

# SUCCESSION OF STAINING FUNGI ON ACETYLATED WOOD AND THE EFFECT OF SELECTED INFLUENCING FACTORS

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## ABSTRACT

Wood used in outside applications is susceptible to weathering and photo degradation, which often leads to surface discoloration, loss of brightness and surface deterioration. Research has shown that acetylated wood is more resistant against brown rot, white rot and soft rot, and more dimensionally stable than untreated wood. However, acetylated wood seems still to be disfigured by surface moulds and staining fungi. Samples of acetylated Southern Yellow pine at three different treatment levels; low, intermediate and high acetyl content were exposed at two test sites, Ås (Norway) and Bogesund (Sweden) against north and south from September 2010 until March/May 2011. Considerably more precipitation was recorded in Ås in the initial potential fungal growth phase than in Bogesund. As expected, untreated wood had higher mould ratings than acetylated wood. At Ås the tendency was that samples with low acetyl content had lower mould ratings than samples with higher acetyl content. This effect was not found in Bogesund. This may be due to considerably less precipitation in Bogesund compared to Ås. At Ås samples exposed against north tended to have higher mould ratings than panels exposed against south which could be due by less direct sun causing longer time of wetness and more ideal conditions for mould growth.

Key words: acetylation, moulds, Southern Yellow pine, staining fungi.

## INTRODUCTION

Blue stain and mould fungi are often seen upon undesirable elements on painted coated and unpainted wood. Rain, temperature, photo degradation, condensation, high relative humidity and wind degrade the surface of outdoor exposed wooden claddings making these more susceptible to fungal attack (de Meijer 2001, Williams et al. 2000). For colonization and growth of staining and mould fungi on the wooden surface, moisture content in the material and the relative humidity and temperature in the ambient air are the critical factors (Viitanen 1996). Wood modification is defined as a procedure involving the action of a chemical, biological and physical agent resulting in a desired property enhancement during the service life of the modified wood (Hill 2006). Furthermore, modified wood should be non-toxic under service conditions and end of

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life. Modified wood, e.g. furfurylated wood, acetylated wood and thermally modified wood, possess enhanced properties such as better dimensional stability, in addition to enhanced protection against biological attack (Boonstra et al. 1998, Kamdem et al. 2002, Lande et al. 2004a, b, Larsson et al. 2000, Rowell et al. 1985, Sailer et al. 2000, Schneider 1995, Westin et al. 1998, Westin et al. 2002). Acetylation of wood is performed by reacting wood with acetic anhydride. This process results in esterification of the hydroxyl groups in the wood cell wall and formation of acetic acid as a by-product (Rowell 2005, Rowell et al. 1994). Acetylated wood shows an increase in resistance against wood degrading fungi (Larsson et al. 2000), and a reduction in hygroscopicity of the wood material (Rowell 1991). On the other hand when considering staining fungi, there are indications that acetylated wood do not resist colonisation and growth of staining fungi more than non-acetylated wood (Beckers et al. 1994, Wakeling et al. 1992). Acetylated wood has in some studies been found to be more susceptible to staining and mould fungi (Gobakken and Lebow 2010, Gobakken et al. 2010, Gobakken and Westin 2008) than other comparable wood substrates. The objectives of this study were to set up a pre-trial to 1) investigate how various levels of acetyl content in the wood affect the speed of colonization, 2) study the effect of cardinal direction on the colonization of staining fungi, 3) investigate the effect of location and climatic factors for the onset of growth of staining fungi.

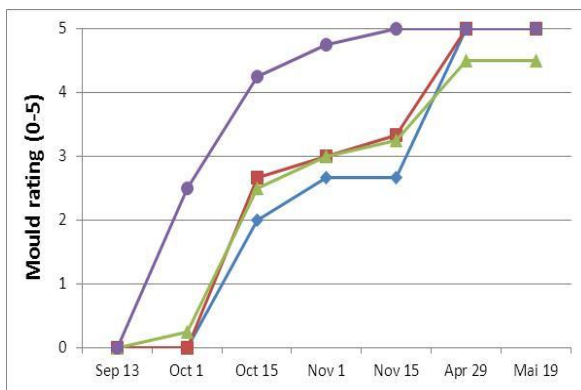
## MATERIAL AND METHODS

Test specimens were prepared from acetylated Southern Yellow pine sapwood and untreated Southern yellow pine sapwood. The test was performed according to a modified version of EN 927-3 (2006). Acetylated wood with three different treatment levels; low (level 1), intermediate (level 2) and high (level 3) acetyl content were included in the test. Samples of untreated Southern Yellow pine were used as reference material. Matching samples were put out in Bogesund, Sweden and Ås, Norway, with samples facing both south and north. The samples mounted facing north in Bogesund were installed at 90° angle. All other samples were installed at 45° angle. The panels were put out September 13<sup>th</sup> 2010 in Ås and September 17<sup>th</sup> 2010 in Bogesund. At Ås the panels were evaluated visually for mould coverage (rating from 0=no mould growth to 5=heavy mould growth, according to EN 927-3 (2000) and scanned on a flatbed scanner 6 times between September 13<sup>th</sup> 2010 and May 19<sup>th</sup> 2011. In Bogesund the panels were evaluated visually for mould coverage 3 times in the time period between September 17<sup>th</sup> and March 22<sup>nd</sup>. Statistical calculations were done in JMP 9 (SAS Institute Inc 2010). Weather data from a close-by weather station were collected for the period the panels were exposed. The amount of precipitation was very different for the two test sites. In the beginning of the test period (September 13 – October 31) the total precipitation in Ås was 158 mm with a daily mean temperature of 6.5°C. Bogesund had a total of 29 mm precipitation in the same period (September 17 – October 31) and a daily mean temperature of 7°C.

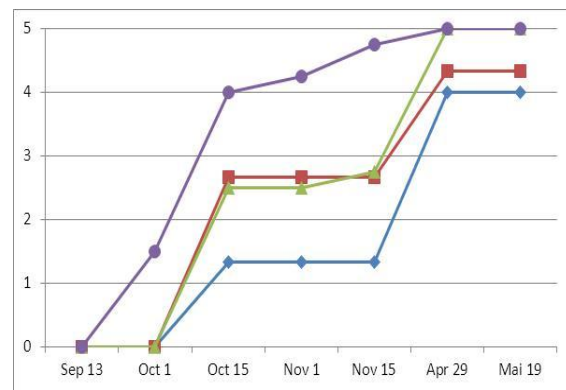
## RESULTS

At Ås the untreated panels had visible mould growth at the first evaluation (17 days of outdoors exposure), and an increase in mould rating continued until November 2010 when a maximum rating of 5 was reached (Fig. 1ab). Close to no mould growth was

detected on the acetylated panels at the first evaluation, but at the second evaluation (October 15<sup>th</sup>) mould ratings from 1 to 3 were recorded. Maximum mould ratings (rating 4-5) were recorded in end of April for the acetylated panels.

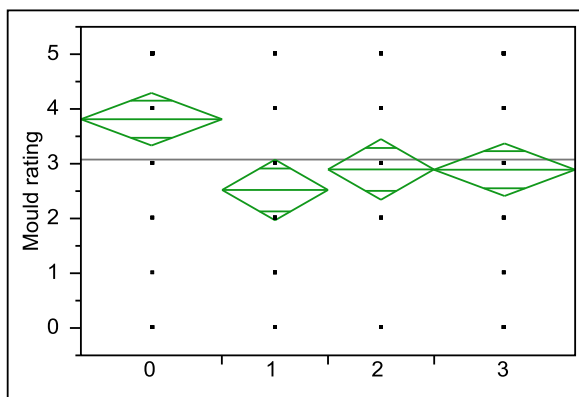


**Fig. 1a.** Mould ratings for untreated and acetylated panels exposed north, Ås.

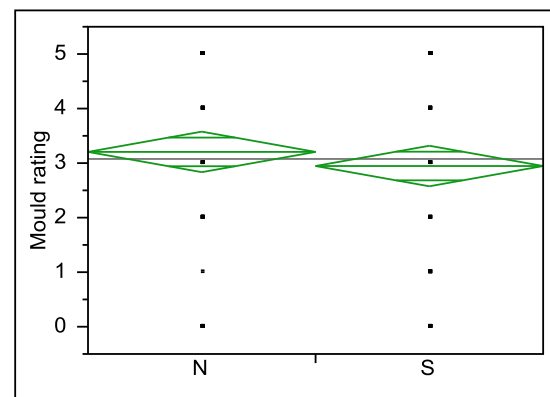


**Fig. 1b.** Mould ratings for untreated and acetylated panels exposed south, Ås.

Untreated panels were found to have significantly higher mould ratings than acetylated panels. No significant differences were found between the three treatment levels, although the tendency was that the lowest treatment level had lower mould ratings than the two higher levels (Fig. 2a). This tendency was most evident for panels exposed towards south (Fig. 1b). Panels exposed to the north had slightly higher mould ratings than panels exposed to the south (Fig. 2b) although this difference was not statistical significant.



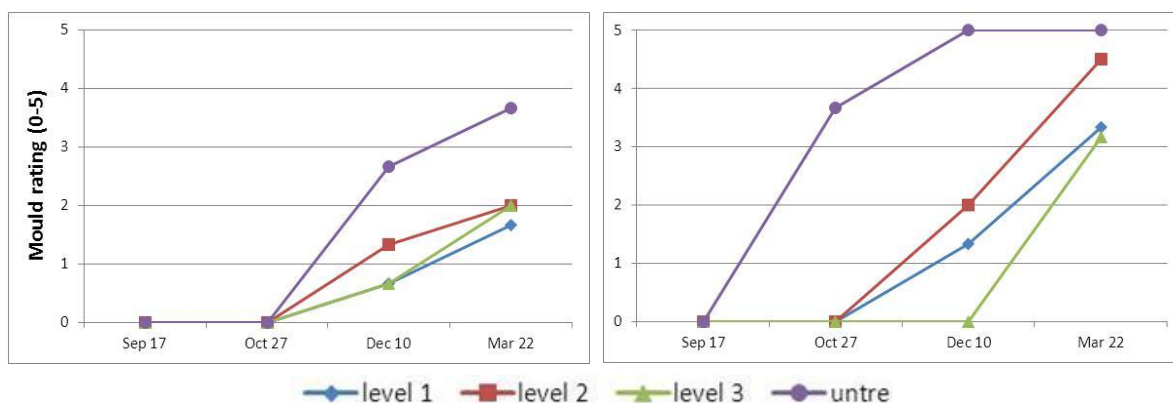
**Fig. 2a.** Variation in mould ratings plotted against treatment level (0=untreated, 1=level 1, 2=level 2, 3=level 3), Ås.



**Fig. 2b.** Variation in mould ratings plotted against cardinal direction (N=north, S=south), Ås.

In Bogesund visible mould growth were detected later than in Ås (Fig.3ab), and the delay in colonization and disfigurement between the two locations were close to 30 days. No mould growth was detected on the acetylated panels at the first evaluation date (October 27<sup>th</sup>), but at the second evaluation (November 10<sup>th</sup>) mould ratings from 0.5 to 2 were recorded. Untreated panels had higher mould ratings than acetylated panels. No clear difference between the three treatment levels were found, although level 2 treated panels exposed against south seems to have slightly higher mould ratings. Acetylated panels exposed to the south had higher mould ratings than panels exposed to the north

which is the opposite of what was found in Ås. In Bogesund panels were exposed to the north at 90° angle.



**Fig. 3a.** Mould ratings for untreated and acetylated panels exposed north, Bogesund.

**Fig. 3b.** Mould ratings for untreated and acetylated panels exposed south, Bogesund.

## DISCUSSION

The temperature in Ås and Bogesund were similar in the start of the exposure period (second part of September and October 2010). However, Ås had substantial more precipitation than Bogesund during this time period, which was likely the reason for faster colonization and succession of staining fungi on both acetylated and untreated panels at this site. Untreated panels had faster colonization of staining fungi and higher mould rating through the whole test period at both test sites.

At Ås, level 1 panels (acetylated panels with a low treatment level) had lower mould ratings in the beginning of the exposure period than level 2 and level 3 panels. The ester bond linking the acetyl group to the cell wall polymer can be hydrolysed, although studies (Rowell et al 1993, Rowell 2006) has shown that acetylated wood will under normal service conditions have good stability. However, heavy rainfall (ie. incidents of 20-30 mm a day) at a horizontal or moderate angled (ie. 45°) the surface of the panels will be intensively washed, and it can be questioned if the ester bonds then would become more unstable. If assuming that deacetylation of acetylated wood is dependent on the content of the acetyl groups, one can discuss if acetylated wood at a low treatment level will have faster deacetylation than acetylated wood at higher levels. Deacetylation byproducts that may be leached out may give an additional protection against staining fungi during a certain time after heavy rainfalls. Bardage (Bardage 2011) showed that there is a fungal toxicity associated with high acetic concentration which is supported by several other studies (Paulose et al. 1989, Schillinger and Villarreal 2010). The panels in Bogesund did not experience the same amount and incidents of rainfall, and the tendency of low mould ratings on level 1 panels were not found.

At Ås the panels exposed to the north had higher mould ratings than the panels exposed south. Longer time of wetness (TOW) due to limited direct sunlight can explain this difference. On the other hand, the panels exposed to the north in Bogesund had slightly lower mould rating compared to panels exposed to the south. The panels exposed north

in Bogesund should therefore have received less direct rainfall since they were mounted vertically, and shorter TOW could explain the lower mould ratings.

Samples of the surface from the panels exposed at Ås were harvested at each evaluation date for future identification of the fungal species using DNA-analysis and traditional microscopy to establish the succession of species that causes the discoloration. Further, chemical analysis will be performed to determine the variation in chemical components on the surface of the panels due to treatment level, cardinal direction and related climatic factors. This work was carried out within the frame of the Competence Centre for eco-efficient and innovative wood based materials (Ecobuild). The project group consists primarily of Gry Alfredsen (Norwegian Forest and Landscape Institute), Stig Bardage (SP Träteknik) and Lone Ross Gobakken (Norwegian Forest and Landscape Institute).

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