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**A fast and economic method to produce grey wooden surfaces for decking and cladding: preliminary results**

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# A fast and economic method to produce grey wooden surfaces for decking and cladding : preliminary results

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## ABSTRACT

Uncoated wood is commonly used in France for cladding and decking to minimise maintenance. However wood surfaces progressively turn grey due to exposure to sunlight and water. This grey colour develops after several months depending on the wood species and the exposure: in the northern hemisphere surfaces facing south and west are most exposed and turn grey more rapidly than those facing north and east. The result is unfortunate differences in the appearance of the building which obviously is not appreciated by the end-users and which leads to a negative image of the wood material.

As a consequence of this some architects would like to have grey wood right from the beginning of the construction.

Producing grey wood using artificial weathering devices or natural weathering exposure is possible but too expensive and too long.

In this project the idea is to develop a non-film forming coating whose colour is similar to the grey appearance produced by the natural weathering. This coating must be durable enough just to allow a soft transition between its own degradation and the development of the grey colour produced by the natural weathering.

**Keywords:** wood, weathering, greying, surface, coating, aesthetics

## 1. INTRODUCTION

Like other biological materials, wood is susceptible to environmental degradation. When exposed outdoors a complex combination of chemical, mechanical, biological changes contribute to its weathering. Exposure of wood to the weather leads to a depolymerisation of lignin and cellulose and to a degradation of cellular structure (Feist and Hon1984, Evans *et al* 1996).

At first these changes cause wood to yellow as unsaturated photodegraded lignin compounds accumulate at exposed surfaces. Then these changes cause wood surfaces to become grey due to leaching of photodegraded lignin and fibre fragments from wood by rain.

It is also reported that the greying of wood can be accompanied by the occurrence of fungi. These either colonize the surface of wood, producing dark brown, incrustated cell complexes, or they are found in the tracheids of the uppermost wood layers in the form of cell packets or chains.

To avoid these colour changes and to ensure long term value protection of wood substrates they are usually coated with opaque or transparent finishes. In France, transparent coating systems are often chosen because they allow the natural beauty of wood such as colour and texture to remain visible. During the last decades important efforts have been made to improve the durability of these transparent coatings. Despite these improvements periodic operations of maintenance are still necessary to increase the service life of wooden surfaces.

To avoid maintenance, wood without coating is sometimes used in applications such as cladding or decking. In this case the surface greying requires several months even several years to appear depending on the wood species and depending on the exposure to the weather. In the northern hemisphere surfaces facing south and west are most exposed and turn grey more rapidly than those facing north and east. The result is unfortunate differences in the appearance of the building which obviously is not appreciated by the end-users and which leads to a negative image of the wood material. An example of such a situation can be shown in Figure 1 and Figure 2 which show the same cladding (Scots pine) after the same duration of natural weathering. Figure 1 shows that the greying on sides facing west and south is considerable, whereas Figure 2 shows that the greying is just beginning on sides facing north and west. The difference of aspect between the sides facing west and south and the sides facing north and east is considerable, and harmful to the general aesthetics of this experimental set-up.

The design has a great influence on the development of wood greying and therefore on the aesthetics of the surfaces.

Even on the same façade differences in the general appearance can be observed due to the influence of design, as shown in Figure 3. This photo shows a 10 year old Douglas fir cladding facing south where the right hand side is not grey due to the protection from rain provided by the eaves.

Figure 4 shows a ten year old Douglas fir cladding facing south where the top is not grey due to a protection by a small overhang eave. The profile of the cladding itself has an influence on wood greying as shown in Figure 5 which shows a ten year old Douglas fir cladding facing south where the recessed surfaces are protected from weathering and are less grey than the projecting part.. For a better aesthetics claddings with flat surfaces are recommended.

Furthermore some end-users are not aware that weathering will produce colour changes and that wood will turn grey. They discover this change with time and regret the use of wood what contributes to give a negative image to the material.

As a consequence of this and also because of the general trend towards natural products some architects would like to have grey wood right from the beginning of the construction.

Producing grey wood by the use of methods reproducing the natural ageing of the wood is possible. Several types of accelerated weathering devices combining the action of UV and water exist on the market. The key to produce grey wood in these equipments is to combine water spray with UV radiation in the artificial weathering cycle. Water condensation combined with UV radiation is not sufficient (Podgorski *et al.* 2003).

However only small surfaces (some cm<sup>2</sup>) can be introduced in these equipments. Furthermore this solution would not be economically interesting (cost of the UV lamps, time of immobilization of equipments, energy consumption).

In this project the idea for producing grey wood is to develop a product whose grey colour matches the natural grey of weathered wood and whose durability is low. This coating must be non-film forming to keep the natural aspect and touch of wood.

Therefore the study concentrates on the development of a low-built stain. Generally the durability of this type of product (for conventional pigmentation) is short.

In this project the product to be developed must be durable enough just to allow a soft transition between its own degradation and the development of the grey colour produced by the natural weathering. By this way the transition between the initial state (artificial grey produced by the low-built stain) and the final state (natural grey produced by the ageing) should be better accepted by the end-users.

The idea is to focus on the development of water-based products for environmental concern.

This study includes two partners: Cidemco (Spain) is in charge of the formulation of the product whereas FCBA is responsible for assessing its performances. The project is funded by the Spanish Basque country and the French region Aquitaine within the common fund of cooperation between these two countries.



Figure 1: Scots pine cladding, sides facing west (on the left) and south (on the right)



Figure 2: Scots pine cladding, sides facing north (on the left) and east (on the right)



Figure 3 : Influence of the design on wood greying



Figure 4 : Influence of the design on wood greying



Figure 5: Influence of the cladding profile on wood greying

## 2. PRE-SELECTION STEP

Different recipes of water-based low-built stains have been prepared by Cidemco using several types of binders: acrylic, acrylic styrenic, vinyl acrylic and acrylic urethane resins.

Five low-built stains were produced with a solid content of 30%. All these recipes had the same amount of graphite and titanium dioxide.

They were applied by brush (50 g/m<sup>2</sup>) on radiata pine and tested at Cidemco in a QUV for 1 000 hours using a cycle made of 4 hours of UV-A radiations followed by 4 hours of condensation.

The general appearance of these samples is shown in Figure 6 .

At the end of the test and depending on the type of resins the most important changes were colour changes which were visually assessed in comparison with the control non exposed to weathering. One of the acrylic resin (acrylic 1) was selected as the most suitable binder concerning the required aspect.

Based on this acrylic resin, different low- built stains have been developed using several types of black pigments (iron oxides, carbon black, graphite) and several types of white substances (titanium dioxide, calcium carbonate, magnesium carbonate) mixed at different rates to obtain the sought-after grey colour.

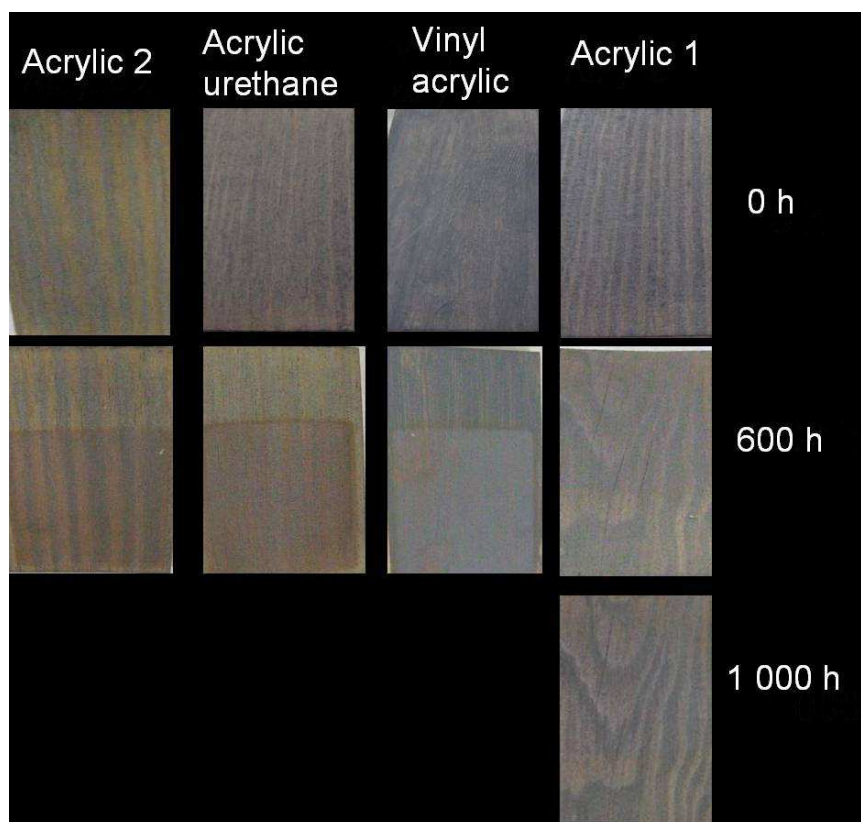


Figure 6 : General appearance of the different resins tested before and after artificial weathering

All these stains were brush applied in one coat by Cidemco without any control of the spreading rate just to control the final aspect obtained after drying.

They were compared to pine samples that were grey due to exposure to natural weathering and used as a benchmark. Two recipes were selected for their capacity to mimic the grey colour produced by the natural weathering. One was based on iron oxide and titanium dioxide and the other one included carbon black and titanium dioxide. They are referred to as 3C and 9.

Then these two recipes were optimised and Cidemco produced 3 other recipes. In total FCBA has tested 5 recipes:

- F1 is based on graphite and titanium dioxide,
- F2 is based on iron dioxide and titanium dioxide,
- F3 is based on carbon black and titanium dioxide,
- 3C is based on iron oxide and titanium dioxide,
- 9 is based on carbon black and titanium dioxide.

They were brush applied in one coat on two sets of Scots pine samples. For one set the spreading rate was higher (see Table 1) in order to see the influence of the quantity applied on the general appearance of the samples.

Table 1: wet spreading rate

Product	1 coat low spreading rate (g/m <sup>2</sup> )	1 coat high spreading rate (g/m <sup>2</sup> )
F1	100,0	171,4
F2	123,1	184,6
F3	123,1	200,0
3C	138,5	230,8
9	114,3	228,6

The general appearance of the samples is shown in Figure 7. This photo compares the aspect of the low (on the left) and the high (on the right) spreading rate with a bare and grey wood sample weathered 1 year at 45° facing south west and used as a reference (in the middle).

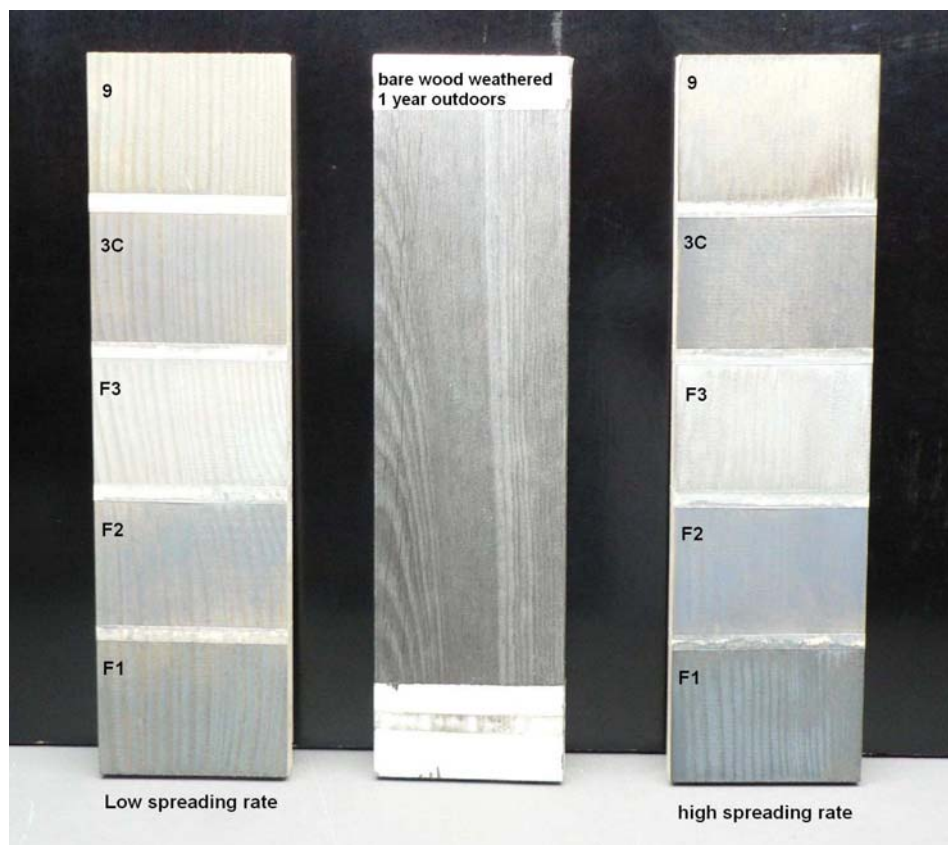


Figure 7 : General appearance of the samples with the 5 selected recipes

### 3. RESULTS

Coatings 9 and F3 show a too light colour compared to the reference and have not been selected for further investigations.

F2 does not provide a natural aspect especially when it is applied at the higher spreading rate. Therefore this stain has not been selected.

The most interesting appearance is provided by 3C and F1.

Iron oxides are usual pigments used in conventional wood coatings that is why recipe 3C (based on iron oxide) was kept for further investigations.

The next step consisted in assessing the performance of the stain 3C after artificial weathering test according to EN 927-6 (2006) in order to check that this stain can fulfil the objectives of the study. The cycle used in this standard is very severe in particular for conventional low-built stains tested in one coat and most of them are generally completely washed out at the end of the 12 weeks.

That is why it was decided to test 3C in two ways:

- 3C brush applied in one coat with a low spreading rate as tested before (see Table 1),
- 3C applied in two coats with the spreading rate of the first coat similar to the one tested before followed by a second coat less loaded in order to keep a natural aspect of the whole system. This application in 2 coats is expected to be less quickly washed out than an application in one coat having a higher spreading rate.

The stain 3C was applied on Scots pine samples, on radiata pine samples and on CCA treated Scots pine samples. These last samples were used in order to see if this grey low-built stain can mask the green colour provided by the copper and which is not always appreciated by the end-users of copper treated wood.

For each sample, only the face to be exposed to weathering as well as the two edges were coated. The rear side was left uncoated and the end grain was sealed with an alkyd paint.

Table 2: wet spreading rate used for the stain 3 C

	1 coat	2 coats		
		Coat 1	Coat 2	total
Scots pine	104 g/m <sup>2</sup>	101 g/m <sup>2</sup>	54 g/m <sup>2</sup>	155 g/m <sup>2</sup>
Radiata pine	101 g/m <sup>2</sup>	104 g/m <sup>2</sup>	56 g/m <sup>2</sup>	160 g/m <sup>2</sup>
CCA treated pine	100 g/m <sup>2</sup>	99 g/m <sup>2</sup>	50 g/m <sup>2</sup>	149 g/m <sup>2</sup>

For each wood substrates (Scots pine, radiata pine, CCA treated Scots pine), 3 samples were exposed to artificial weathering for 12 weeks using the cycle described in EN 927-6. At the end of the test they were conditioned at 20°C and 65 % RH. The general appearance was assessed and rated according to ISO 4628-1 on a scale from 0 (no change) to 5 (severe changes) in comparison to the unexposed reference sample.

Results are reported in Table 3 which shows the individual score assessed on the 3 replicates. Scots pine samples are shown in Figure 8.

Table 3: General appearance of samples coated with 3C after 12 weeks of artificial weathering.

	1 coat	2 coats
Scots pine	2/2/2	2/2/2
Radiata pine	2/2/2	3/2/2
CCA treated Scots pine	3/4/4	2/2/2



Figure 8 : Appearance of the Scots pine samples coated with the stain 3C before and after EN927-6 test

Table 3 shows that samples are still in good conditions after 12 weeks of weathering: most of the samples have a general appearance of 2. Such a good score was not expected as most of the low-built stains applied in 1 coat and tested using EN927-6 usually present a general appearance of 4 or 5 due to the severity of the test.

On CCA Scots pine samples it is recommended to apply 2 coats as they provide a better general appearance during weathering. Furthermore, when applied in a single coat it was observed some zones where the product was not absorbed by the wood probably due to a higher content in copper at these places and thus a higher water repellency.

On radiata pine which were a little bit rougher than Scots pine the test results show that an application in 2 coats reduces the influence of the roughness. Indeed the roughness can induce an early washing of the stain.

The next step will consist in testing this stain in natural weathering on exposure racks inclined at 45° but also at 90° (cladding end-use) and facing the different points of the compass.

Horizontal exposure will also be tested for the decking application. Results will be presented when available.

#### 4. CONCLUSIONS

Wood surfaces progressively turn grey due to exposure to sunlight and water. In the northern hemisphere surfaces facing south and west are generally most exposed and turn grey more rapidly than those facing north and east. The result is unfortunate differences in the appearance of the building which obviously is not appreciated by the end-users and which leads to a negative image of the wood material. As a consequence of this some architects and end-users would like to have grey wood right from the beginning of the construction.

The aim of this project is to develop a non-film forming coating whose colour is similar to the grey appearance produced by the natural weathering. This coating must be durable enough just to allow a soft transition between its own degradation and the development of the grey colour produced by the natural weathering.

Several waterborne low-built stain have been developed and tested by Cidemco in cooperation with FCBA. One was selected as the most suitable to mimic the grey colour produced by the natural weathering. This stain applied in one or 2 coats shows good performance when tested in artificial weathering according to EN 927-6.

It is also suitable to mask the green colour of wood treated by preservative treatment based on copper. This green colour due to the preservative treatment is not always appreciated by the end-users who turn more and more towards natural wooden substrates.

### **Acknowledgements**

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