Mould growth on wood-based materials – a comparative study

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ABSTRACT

Ten different wood-based materials - preservative-treated wood, fire retardant-treated wood, modified wood, WPCs and untreated references of pine sapwood and spruce - were tested for mould growth according to SP method 2899 during 42 days at 90% RF and 22°C.

Even though the results must be interpreted carefully, they indicate significant differences in mould resistance between the materials tested.

Sapwood of pine, thermally treated wood and furfurylated wood had the highest ratings of mould growth at the specific climatic conditions selected for this study. All other treatments seemed to retard mould growth and the least mould growth appeared on WPC samples prepared of fibres treated with an isothiazolone type preservative.

Further studies at different climates and at fluctuating climates are required in order to get a better understanding of the resistance to mould growth of the materials tested.

Keywords: mould, preservative-treated wood, fire retardant-treated wood, modified wood, WPC

1. INTRODUCTION

The study is part of a series of tests to determine limit states for mould growth on wood-based materials, and the aim was to investigate the resistance to mould growth of ten different wood-based material at 90% RH and 22 °C.

According to the test method used, SP Method 2899, the mould growth is to be examined after 28 days at 95% RH and 22 °C. At the climate used one could expect slower growth of fungi, and the test period was therefore extended to 42 days and the result after 42 days was compared to the result after 28 days.

2. EXPERIMENTAL METHODS

2.1 Materials
The materials tested consisted of preservative-treated wood, fire retardant-treated wood, modified wood, WPCs and untreated references and are specified in Table 1.
Table 1. Materials tested.

<table>
<thead>
<tr>
<th>Material</th>
<th>Description</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated wood (references)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pine (<em>Pinus sylvestris</em>) sapwood</td>
<td>Planed</td>
<td></td>
</tr>
<tr>
<td>Spruce (<em>Picea abies</em>)</td>
<td>Planed</td>
<td></td>
</tr>
<tr>
<td>Preservative-treated wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Celcure AC 800</td>
<td>Active ingredients Copper, benzalkoniumchloride</td>
<td>Treated according to Nordic class AB, i.e. use class 3 (above ground); purchased by SWPA* from timber yards.</td>
</tr>
<tr>
<td>Tanalith E-7</td>
<td>Copper, propiconazole, tebuconazole</td>
<td></td>
</tr>
<tr>
<td>Wolmanit CX-8</td>
<td>Copper, boron, bis-(N-cyclohexyldiazenium-dioxy-) (HDO)</td>
<td></td>
</tr>
<tr>
<td>Fire retardant-treated wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dricon</td>
<td>Planed <em>P.sylvestris</em> treated with Dricon, fire-retardant system by Arch Chemicals</td>
<td>Treatment carried out by Woodsafe AB</td>
</tr>
<tr>
<td>Modified wood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acetylated pine (<em>P.sylvestris</em>)</td>
<td>Acetyl content 22-23%</td>
<td>Prepared at SPs pilot plant</td>
</tr>
<tr>
<td>Furfurylated pine (<em>P.sylvestris</em>)</td>
<td>WPG approximately 35%</td>
<td>Submitted by Kebony ASA</td>
</tr>
<tr>
<td>Thermally treated pine (<em>P.sylvestris</em>)</td>
<td>The thermal process had a maximum temperature of 212 °C for a duration of one hour.</td>
<td>Thermal treatment carried out by Scandinavian Finewood AB</td>
</tr>
<tr>
<td>WPC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WPC untreated</td>
<td>~50% m/m <em>P.sylvestris</em> fibres (untreated)</td>
<td>Preservative formulation submitted by Viance LLC</td>
</tr>
<tr>
<td>WPC preservative-treated</td>
<td>~50% m/m <em>P.sylvestris</em> fibres treated with a isothiazolone based solution to a retention of approximately 700 ppm, giving a retention of approximately 350 ppm in the WPC ~50% m/m polypropylene</td>
<td></td>
</tr>
</tbody>
</table>

*Swedish Wood Protection Association

2.2 Spore suspension
Freeze dried strains of *Aureobasidium pullulans* (CBS 101160), *Aspergillus versicolor* (CBS 117286), *Cladosporium sphaerospermum* (CBS 122.63), *Eurotium herbariorum* (CBS 115808), *Penicillium chrysogenum* (CBS 401.92) and *Alternaria alternata* from Centraalbureau voor Schimmelcultures, Utrecht, The Netherlands, were kept on malt extract agar for 7-14 days until sporulation.

10 ml of distilled, autoclaved water was poured into each subculture. The surface of the growth was then scraped to liberate spores into the water, which was then poured into a flask containing glass beads. The flask was shaken to liberate the spores from the fruiting body and to break the spore clumps. After that the suspension was filtered through glass wool contained in a glass funnel and then centrifuged and washed three times in distilled, autoclaved water. The spore concentration in the final residue was determined microscopically (in a Bürker counting cell) and
then diluted, aiming at a spore concentration of approximately $10^6$ spores/ml. The final spore suspension was then prepared by mixing equal volumes of spore suspension from each species.

0.4 ml of the spore suspension was sprayed onto each test sample (~50x100 mm) by using an airbrush (Clas Ohlson Model AB-119) attached to a mini-compressor (Cotech) with a pressure regulator with water separator and working pressure of 2 bar. This device atomizes the suspension through a nozzle. The airbrush was swept along the samples at an even speed. Six replicates of each material were used and they were conditioned at room climate approximately three weeks before the spore suspension was sprayed on the samples. The conditioning climate was not favourable for mould growth and all samples were free of mould growth before the start of the test.

### 2.3 Incubation
Directly following the spraying with the spore suspension the test samples were placed in a climate chamber (CTS C-20/350) and incubated in the dark at 90% RH and 22°C for 42 days.

### 2.4 Assessment of mould growth
Once a week the incubated samples were removed from the climate chamber and the surfaces were studied by a stereo microscope (up to 40x magnification). In this way it was possible to examine mould growth, not only the growth that is visible to the naked eye. A laminar air flow (LAF) bench was used to avoid further contamination of the test samples.

Mould growth was assessed according to the rating criteria in Table 2.

**Table 2. Rating scale for assessment of mould growth**

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No fungal growth</td>
</tr>
<tr>
<td>1</td>
<td>Initial fungal growth consisting of scattered hyphae on the surface</td>
</tr>
<tr>
<td>2</td>
<td>Still scattered growth, but more apparent than in 1. Conidiophores may have started to develop.</td>
</tr>
<tr>
<td>3</td>
<td>Patchy distributed, heavy growth. Hyphae with developed conidiophores.</td>
</tr>
<tr>
<td>4</td>
<td>Heavy growth over the entire surface</td>
</tr>
<tr>
<td>5</td>
<td>Very heavy growth</td>
</tr>
</tbody>
</table>

### 3. RESULTS AND DISCUSSION

#### 3.1 Progress of mould growth
The progress of mould growth during the test period is presented in Figures 1-3 as medians of ratings according to Table 2. As can be seen from Figures 1-3 the onset and development of mould growth varied between materials:
• On pine references mould started to grow after only 7 days of incubation while the growth on spruce references started after 31 days.

• For the preservative-treated wood mould started to develop on samples of Tanalith E 7-treated and Wolmanit CX-8 treated wood after 17-24 days, whereas growth on samples of Celcure AC 800 and Dricon started after 31 and 28 days respectively, see Figure 1. The median was never bigger than 1, which means very sparse growth.

• Mould started to grow very early (after 7 days) on thermally treated wood, Figure 2. After 17 days mould started to grow on furfurylated wood. Even though the growth started later on furfurylated wood than on thermally treated wood, the median rated mould growth was the same for both types of wood after the test period. On samples of acetylated wood the growth started during the last week of the test period and the growth was very sparse.

• For the WPC that did not contain any fungicide mould growth started to develop after 17 days, compared to the WPC with fungicide content, for which mould growth started after 31 days, Figure 3. Also for this material the mould growth was very sparse since the median was never bigger than 1.

![Figure 1.](image)

Figure 1. Development of mould growth according to Table 2 on wood treated with wood preservatives and fire retardant compared to reference materials. Median growth of six replicates.
Figure 1. Development of mould growth according to Table 2 on modified wood compared to reference materials. Median growth of six replicates.

Figure 3. Development of mould growth according to Table 2 on WPCs compared to reference materials. Median growth of six replicates.
3.2 Comparison of mould growth after 28 days and 42 days incubation

As mentioned above, the mould growth should be finally examined after 28 days according to the test method used. The test was extended to 42 days and the ratings after 28 and 42 days compared.

In Figure 4 the results of the assessment of fungal growth after 28 days is shown with box-plots, which give information of the distribution of the ratings and possibility to compare the distribution of ratings for the different materials. The distribution of ratings is represented by a box and protruding lines. Each box contains 50% of the values and the horizontal line inside the box represent the median of values, that is the value below which 50% of the cases are included. The whiskers emanating from the box represent the smallest and largest values. Stars represent extremes. If the boxes do not overlap a significant difference between the medians can be expected.

![Figure 4. Assessment of fungal growth after 28 days.](image)

After 28 days sapwood of pine and thermally treated wood had more mould growth than the other materials, and the growth was heavy, see Figure 4. Acetylated wood seems to have the best effect of the modified wood materials against mould growth in this test, although all other treatments do not have more than sparse growth. Among the preservative treatments Dricon has the lowest mould growth, while the other treatments show sparse growth.

As the test continued for 42 days, box-plots are shown for this period in Figure 5. After 42 days pine sapwood still has most fungal growth. Furfurylated and thermally treated wood also show heavy growth and do not differ significantly from each other.
4. CONCLUSIONS

The materials used in this test were supplied by commercial producers with the exception of the acetylated wood and the WPCs. The origin of the wooden raw material was therefore not the same, and differences between the different materials may be due to differences in mould resistance between the wooden raw material and not only to the various treatments. Moreover, any variation of treatments between batches is not reflected in this study. The results are therefore only valid for the tested samples.

Even though the results must be interpreted carefully, they indicate significant differences in mould resistance between the materials tested.

Sapwood of pine, thermally treated wood and furfurylated wood had the highest ratings of mould growth at the specific climatic conditions selected for this study. All other treatments seemed to retard mould growth and the least mould growth appeared on WPC samples prepared of fibres treated with an isothiazolone type preservative.

The results cannot be used to predict how long time a particular material can be exposed without onset of mould in an environment critical for mould growth. It is a comparative study between the different materials. The susceptibility to onset of mould varies between materials at the same climatic conditions.

Further studies at different climates and at fluctuating climates are required in order to get a better understanding of the resistance to mould growth of the materials tested and how test results correspond to experience from practice.

Figure 5. Assessment of fungal growth after 42 days.
5. ACKNOWLEDGEMENT

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6. REFERENCES