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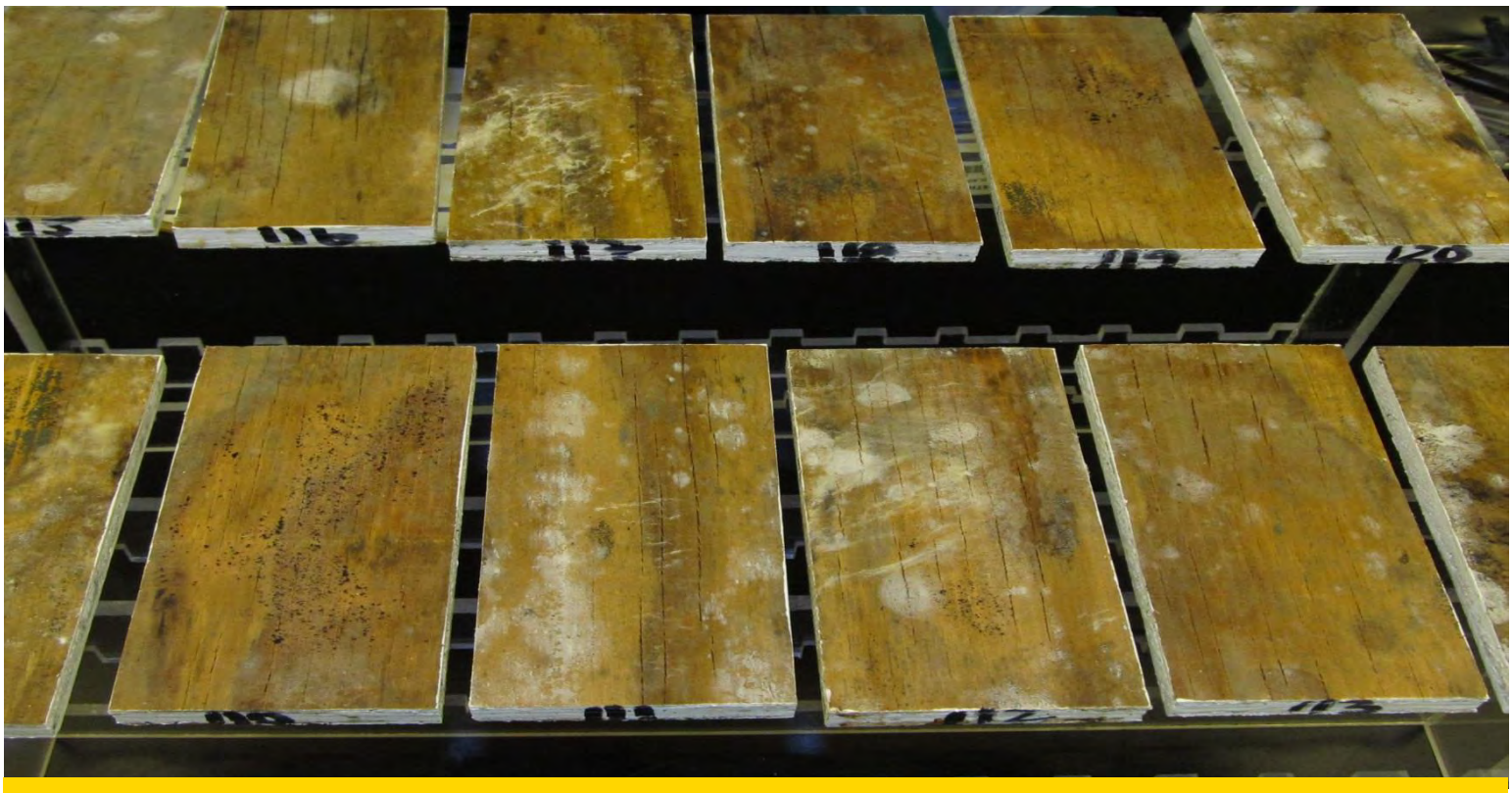

Assessing Remedial Treatments for Mouldy Sheathing in Ventilated Attics in Coastal Climates

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SUMMARY

Water vapour condensation and subsequent growth of moulds has been increasingly noticed on sheathing in ventilated attics in the Lower Mainland of British Columbia. Sheathing in attics may need fungicidal protection if the roof design cannot be changed to prevent wetting from condensation in the absence of rapid drying. Furthermore, attics with existing mould problems will need remedial treatment.

BC Housing approached FPInnovations to assist in evaluating protective treatments to prevent mould growth as well as in exploring remedial treatments for mouldy sheathing. Previous reports covered the evaluation of preventative measures. In the present work, six different products were evaluated for their ability to conceal and prevent the regrowth of mould on a mouldy wood substrate that had been treated without cleaning, or cleaned by various methods prior to a treatment. After 12 weeks of exposure in a modified AWPA E24-12 test, samples were evaluated for new mould growth, overall mould appearance, and the treatment's ability to mask any pre-existing mould and mould-related discolouration.

The three cleaning methods employed (soap, bleach, Product E) were all successful in immediate reduction of average mould rating (from 5 to 2.2 or less), but were not successful on their own to prevent further mould growth after an additional 12 weeks of exposure.

Preventing new growth of mould as well as ability to mask and conceal existing mould or stain were key attributes when assessing products effectiveness. It was found that the best results were achieved with a combination of a good cleaning technique and application of products able to mask existing mould stain and prevent further mould growth.

Product D was the best product for masking mould and discolouration and was effective at reducing further mould growth. Product B was the best product at preventing mould re-growth, but was not quite as good at masking. Other products, such as Product G and Product F, had good performance at preventing further mould growth, but did not provide any masking capabilities and for this reason they may be less desirable for consumers.

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1. OBJECTIVE

Evaluate the ability of selected treatments to conceal and prevent the regrowth of mould on test samples using a modified AWPA E24-12 test.

2. INTRODUCTION

Water vapour condensation and subsequent growth of moulds have been increasingly noticed on sheathing in ventilated attics of structures in the Lower Mainland of British Columbia. Public perceptions of human health risks from exposure to mould have reduced tolerance in the marketplace for building products prone to mould growth. Sheathing in attics may need protection if the design cannot be changed to prevent sustained wetting from condensation that supports mould growth. Furthermore, attics with existing mould problems will need remedial treatment.

BC Housing approached FPInnovations to assist in identifying protective treatments that prevent mould growth on sheathing in ventilated attics. Previous work evaluated 10 products for mould resistance when tested by the American Wood Protection Association (AWPA) standard E24-12 test method in a humidity chamber (Uzunovic *et. al*. 2013). In these tests a highly mould susceptible substrate, sapwood surfaces of Douglas-fir plywood, was used for the test and reference materials. Douglas-fir plywood is also a commonly used attic sheathing material in B.C. The products selected for testing were either registered by Health Canada's Pest Management Regulatory Agency, or in the process of applying for this registration. The second phase of work focused on the development of a modified mould testing method that incorporated intermittent vapour condensation on sample surfaces to better represent real attic conditions. This modified method was then used to test the ability to resist mould growth of three of the best performing products identified in the initial phase of work. Four promising commercially available water-repellent paints were also included in the third phase of work. These products were used alone and in combination to assess their ability to prevent absorption of condensate onto sheathing and consequentially prevent mould growth (Uzunovic *et. al.* 2014).

An advisory committee for the project was formed to help understand the challenges faced with attic remediation, to advise on common practices, and to help with product selection. The committee consisted of Patrick Roppel (Morrison Hershfield), Graham Finch (RDH), Denisa Ionescu (BC Housing), and Mike Kus (Construction Analyst, FPInnovations).

The present work focused on evaluating the efficacy of remedial treatments of mouldy sheathing. Once again, the modified AWPA E24-12 mould test was employed to test a selection of most promising products (some previously tested as well as those highlighted by the advisory committee) for efficacy in preventing further mould growth when applied to samples initially subjected to mould. Moulded plywood test samples were cleaned or left uncleaned in a mouldy state then treated with one of six selected treatments. Products were then assessed for their ability to prevent further mould growth, the degree of masking of existing mould and mould staining which they provided, and given an overall product assessment.

3. STAFF

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4. MATERIALS AND METHODS

4.1 Sample Preparation and Treatment

4.1.1 Test Protocol

The protocol used in this test is a modified version of the American Wood Protection Association (AWPA) standard E24-12 (AWPA 2014) as described in the Phase 3 report (Uzunovic *et. al.* 2013). Rather than maintaining constant high relative humidity suitable for mould growth throughout the test, wetting and drying cycles were used to simulate attic conditions and create condensation on sample surfaces. Only the sample face inside the chamber was rated for mould growth. The test was extended to run for 12 weeks to ensure there was sufficient time for the mould to grow again. Mould ratings were completed bi-weekly.

4.1.2 Preparation of Test Substrates

FPInnovations staff selected Douglas-fir (*Pseudotsuga menziesii*) 125 mm Can-Ply unsanded Degrade sheets from Northern Building Supplies, Vancouver. This material was chosen due to the greater amount of sapwood on face veneers than evident on other types of Douglas-fir plywood. Heartwood/sapwood boundaries on each face were marked and the plywood was cut into 160 by 65 mm samples, with one face having an all-sapwood veneer used as the test face. Samples were further sorted to eliminate defects (e.g. stain, knots, and checks). Two coats of a two-part epoxy (Intergard 740, International Marine Coatings) were applied to the edges of the test panels to prevent uptake of treatment, and movement of moisture into or out of the samples (via edge grain) during exposure in the test chambers. Two hundred and forty samples were selected for pre-moulding. Six samples were left untreated as positive controls. For this test, ponderosa pine sapwood and heartwood that are usually used as positive and negative control were not included, because these two substrates were shown to be unreliable in previous modified AWPA E24-12 tests. Both substrates tend to have mould ratings close to 3, making them both only moderately susceptible to mould growth.

Moisture content measurement has not been included in this test as only the surface of test pieces was subjected to moisture throughout this test and a total moisture of the whole piece does not provide any useful information as moisture content within the sample varies significantly between the surface of the sample test face exposed to the chamber and the surface outside the chamber. With respect to mould growth susceptibility, wetting of the test surface by condensation and humidity is the focus of this test. Mould growth on untreated controls, Douglas-fir plywood, confirmed sufficient moisture was present to promote mould growth.

4.1.3 Pre-mould

The inoculum was prepared as per AWPA E 24-12 (Uzunovic *et al*. 2014). The following organisms collected from FPInnovations culture collection and known to colonize wood were employed:

Alternaria tenuissima	Ftk 691B
Aspergillus niger	Ftk 207F
Aureobasidium pullulans	Ftk 132F
Penicillium citrinum	Ftk 595C
Cladosporium cladosporioides	Ftk 273C

All test wood samples were wetted to a minimum of 50% moisture by submerging them in water and subjecting them to a 20-minute vacuum at 83 kPa (12 psi). Once wetted, the samples were first inoculated with *Cladosporium cladosporioides* and *Aureobasidium pullulans* to increase the likelihood that these two fungi would colonize the samples. A slurry mixture of spores and fragmented mycelia was obtained by scraping two-week-old colonies on 2% malt agar with a blunt scalpel into sterile water. This slurry was collected with a dropper and applied on top of samples in a strip along the test sample surface. The samples were held at room temperature in sealed plastic bags for 48 hours. After 48 hours, the samples were moved into trays where they were held vertically and sprayed with an inoculum mixture that contained all five test species. The samples were again sealed in bags and held at room temperature for 48 hours to allow further colonization for the samples. After 48 hours, initiation of mould growth across the samples was visible. The samples were moved into the mould chambers to allow mould growth to continue for four weeks.

After four weeks, the test samples were removed from the chambers and assessed for mould growth using the rating method described in Table 1. All samples selected for the test were rated a five for mould growth after the four-week incubation period (Table 2). Figure 1 is an example of the pre-moulded samples selected for the test. Selected samples were randomly assigned to test groups with 16 test groups in total.

Table 1. Mould ratings method used to evaluate mould present

Rating	Description
0	No visible growth.
1	Mould covering up to 10% of surfaces providing growth is not so intense or coloured as to obscure the sample colour over more than 5% of surfaces.
2	Mould covering between 10% and 30% of surfaces providing growth is not so intense or coloured as to obscure the sample colour on more than 10% of surfaces.
3	Mould covering between 30% and 70% of surfaces providing growth is not so intense or coloured as to obscure the sample colour on more than 30% of surfaces.
4	Mould on greater than 70% of surfaces providing growth is not so intense or coloured as to obscure the sample colour over more than 70% of surfaces.
5	Mould on 100% of surfaces or with less than 100% coverage and with intense or coloured growth obscuring greater than 70% of the sample colour.

4.1.4 Cleaning of Samples

Product label instructions as well as advice from the advisory committee were employed to determine cleaning regimes. Samples selected for cleaning with soap were cleaned with a solution of Liquid dish soap (widely available at grocery stores) in tap water and wiped clean with a synthetic cloth rag. Samples cleaned with Product E were sprayed to refusal with the Product E solution, as received, using a garden sprayer. The product contains TSP (trisodium phosphate) as the cleaning agent. The Product E-cleaned samples were then allowed to air dry for 24 hours and wiped with a Product E-soaked cloth the following day. Samples cleaned with a 10% solution of Chlorine bleach (widely available at grocery stores) were sprayed to refusal with a hand sprayer and allowed to air dry; no mechanical action was applied. All samples were held at a 45-degree angle for all cleaning procedures to simulate an attic setting. Samples were cleaned upon removal from the mould chamber to prevent mould from drying on the sample surfaces. All samples air dried for at least 48 hours after cleaning, then rated again for mould presence using rating system as described in Table 1.

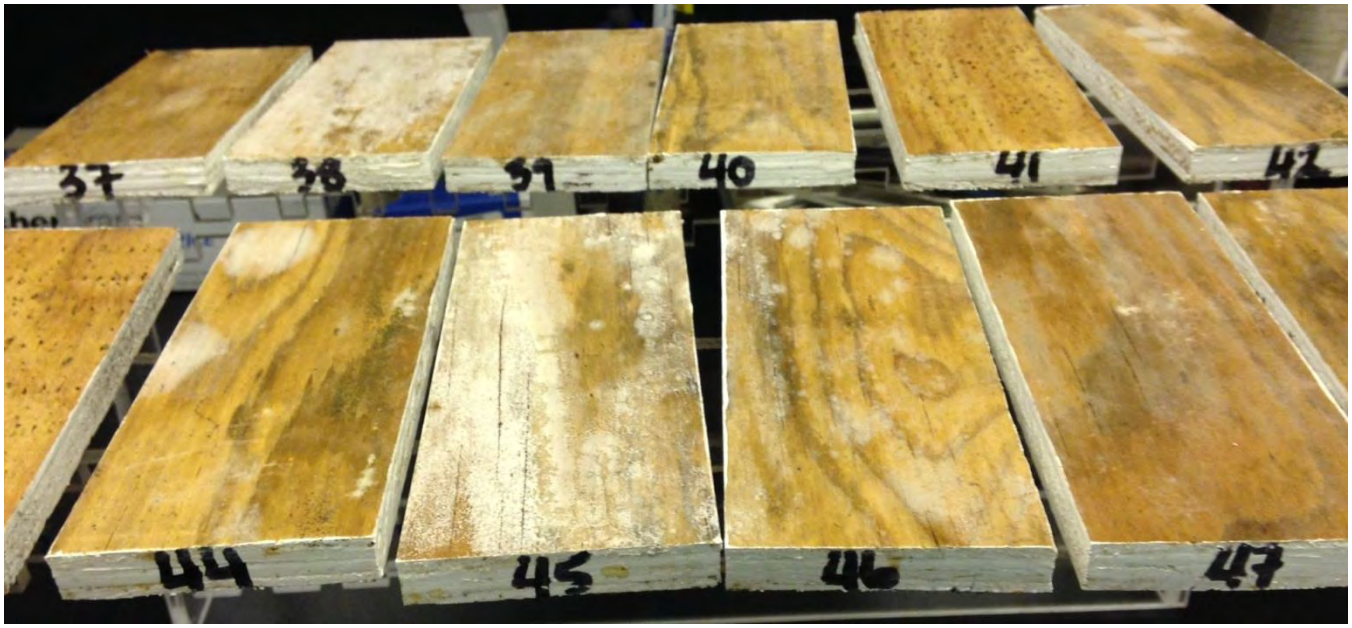

Figure 1. Pre-moulded samples before cleaning and treatment applications

4.1.5 Products Tested

Through consultations with the advisory committee and using results from previous successful treatments, six commercial remedial treatment products and one non-commercial product were selected for use in this test. The six commercial products chosen were:

- Product A, The non-commercial product, Product A, was an experimental formulation incorporating proprietary multiple active ingredients at high concentrations (as a positive control) applied at 6:1 dilution of the product from the concentrations used originally in phase 1 of the project.

- Product B, Industrial, in situ, moisture, mold and decay resistant coating for wood, based on a proprietary penetrating water borne KP-Alkyd formulation, used as received.
- Product C, Industrial unpigmented Weather Resistance System, diluted 35:1. Contains EPA/PMRA registered protectant preservatives in a proprietary and patented water-emulsified polymeric matrix.
- Product D, Retail white water-based interior/exterior primer, sealer and stain-blocker, used as received, based on 100% acrylic.
- Product E, Retail mould remediation and prevention treatment (patented solution comprised of three naturally-occurring salt compounds), containing trisodium phosphate, used as received.
- Product F, Retail mould resistant sealer, based on durable acrylic polymer, formulated with selected EPA-registered antimicrobials, used as received.
- Product G, Commercial preventive and remedial wood preservative to protect against decay, beetle attack and mould growth, contains 19.6%W/W DOT and 1% DDAC, used as received.

4.1.6 Treatment

Twelve replicates were initially treated with each product or combination of products and cleaning method. Due to limited space in the test chambers, two products were used only with soap-cleaned samples (Product G, and Product F). All samples were weighed before and after products were applied. A 1½-inch paintbrush was used to apply the coatings evenly to the sapwood face of the sample targeting a pre-determined weight of product based on label recommendations. Samples were held at a 45-degree angle while the treatment was applied to simulate attic conditions. Once weighed, samples were placed horizontally on racks until surfaces appeared dry, after drying the samples were transferred to vertical racks for 10 days of venting. Sample surfaces were not allowed to touch during treatment and venting. In all cases the uncleaned mouldy samples were treated after the cleaned samples to ensure no cross contamination of mould to the cleaned surfaces.

From the 12 samples treated, six were selected for testing based on similarity of weight uptake closest to the target of the product applied. The average amount of product retained on the samples selected for testing is shown in Table 2. Variation between products is due to the method of treatment, properties of the products, or supplier recommended application rate.

The samples were rated at each preparation step to get an indication of the influence that each step had on the test samples. Ratings were measured after cleaning to understand the effect of the cleaning method, and after treatment to determine the product-masking attributes. An overall mould appearance rating was also included before samples were put into test. These initial average ratings for all samples can be found in Table 2. A random number generator was used to randomize individual sample locations within the nine test chambers.

Table 2. Sample ratings following moulding, cleaning, and after application of treatments and before re-growth

Product	Application Method	Product Dilution	Average Mould Rating of Pre-Mould	Cleaning Method	Mould Rating After Cleaning		Product Uptake	Mould Rating After Treatment		Product Masking Total = 0 None = 5
					AVG	Max-Min		AVG	Max-Min	
None	none	none	5	none	5.0	5-5	NA	5.0	5-5	5.0
				soap	2.0	3-1	NA	2.0	3-1	5.0
Product A	brush	6 :1	5	none	5.0	5-5	131.5 (4.8)*	2.7	4-2	5.0
				soap	1.5	2-1	132.1 (2.4)	2.5	3-2	5.0
Product B	brush	none	5	none	5.0	5-5	157.2 (3.9)	1.8	3-1	1.3
				soap	0.7	2-1	155.6 (4.7)	1.3	2-1	1.2
				Product E	1.8	3-1	159.1 (3.3)	0.7	1-0	1.0
				bleach	1.8	4-0	153.6 (6.1)	1.8	2-1	1.7
Product C	brush	35 :1	5	none	5.0	5-5	119.1 (6.1)	2.8	4-2	5.0
				soap	2.0	3-1	112.3 (5.2)	2.2	3-1	5.0
Product D	brush	none	5	none	5.0	5-5	126.6 (2.5)	1.0	3-1	1.2
				Product E	1.3	2-0	131.2 (2.6)	0.0	0-0	1.0
				bleach	2.2	3-1	125.2 (4.7)	0.2	1-0	1.0
Product E	spray/wipe	none	5	none	2.0	3-1	NA	2.0	3-1	5.0
Product F	brush	none	5	soap	1.2	2-0	123.2 (1.7)	1.5	2-1	5.0
Product G	brush	none	5	soap	1.3	2-1	191.3 (7.8)	2.0	3-1	5.0

* Standard deviation given in parentheses

4.1.7 Test Chamber and Conditions

Test chamber set up was the same as described by Uzunovic *et. al*. (2014). The soil employed was Non-sterilized, commercial potting soil purchased from a wholesaler in Vancouver. Before the wetting and drying cycles were initiated, samples were subjected to three days of non-stop condensation, during which time the chamber conditions were at 25°C and near 100% RH (relative humidity) with no periods of drying. This ensured that sample surfaces were wet when the wetting-drying cycles began, since dry plywood is initially resistant to wetting. Wetting-drying cycles consisted of a three day condensation-absorption period followed by four days of continuous drying period without any condensation, to provide an accelerated simulation of attic conditions. The three day condensation-absorption period consisted of repeated 30 minutes of condensation where chamber condition was about 26°C and 96% RH, followed by a 30-minute absorption period where chamber conditions reduced to 22°C and 75% RH by the introduction of cool room air. Increasing the water-holding capacity of the chamber air and encouraging the formation of condensation on sample surfaces is integral to an effective test. The four-day drying period was created by turning off the chamber's water heater and not allowing the fans to operate. The chambers slowly equilibrated to near room temperature (about 15°C), reducing the RH to about 85% with the presence of water in the chamber and no air exchange.

4.1.8 Ratings/Assessment

After two weeks in the test, each chamber-exposed surface was rated for overall mould re-growth. Due to the complexity of rating these samples, the two-week rating was done on overall appearance of mould on the samples and included previous mould that was noticeable through the sample surface treatments. This was not adequate in assessing whether the remediation method would prevent new mould from growing. Therefore, a new mould growth rating and overall mould appearance rating was completed for all successive rating intervals. Table 3 contains the overall rating for week 2 as well as the final new growth mould ratings and the final overall mould appearance ratings at 12 weeks. New mould growth ratings were conducted in a similar way as regular mould ratings described in Table 1. For some samples a strong light source applied on the sample surface while inspecting the surface at all angles was necessary to clearly distinguish new mould growth from previous mould, a microscope at x10 magnification was employed when necessary to confirm new mould growth.

New mould growth and overall mould appearance inspections continued biweekly at four, six, eight, 10, and 12 weeks of exposure in the test chambers. All rating data is included in the appendix table. The rating system considers the extent and intensity of growth.

Remedial treatment masking was rated similarly to mould: a scale of 0-5 was used, where 0 indicated the treatment's ability to provide total surface masking (where no previous mould growth or staining was visible through the coating) and 5 indicating the product provided no surface masking (all previous mould and mould staining was visible). The final overall appearance of mould rating at 12 weeks represents the final appearance of mouldy or stained sheathing as it would appear to consumers if employed as remediation treatments in attics prone to condensation issues.

5. RESULTS AND DISCUSSION

The following results apply only to the samples tested under the conditions reported.

Untreated Douglas-fir plywood sapwood, both pre-moulded and non-pre-moulded, used as positive controls, was susceptible to mould growth with an average rating of 3.8 and 4.8 respectively (Table 3, Fig 2). The maximum and minimum ratings for individual samples were 5 and 3 respectively for both sample groups. This confirms a viable test.

Figure 2. Control Samples: Top left: six plywood samples as-received and unexposed. Top right: six pre-moulded samples with no further treatment. Bottom left: six exposed as-received plywood, put into test with no previous moulding or treatment. Bottom right: six pre-moulded plywood cleaned with soap

5.1 Efficacy of Cleaning Agents in Reducing Mould Discoloration and Re-growth

All cleaning methods were effective in decreasing the amount of visible mould growth as described in Table 2. Soap cleaning alone reduced the rating from 5 to an average of 0.7–2.0. However, soap-cleaned samples that did not receive any further treatment did not prevent mould regrowth (rating 4.2)

and had overall mould appearance at 12 weeks rating of 4.2. Product E-cleaned samples had a rating of 5 reduced to 1.3–2.0 after cleaning and overall mould 12-week rating of 3.7 (Table 3). Bleach-cleaned samples had a mould rating of 1.8–2.2 after cleaning. Unfortunately, no bleach-cleaned-only samples were included in the test for re-growth, but bleach is generally known not to be effective (New York State Toxic Mold Task Force 2010).

5.2 Efficacy of Remedial Treatments in Preventing Mould Re-growth

The ability of a product to prevent re-growth and new growth of mould is one of the most important attributes for selecting a remedial treatment. For non-cleaned samples the best performance was by Product B (0.8) followed by Product D (1.3), Product A (1.8), Product C (3.0), and Product E (3.7), There were no data for Product F and Product G on the ability to prevent re-growth on non-cleaned samples. Product B, Product D, Product F, and Product G all performed well on cleaned samples and prevented mould re-growth after 12 weeks with ratings of 1 or less.

5.3 Efficacy of Remedial Treatments in Masking Mould Discoloration

Masking capabilities of a remedial treatment is another key attribute. Some products could mask both existing mould and mould discolouration left after cleaning, while other products provided no masking and were transparent to previous mould growth and mould discolouration. Product D worked best at masking the previous mould growth (rating of 1.2 for masking when applied over non-cleaned samples and 1 for Product E- or bleach-cleaned samples (Table 2). Product B also worked well at masking the non-cleaned mould samples (rating 1.3) and similar ratings when applied on cleaned samples (1.2, 1.0, and 1.7). However, Product B had a slight highlighting effect on the mould staining left on the samples after cleaning and this highlighting effect was especially pronounced when the samples were rewetted. Product A, Product C, Product E, Product F, and Product G did not provide any masking from previous mould growth and mould staining (Table 2, Figure 3 and 4). In addition, Product G treated samples had a white residue (crystallisation of borate) form on the wood surface after treatment (Figure 3, top row). This residue remained visible throughout the test and could cause unjustified concern to customers as it could be mistaken for mould growth.

5.4 Overall Cleaning, Remedial Treatment Effects and Visual Impact

The ability to be effective when applied over non-cleaned moulded samples and prevent new growth while masking any previous mould and discolouration avoids the additional costs associated with the need to first clean the sheathing surface. Among the products tested under the conditions outlined in this test Product D met this objective. The uncleaned Product D samples had an average 12-week rating of 1.7 (overall mould appearance, table 3) compared with 3 and above for all other uncleaned and treated samples included in this test.

Prior cleaning and type of cleaning had an effect on some treatments as observed in the new mould ratings. Product B treated samples had an average rating for new mould growth of 0.8 at 12 weeks when applied on non-cleaned samples, 0.8 for soap-cleaned samples, 1.0 for Product E-cleaned

samples, and 0.5 for bleach-cleaned samples (Table 3). The Product D-treated samples had average new mould ratings of 1.3 after 12 weeks for non-cleaned samples, 0.3 for bleach-cleaned, and 0.5 for Product E-cleaned samples. No soap-cleaned samples treated with Product D were included in this test, because Product D product label does not recommend using soap prior to use. Product A, Product F, and Product G also had great performance with ratings of 0.7 when applied on soap cleaned samples. The Product E and Product C treatments did not prevent new mould growth, because both had an average new growth rating of 3 or greater after 12 weeks of exposure. The overall mould appearance ratings were the same as new mould growth for these treatments.

Prior cleaning also had an effect on the overall mould appearance rating at 12 weeks for some treatments but not all. Samples cleaned with Product E or bleach and treated with Product D had a final overall mould appearance rating of 0.8 compared to 1.7 when Product D was applied to non-cleaned samples. For Product B, all three cleaning methods had average overall appearance ratings of 2.2 or less compared to 3.0 when Product B was applied over non-cleaned samples. Product A had the same rating for non-cleaned samples and soap-cleaned, with average overall appearance rating of 3.2. Similarly, Product C also had no significant change in overall appearance rating for non-cleaned and soap cleaned samples (3.3, 3.5).

Due to lack of masking ability for the Product A, Product F, and Product G treatments, the final overall mould appearance ratings were higher for all three of these products with ratings of 3.2, 2.3, and 2.5 respectively.

The visual impact of treatment and the overall mould assessments are important qualities for the consumer. However, the overall ratings determined in this test include pre-existing mould or mould staining that shows through some treatments, influencing the overall appearance. For many of these treatments the pre-existing mould may be encased in the treatment and therefore non-active. Products that can successfully prevent mould regrowth but do not have masking capabilities may appear less effective for an average consumer, because the previous mould discolouration will show through and influence the overall appearance of mould. Products like Product B, which had negligible additional mould growth following the treatment (rating of 0.8 for uncleaned samples), can be overlooked if the overall appearance is focused on (Figure 5). Product D and Product B were both successful when used over existing mould, although visually Product D out-performed Product B due to its better masking ability.

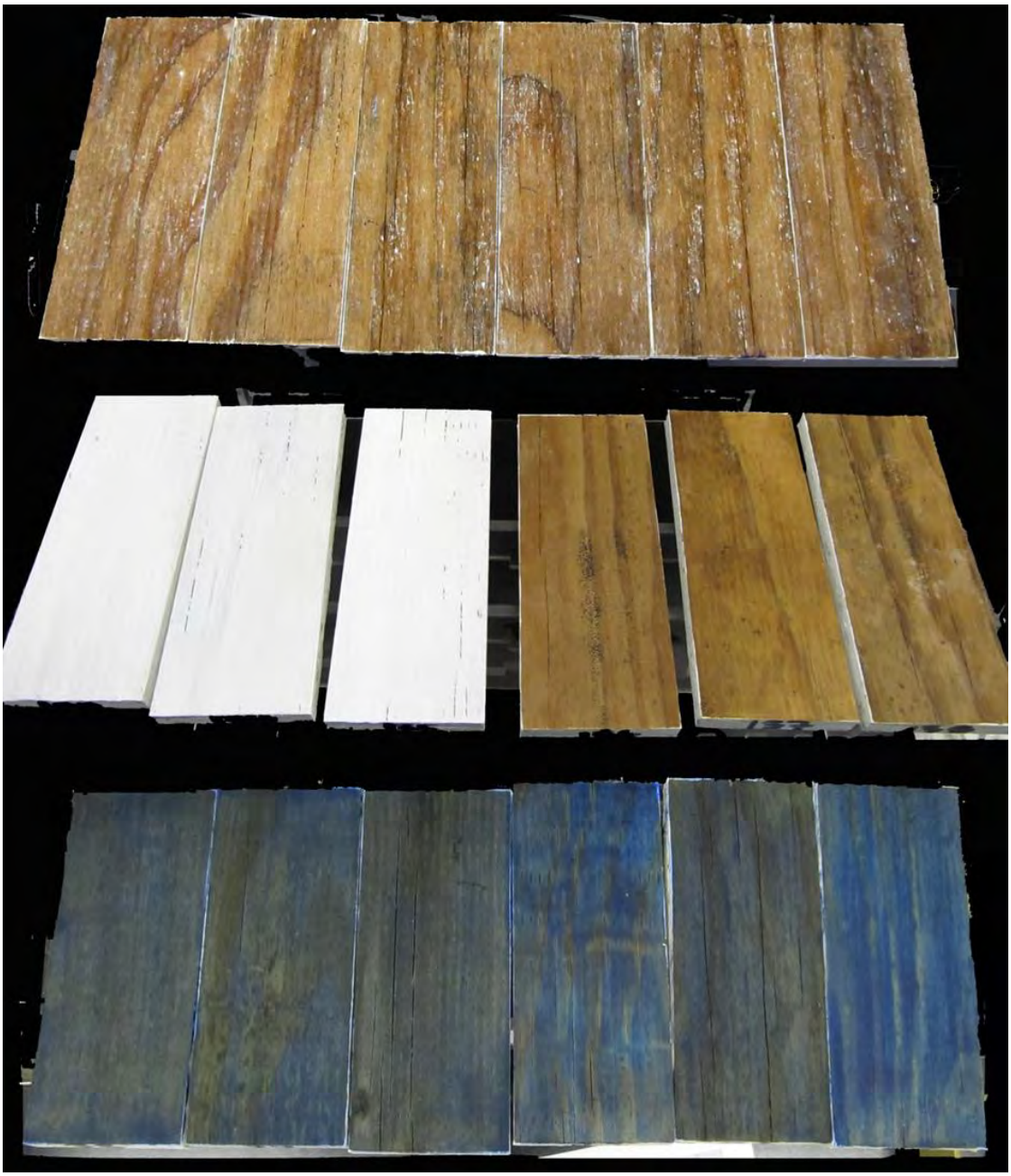

Figure 3. Examples of treatments and masking. Top row: Product G-treated samples showing white residue observed on samples after treatment. Middle row: Product D applied over moulded samples showing the masking ability (first three samples treated with Product D compared with the adjacent three samples not yet treated with Product D). Bottom row: Product B-treated samples; dark blue colour of product partially masks wood grain and previous mould stain.

Figure 4. Samples after 12 weeks' exposure. Top left: Product D remains white, but appears aged and a bit greyer/yellower and clear of any new mould growth. Top right: Product B has some loss of blue colour intensity, when wet the wood grain and stain below become more visually pronounced. Bottom left: Product C-treated samples, both new and previous mould visible. Bottom right: sample treated with Product A does not mask previous mould or stain while some new growth was inhibited.

Rating previously moulded and cleaned products was challenging and to an extent subjective. What appeared to be mould and mould stain for some may not be for others. We conducted an overall appearance rating test among five people who are involved in regular mould testing and got differing results. The previous mould staining caused an issue between raters, because some included it in the overall appearance rating while others did not. However, the perspective of a consumer was considered from the onset of this test, which is represented in the overall appearance rating. It should also be noted that the same person performed all the rating throughout this experiment to ensure consistency.

Another highly discussed property was the overall appearance of each treatment, speculating what consumers may prefer such as the clean, white-paint-like look of Product D while others might like the deep blue colour of the Product B product. Some consumers may still prefer a natural wood colour when Product F or Product G products were used, knowing that they both successfully prevented regrowth or new mould growth.

Table 3. Final mould rating of samples after 12 weeks' exposure, including new growth and overall mould appearance. Initial overall mould rating at test start, product colour, and masking ratings are included for reference.

Treatment	Pre-treatment	Cleaning Method	Initial Mould Rating (after cleaning and applied treatments)		Masking of Mould	Colour of Product	Fresh Mould Growth after 12 weeks		Overall Mould Appearance (12 weeks' rating)	
			AVG	max-min			AVG	max-min	AVG	max-min
None	None	None	0.0	0-0	Not applicable	Not applicable	3.8	5-3	3.8	5-3
	Mould	None	5.0	5-5	No	Not applicable	4.8	5-4	4.8	5-4
		Soap	2.0	3-1	No	Not applicable	4.2	5-3	4.2	5-3
Product A	Mould	None	2.7	4-2	No	Sheer Yellow	1.8	3-1	3.2	4-3
		Soap	2.5	3-2	No	Sheer Yellow	0.7	2-0	3.2	4-3
Product B	Mould	None	1.8	3-1	Yes	Deep Blue	0.8	1-0	3.0	4-2
		Soap	1.3	2-1	Yes	Deep Blue	0.8	2-0	2.2	3-2
		Product E	0.7	1-0	Yes	Deep Blue	1.0	2-0	2.0	3-1
		Bleach	1.8	2-1	Yes	Deep Blue	0.5	1-0	2.2	3-2
Product C	Mould	None	2.8	4-2	No	Sheer Yellow	3.0	4-2	3.3	4-3
		Soap	2.2	3-1	No	Sheer Yellow	3.2	4-1	3.5	4-2
Product D	Mould	None	1.0	3-1	Yes	White	1.3	2-1	1.7	2-1
		Product E	0.0	0-0	Yes	White	0.5	1-0	0.8	1-0
		Bleach	0.2	1-0	Yes	White	0.3	1-0	0.8	2-0
Product E	Mould	None	2.0	3-1	No	None	3.7	4-3	3.7	4-3
Product F	Mould	Soap	1.5	2-1	No	Clear Coat	0.7	1-0	2.3	3-2
Product G	Mould	Soap	2.0	3-1	No	Clear Coat	0.7	2-0	2.5	3-2

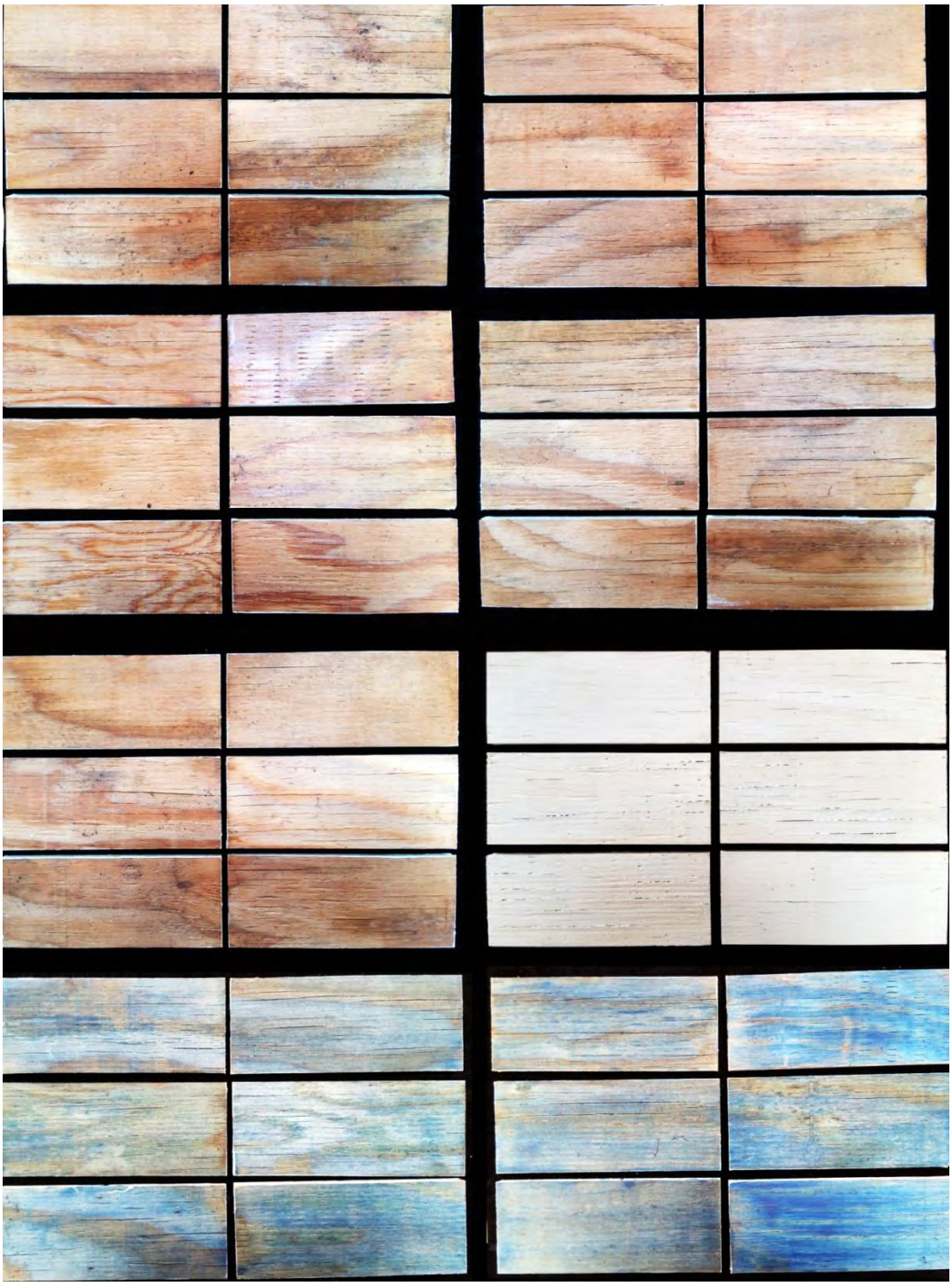

Figure 5. Cleaning effect of the masking of existing mould and overall appearance of sets of six replicas of pre-moulded, cleaned, and coated samples after the experiment. From top left to bottom right: I – control, not-cleaned samples; II – not-cleaned samples treated with Product E; III – soap-cleaned + Product F; IV – soap-cleaned + Product G; V – soap-cleaned + Product C; VI – bleach + Product D; VII – soap-cleaned + Product B. VIII – bleach + Product B.

6. CONCLUSIONS

The best overall mould ratings for products applied over non-cleaned samples were for Product D, which combined the masking ability and mould prevention that is important for a one-step remediation treatment. Product B also performed well and was superior in preventing further mould growth when applied over non-cleaned samples, but its inability to completely mask underlying mould impacted its overall remediation ability as a one-step treatment.

Cleaning reduced the initial mould ratings significantly from ratings of 5 to 2 or less. Bleach cleaning appears to be the best cleaning method, since both Product B and Product D samples initially treated with bleach had slightly lower regrowth ratings. Bleach cleaning was also the most cost effective. Since it was only sprayed on and left to dry with no scrubbing applied, it is therefore assumed the labour cost associated with this step would be less to complete. Samples where just cleaning alone was applied were insufficient in preventing further mould growth.

Product D worked best to mask the existing mould discolouration, followed by Product B. Product B's masking capability was better if applied over cleaned samples. Other products had little or no masking capabilities and because of that they may appear less effective to an average consumer.

The ability to prevent mould regrowth was shown by several products including Product A, Product B, Product D, Product F, and Product G. They all performed well after 12 weeks in test, providing a level of confidence to use them in real-life applications because they will prevent new mould growth. The Product E and the Product C treatments did not prevent new mould growth after 12 weeks of exposure.

The overall look of treatment may meet different preferences among consumers. Some may like the white-paint-like look of Product D while others may prefer the blue look of Product B or even the natural-wood look that Product F and Product G provide, while understanding that they all successfully prevented new mould growth.

7. REFERENCES

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APPENDIX I –
RATINGS FOR NEW MOULD GROWTH AND OVERALL MOULD APPEARANCE

Treatment	Pre-treatment	Cleaning method	2-Week Overall Rating		4-Week Ratings				6-Week Rating				8-Week Rating				10-Week Rating				12-Week Rating			
					New Growth		Overall		New Growth		Overall		New Growth		Overall		New Growth		Overall		New Growth		Overall	
			AVG	max-min	AVG	max-min	AVG	max-min	AVG	max-min	AVG	max-min	AVG	max-min	AVG	max-min	AVG	max-min	AVG	max-min	AVG	max-min	AVG	max-min
None	None	None	2.3	4-0	2.5	4-1	2.8	4-1	3.2	4-2	3.2	4-2	3.7	4-3	3.7	4-3	3.7	**4-3**	3.7	4-3	3.8	5-3	3.8	5-3
	Mould	None	5.0	5-5	3.5	5-2	4.3	5-4	4.3	5-3	4.7	5-4	4.5	5-3	4.7	5-4	4.8	5-4	4.8	5-4	4.8	5-4	4.8	5-4
		Soap	3.2	5-2	2.0	4-1	3.0	5-4	3.3	4-3	3.3	4-3	3.5	4-3	3.5	4-3	3.8	5-3	3.8	5-3	4.2	5-3	4.2	5-3
Product A	Mould	None	3.0	4-2	0.7	2-0	2.8	4-2	1.0	2-0	2.8	4-2	1.3	2-1	3.0	4-2	1.5	3-1	3.0	4-2	1.8	3-1	3.2	4-3
		Soap	3.3	4-3	0.5	2-0	2.8	4-2	0.5	2-0	3.0	3-3	0.8	2-0	3.0	3-3	0.8	2-0	3.0	3-3	0.7	2-0	3.2	4-3
Product B	Mould	None	2.5	4-2	0.3	1-0	2.3	4-1	0.5	1-0	2.3	4-1	0.5	1-0	2.5	4-1	0.7	1-0	2.7	4-2	0.8	1-0	3.0	4-2
		Soap	1.8	2-1	0.7	1-0	1.8	2-1	0.5	1-0	2.0	2-2	0.7	1-0	2.2	3-2	0.7	1-0	2.0	2-2	0.8	2-0	2.2	3-2
		Product E	1.3	2-1	0.5	1-0	1.3	2-1	0.3	1-0	1.5	2-1	0.2	1-0	1.8	2-1	0.8	2-0	1.8	2-1	1.0	2-0	2.0	3-1
		Bleach	2.2	3-2	0.0	0-0	2.0	2-2	0.3	1-0	2.0	2-2	0.5	1-0	2.2	3-2	0.7	1-0	2.2	3-2	0.5	1-0	2.2	3-2
Product C	Mould	None	3.0	4-2	1.8	3-1	2.8	3-2	2.3	3-1	3.0	3-3	2.5	3-1	3.0	3-3	2.8	4-2	3.2	4-3	3.0	4-2	3.3	4-3
		Soap	2.7	3-2	1.2	3-0	2.8	3-2	1.7	4-0	3.2	4-2	1.8	4-0	3.2	4-2	3.0	4-1	3.3	4-2	3.2	4-1	3.5	4-2
Product D	Mould	None	1.7	3-1	1.3	2-1	1.8	3-1	1.3	2-1	1.7	2-1	1.3	2-1	1.7	2-1	1.2	2-1	1.5	2-1	1.3	2-1	1.7	2-1
		Product E	0.0	0-0	0.2	1-0	0.3	1-0	0.2	1-0	0.5	1-0	0.2	1-0	0.5	1-0	0.2	1-0	0.3	1-0	0.5	1-0	0.8	1-0
		Bleach	0.5	1-0	0.0	0-0	0.5	1-0	0.0	0-0	0.5	1-0	0.0	0-0	0.5	1-0	0.3	1-0	0.7	2-0	0.3	1-0	0.8	2-0
Product E	Mould	Product E	2.3	3-2	1.5	3-1	2.5	3-2	2.2	4-0	3.2	4-3	2.7	4-0	3.3	4-3	3.5	4-3	3.5	4-3	3.7	4-3	3.7	4-3
Product F	Mould	Soap	1.8	3-1	0.2	1-0	2.2	3-2	0.2	1-0	2.2	3-2	0.7	1-0	2.3	3-2	0.7	1-0	2.3	3-2	0.7	1-0	2.3	3-2
Product G	Mould	Soap	2.2	3-1	0.7	1-0	2.3	3-2	0.7	2-0	2.5	3-2	0.7	2-0	2.5	3-2	1.0	2-0	2.5	3-2	0.7	2-0	2.5	3-2

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