a major effect on the fungal attack compared to other influencing factors. This assumption is confirmed if one compares the results for the series (B) and (C), and the drastic decrease of the fungal attack for series (C), although the fraction of boron-solids were increased only from 2–4 wt.%. It is rather assumed that the degree of fiber covering by inorganic solids but as well as an already existing contamination of the fiber materials influence the results of the tests. An insight into the grade of fiber coverage for samples (A) by water glass is given in Fig. 1. Therefore, only the fibres of production run (C) are considered as nearly completely surrounded by water glass and Borax and that, with the first boron spraying, a great deal of the given fungal decay was killed. The results suggest, that the degree of fibre retting should be under permanent control and, if one lowers the grade of contamination, lower amounts of inorganic solids should be needed as well to bind and protect the fiber materials. An important criterion for insulation mats is their behavior in the case of fire. That applies particularly using them e.g. as isolation- or splice material for buildings. The investigations concerning the fire resistance were carried out by employing samples of the production runs (B), which were assumed to have the lowest degree of fiber-coverage by inorganic solids. This should assure that a sufficient fire protection for all samples is given. Finally, the samples perform DIN 4102-B2 and are certificate as normal flammable (B2) and not burning dripped off. Thus, the fabricated insulation mats are suitable for interior application.

Table 1. Composition of insulation mats, whose biological resistance and fire properties
Tabelle 1. Zusammensetzung von Dämmstoffmatten, deren biologische Resistenz und Feuerwerte

Sample	Composite of the material			Biological resistance QCR [no. of samples]	Fire properties Certificate
	Fractions of materials				
	Fibres [wt.%]	WG [wt.%]	B [wt.%]		
A	79–81	19–21	–	1–2 [3]; 2 [2]	n.m.
B	77–79	19–21	2	2 [3]; 3 [2]	B2
C	75–77	19–21	4	0 [2]; 1 [3]	n.m.

n.m.: not measured WG: solid water glass; B: solid borate QCR: quality class rating of fungal attack: 0 (no attack seen by a loop), 1 (a contamination is not or hardly noticeable to the naked eye, but by a loop), 2 (less than 25% of the samples is covered and seen to the naked eye) and 3 (= more than 25% of the samples is covered and seen to the naked eye)

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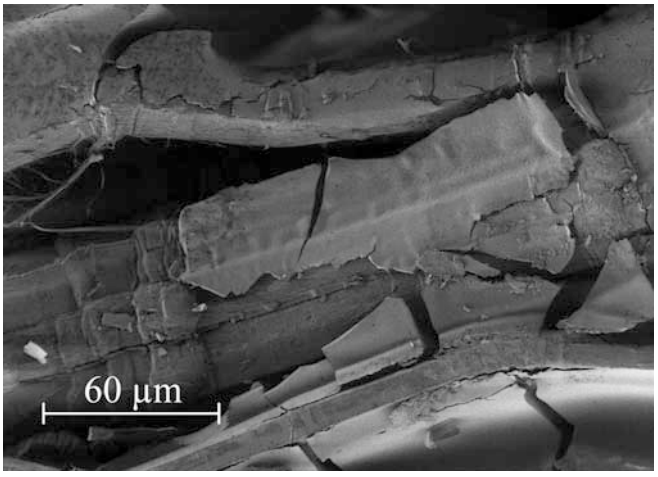

Fig. 1. Scanning electron micrograph of non-textile flax fibres of samples fabricated via the production run (A), without deploying borate solutions. The partly coverage of the fibres with water glass can be clearly seen
Abb. 1. Rasterelektronenmikroskopische Aufnahme von nicht-textilen Flachsfasern von Proben, die über den Produktionsverlauf (A) hergestellt wurden, ohne Boratlösungen einzusetzen. Die Teilbedeckung der Fasern mit Wasserglas kann man deutlich erkennen

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