Chapter 6
Portfolio of Bio-Based Façade Materials

Each material has its specific characteristics which we must understand if we want to use it.

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Abstract This chapter presents a selection of biomaterials identified by industry and academia as superior for building façades. Time series of photographs demonstrating changes of material appearance during use phase are provided for each case. In addition, selected technical characteristic, durability, recyclability potential as well as costing estimates are provided for each biomaterial.

The trend for rapid deployment of novel/advanced material solutions at reduced costs through predictive design of materials and innovative production technologies is observed nowadays. Such materials are optimized for specified applications, assuring at the same time expected properties and functionality at elongated life, minimizing the environmental impact, and reducing risk of product failure. As a consequence, higher numbers of well-performing (also in severe environments) construction materials are available on the market. It is extremely important for the biomaterial production sector to follow this trend and to continuously improve its offer. Today's bio-based building materials, even if well characterized from the technical point of view, are often lacking reliable models describing their performance during service life. The other factor, often underestimated (but critical for the sustainable use of bio-based building materials), is related to the transformations of building materials after their service life. The development of really innovative and advanced bioproducts relies on the deep understanding of the material properties, structure, assembly, formulation, and its performance along the service life.

A. Sandak et al., *Bio-based Building Skin*, Environmental Footprints and Eco-design of Products and Processes, https://doi.org/10.1007/978-981-13-3747-5_6

6.1 BIO4ever Project

The BIO4ever project was dedicated to fulfilling gaps of lacking knowledge on some fundamental properties of novel bio-based building materials. The two driving objectives of the projects were:

- To promote use of biomaterials in modern construction by understanding/modelling its performance as function of time and weathering conditions
- To identify most sustainable treatments of biomaterial residues at the end of life, improving even more their environmental impact.

The overall goal was to assure sustainable development of the wood-related construction industry, taking into consideration environmental, energy, socio-economic, and cultural issues. This has been achieved by developing original, trustworthy tools demonstrating advantages of using bio-based materials when compared to other building resources.

6.1.1 BIO4ever Project Materials

Hundred twenty samples investigated within the BIO4ever project were provided by 30 industrial and academic partners from 17 countries. The experimental samples include different wood species from various provenances, thermally and chemically modified wood, composite panels, samples finished with silicone and silicate-based coatings, nanocoatings, innovative paints and waxes, impregnated wood, bamboo composites, reconstituted slate made with bioresin, and samples prepared according to traditional Japanese technique: Shou Sugi Ban. The experimental samples were classified into seven categories, according to the treatment applied: natural wood (or other bio-based materials), chemically modified, thermally modified, impregnated, coated and/or surface treated, composites, and hybrid modified. Hybrid modification was defined here as a combination of at least two different treatments (Table 6.1).

6.2 Weathering of Biomaterials

In order to properly use biomaterials, it is indispensable to thoroughly understand their properties and performance in service. In any case, the actual performance highly depends on the local conditions, specific microclimate, and architectural details of the building (among the others). There are several commonly accepted protocols developed for comparison of the façade material performance and resistance to weathering, including two ways of testing:

Table 6.1 Categories of bio-based materials suitable for building façades tested within BIO4ever project

Category	Examples	Number of cases
Natural	Wood, bamboo	19
Impregnated	Furfurylation, DMDHEU, Knittex, Madurit, Fixapret	28
Thermally modified	Vacuum, saturated steam, oil heat treatment	20
Chemically modified	Acetylation	5
Coating and surface treatments	Different coatings, carbonized wood, nanocoatings	16
Hybrid modification	Thermal treatment + coating, thermal treatment + impregnation, acetylation + coating, etc.	25
Composites	Panels, bioceramics, Tricoya®, wood–plastic composites	7

- Natural weathering in the exterior
- Accelerated ageing performed usually in UV chambers with water spraying.

More details regarding technical requirements, interpretation of results, and comparison between diverse materials were described in detail in several publications, including Reinprecht (2016) and Jones and Brischke (2017).

6.2.1 Natural Weathering

Natural weathering procedure is defined in standard EN 927-3—Paints and varnishes—Coating materials and coating systems for exterior wood—Part 3: Natural weathering test (CEN EN 927-3 2014). This standard evaluates the resistance to natural weathering of the tested coating system, applied to a wood substrate. The durability is evaluated by determining the changes in decorative and protective properties of coatings after 12 months of exposure. In this case, samples are exposed on the racks, inclined at an angle of 45° to the horizontal level and facing south.

The list of surface aspects altered by the exposure to the weather conditions as recommended by the standard to evaluate along the test includes:

- Specular gloss to be assessed by gloss meter
- Colour and colour difference in CIE *Lab* colour coordinates measured by colorimeter or spectrophotometer
- Paint adhesion test by the pull-out or scratch trial
- Visual surface defect assessment with microscope of ×10 magnification
- Change of film thickness
- Chalking by self-adhesive, transparent tape.

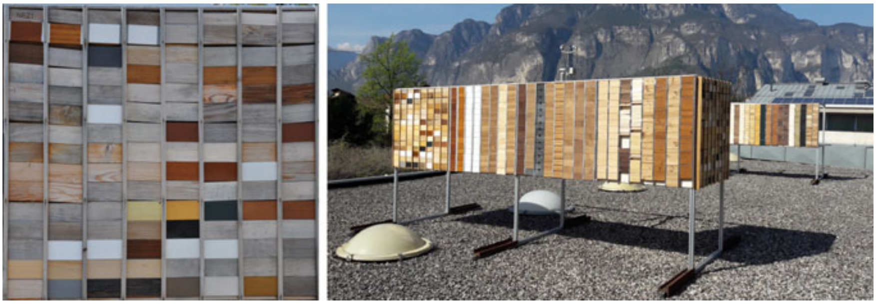


Fig. 6.1 Natural weathering experiment conducted within BIO4ever project

All the biomaterials presented here undergo a natural weathering test conducted in San Michele all'Adige, Italy (46° 11′ 15″N, 11° 08′ 00″E) in the period from April 2016 to July 2018. An image of the experimental stands is shown in Fig. 6.1.

6.2.2 *Artificial Weathering*

Artificial weathering procedure is described in standard 927-6 "Paints and varnishes—Coating materials and coating systems for exterior wood—Part 6: Exposure of wood coatings to artificial weathering using fluorescent UV lamps and water" (CEN EN 927-3 2006). The standard defines the method for determining the resistance of wood coatings to artificial weathering performed in an apparatus equipped with fluorescent UV lamps, combined with system of vapour condensation and water spray. The laboratory test is carried out taking into consideration a limited number of variables (radiation, temperature, and humidity) which can be fully controlled and monitored. Accordingly, the artificial weathering test results are much more reproducible and comparable than these from natural weathering. The usual setting of the artificial weathering cycle contains 2.5 h of UV light irradiation (e.g., lamp UVA-340 simulating the sunlight radiation from 365 to 295 nm, with a peak emission at 340 nm) followed by 0.5 h of water spray. The standard unit test lasts for 168 h (1 week). However, it is recommended that such a test has to be continued for 12 times resulting in the total test duration of 2016 h (12 weeks). Figure 6.2 presents sample after 672 h of artificial weathering.

6.3 Characterization of the Biomaterial's Surface Properties

Investigated biomaterials should be characterized before, during, and after degradation by biotic and abiotic agents, in order to quantify the deterioration progress as well as to provide experimental data for further analysis. Such data are critical for

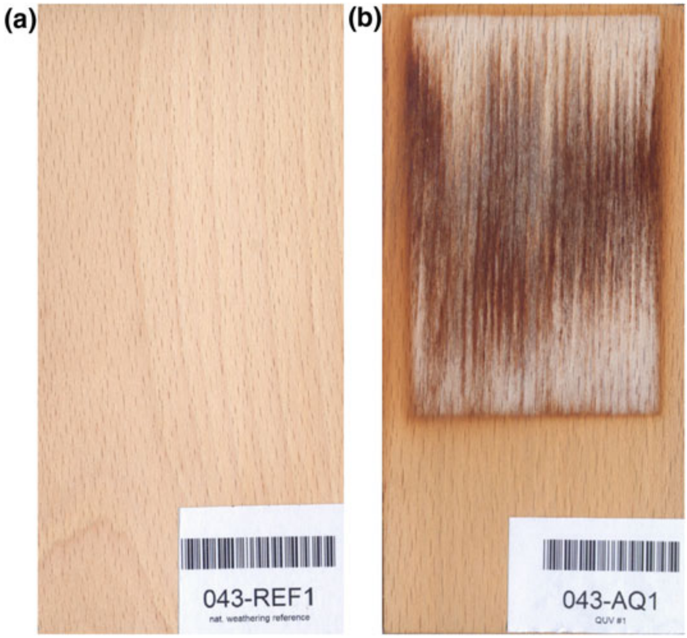


Fig. 6.2 Appearance of samples before and after artificial weathering

understanding the physical–chemical mechanisms of biomaterial degradation as a function of time and to model their performance during service life. The set of surface properties assessed for the needs of this portfolio included image acquisition, colour measurement, glossiness, and durability. The methodology and measurement protocols are described below.

6.3.1 Digital Colour Image

Digital colour images of samples surfaces were collected by means of HP G2710 office scanner. The sample was conditioned before scanning in the room conditions (temperature of 20 °C and 55% of relative humidity) in order to eliminate any effect of the moisture on the surface appearance. All the images were acquired with a resolution of 300 DPI.

6.3.2 Colourimetry

Changes in colour can be assessed by a spectrometer following the CIE *Lab* system where colour is expressed with three parameters:

- *CIE L**—correlated to lightness
- *CIE a**—defining red-green tone
- *CIE b**—defining yellow-blue tone.

Even if CIE *Lab* is not the only way to define colour, it is considered as an industrial standard when controlling quality or characterizing colour of surface. However, it is most suitable for measurement of homogenous surfaces and defines an average colour over the surface measured by the aperture of the entrance slit. It is impossible therefore to determine both, surface pattern and variability of colour within the sample by means of a single CIE *Lab* value. It is especially important in a case of wood and other biomaterial possessing very complex surface and pattern distribution. The colour determination procedure implemented here for assessment of the biomaterial samples included:

- Instrument calibration with white and dark references
- Setting of the measurement conditions and colour computation variables (Illuminant D65 and viewer angle 10°)
- Positioning the probe over the measured surface
- Measurement and data collection.

CIE *Lab* colours were measured using MicroFlash 200D spectrophotometer (DataColor Int, Lawrenceville, USA). All specimens were measured on ten different spots. The standard deviation of such measurement was considered as an indicator of the texture colour variability of the material.

6.3.3 Gloss

The light-irradiating surface is partially reflected following two physical principles: specular and diffuse reflections. The specular mode with incidence/reflectance angle of 60° was measured here by using REFO 60 (Dr. Lange, Düsseldorf, Germany) gloss meter. Ten measurements were taken on each specimen, following along the fibre direction.

6.4 Biotic Durability

The natural durability of a wood species is defined as its inherent resistance to wood-destroying agents. Two of the fundamental standards EN 350-1 (CEN 1994a) and EN 350-2 (CEN 1994b), developed by the CEN/TC 38, were recently replaced by revised standard EN 350 (CEN 2016) “Durability of wood and wood-based products—Testing and classification of the durability to biological agents of wood and wood-based materials” published in 2016. The standard covers wood-decaying fungi (basidiomycete and soft-rot fungi), beetles capable of attacking dry wood and termites and marine organisms capable of attacking wood in service. EN 350 provides the durability classes of wood-based materials to various wood-destroying organisms as summarized in Tables 2.1 and 2.2 (Chap. 2). Unfortunately, the standard EN 350 is not meant to test ligno-cellulosic materials other than wood. For that reason, custom methodological adaptations for testing other organic materials such as bamboo, reed, straw, or flax are proposed by diverse laboratories (Kutnik et al. 2014, 2017).

Field performance can be assessed by tests simulating in-service conditions. For example, EN 252 (CEN 2014) evaluates the performance of wood and wood-based materials to withstand biodeterioration. Evaluated materials in the form of stakes are half-buried in the soil and visually assessed and rated according to the attack severity. Additionally, mass loss is calculated according to Eq. 6.1:

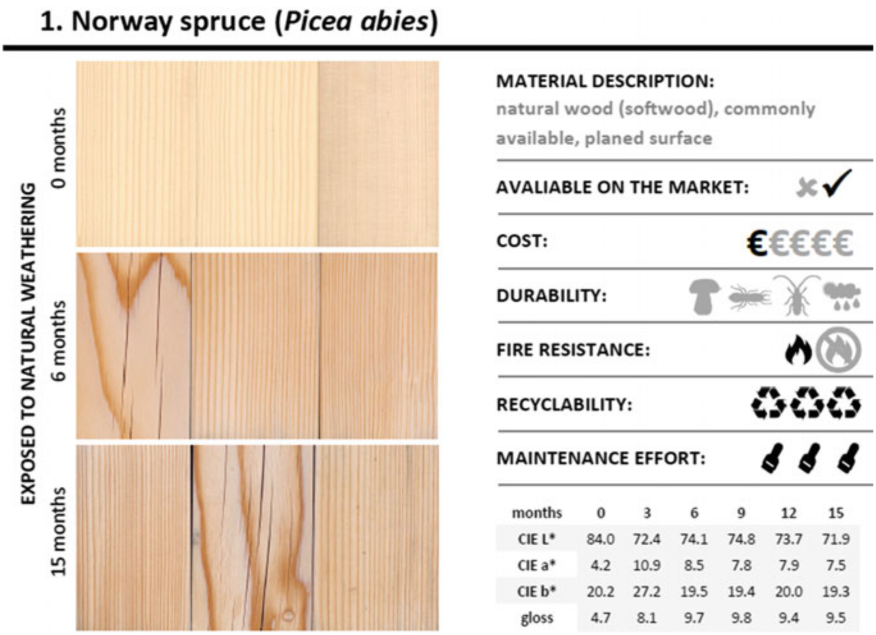
$$\mathrm{ML} = \frac{m_0 - m_t}{m_0} \cdot 100\% \tag{6.1}$$

where ML is mass loss (%), m_0 is dry weight of the sample before the test (g), and m_t is dry weight of the sample after the test (g). Examples of durability test performed in the field and in the laboratory conditions according to EN 350 standard are presented in Fig. 6.3.

6.5 Portfolio of Selected Biomaterials Tested Within Frame of BIO4ever Project

The progress of natural weathering and appearance change of investigated samples are presented on the left part of Figs. 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, 6.11, 6.12, 6.13, 6.14, 6.15, 6.16, 6.17, 6.18, 6.19, 6.20, 6.21, 6.22, 6.23, 6.24, 6.25, 6.26, 6.27, 6.28, 6.29 and 6.30. Some materials appear to not change the outlook; however, several of these changed (usually become pale and less saturated), like in the case of natural wood or acetylated wood. Changes in material appearance (numerical data regarding colour and gloss) are summarized in the table situated on right, down side of each figure. Technical details regarding selected samples representing seven treatment categories are presented on the right upper side. Short materials’ description is followed by a selection of the basic information regarding product availability on the market, estimated cost range, performance characteristics (durability against fungi, termites, wood-boring insects, and weather), fire resistance, recyclability potential, and maintenance effort. The meaning of symbols is described in Tables 6.2 and 6.3.

Fig. 6.3 Experimental samples under durability assessment: **a** tested in the laboratory against termites, **b** field test according to EN 252 (adapted to mini-size steaks), **c** samples after 3 months of laboratory test, **d** assessment of samples in field



months	0	3	6	9	12	15
CIE L*	84.0	72.4	74.1	74.8	73.7	71.9
CIE a*	4.2	10.9	8.5	7.8	7.9	7.5
CIE b*	20.2	27.2	19.5	19.4	20.0	19.3
gloss	4.7	8.1	9.7	9.8	9.4	9.5

Fig. 6.4 Technical characteristics of Norway spruce wood

2. Sessile oak (*Quercus petraea*)

MATERIAL DESCRIPTION:
natural wood (hardwood), commonly available, sanded surface

AVALIABLE ON THE MARKET:

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	69.4	67.5	69.8	73.5	71.4	73.1
CIE a*	6.5	9.2	8.2	6.6	6.7	6.0
CIE b*	20.0	25.6	23.7	20.9	21.1	17.7
gloss	2.7	3.6	4.3	4.9	4.7	5.1

Fig. 6.5 Technical characteristics of Sessile oak wood

3. Teak (*Tectona grandis*)

MATERIAL DESCRIPTION:
natural wood (exotic species from sus-tainable plantation), planed surface

AVALIABLE ON THE MARKET:

COST: €€€€€

DURABILITY:

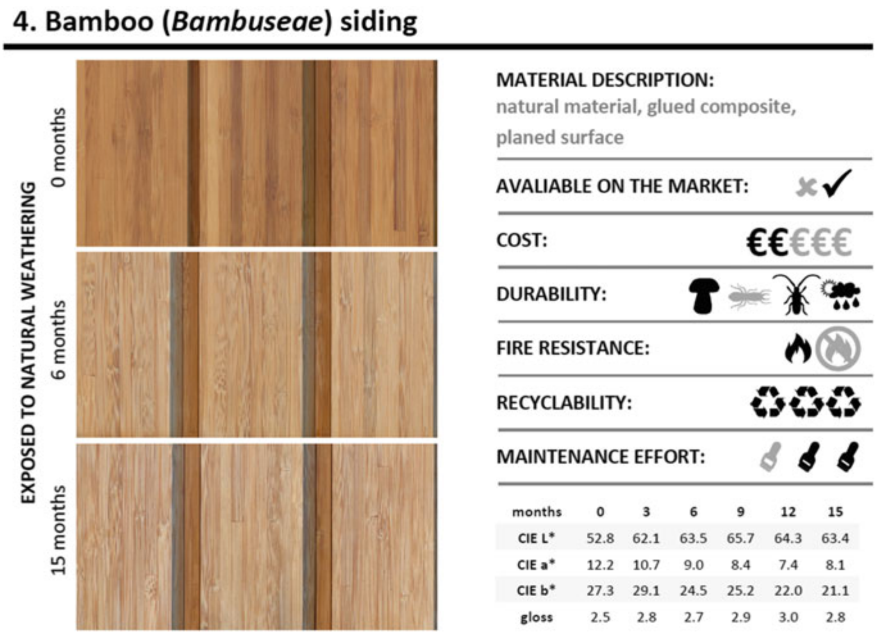
FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

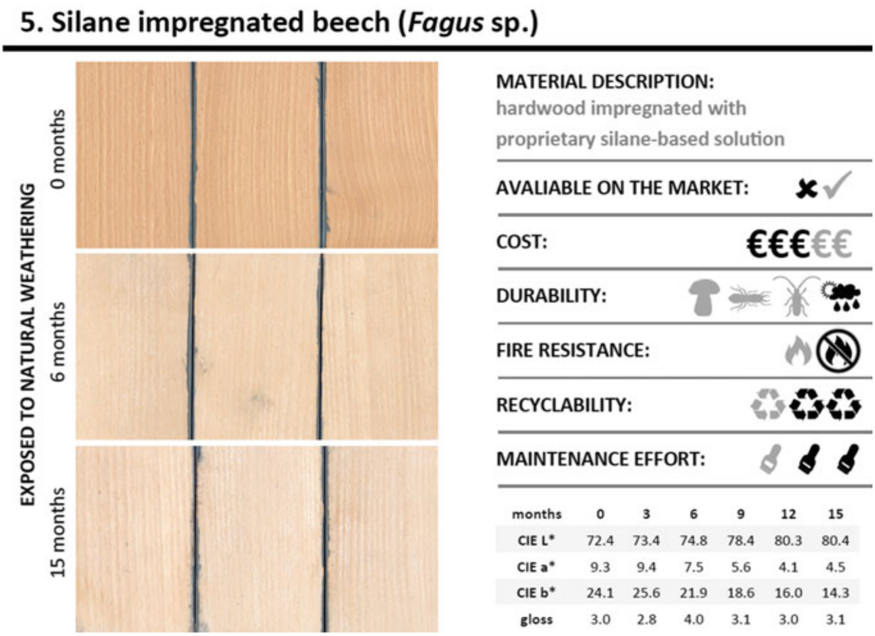
months	0	3	6	9	12	15
CIE L*	63.4	72.9	75.2	76.4	77.4	76.2
CIE a*	8.7	7.9	6.5	6.0	5.4	5.8
CIE b*	23.3	20.7	17.2	16.8	15.6	16.8
gloss	5.2	8.2	8.6	7.2	7.4	7.4

Fig. 6.6 Technical characteristics of teak wood



months	0	3	6	9	12	15
CIE L*	52.8	62.1	63.5	65.7	64.3	63.4
CIE a*	12.2	10.7	9.0	8.4	7.4	8.1
CIE b*	27.3	29.1	24.5	25.2	22.0	21.1
gloss	2.5	2.8	2.7	2.9	3.0	2.8

Fig. 6.7 Technical characteristics of bamboo



months	0	3	6	9	12	15
CIE L*	72.4	73.4	74.8	78.4	80.3	80.4
CIE a*	9.3	9.4	7.5	5.6	4.1	4.5
CIE b*	24.1	25.6	21.9	18.6	16.0	14.3
gloss	3.0	2.8	4.0	3.1	3.0	3.1

Fig. 6.8 Technical characteristics of silane impregnated beech

6. Furfurylated radiata pine (*Pinus radiata*)

MATERIAL DESCRIPTION:
softwood impregnated with furfuryl alcohol

AVALIABLE ON THE MARKET:

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	32.6	45.1	47.9	51.9	52.5	51.5
CIE a*	8.4	6.5	6.8	7.5	7.7	8.2
CIE b*	9.2	17.7	17.6	19.6	19.9	18.6
gloss	6.1	4.5	4.7	4.5	4.2	4.4

Fig. 6.9 Technical characteristics of furfurylated radiata pine

7. Impregnated poplar (*Populus tremula*)

MATERIAL DESCRIPTION:
under utilized hardwood impregnated with proprietary silane-based solution

AVALIABLE ON THE MARKET:

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

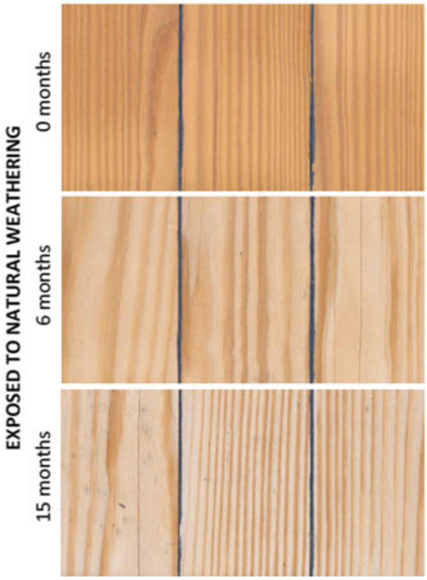
RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	82.1	74.2	67.2	73.3	67.5	66.9
CIE a*	8.9	10.6	13.4	9.5	12.4	12.7
CIE b*	35.9	63.6	40.2	31.2	38.5	33.5
gloss	4.3	5.2	4.2	3.9	4.0	3.6

Fig. 6.10 Technical characteristics of impregnated poplar

8. Impregnated Southern yellow pine (*Pinus echinata*)



MATERIAL DESCRIPTION:
melamine treated softwood

AVALIABLE ON THE MARKET:

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	64.0	66.4	71.4	74.9	73.9	73.5
CIE a*	11.8	11.6	8.4	7.3	6.5	6.7
CIE b*	30.8	30.0	23.1	21.2	19.2	18.7
gloss	4.5	4.3	6.4	9.1	8.0	8.6

Fig. 6.11 Technical characteristics of impregnated yellow pine

9. Thermally modified Scots pine (*Pinus sylvestris*)

MATERIAL DESCRIPTION:
common softwood thermally treated in hot oil

AVALIABLE ON THE MARKET:

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	37.5	56.6	67.0	69.4	70.8	71.0
CIE a*	11.1	9.8	6.0	5.3	4.1	3.9
CIE b*	18.0	23.6	20.2	19.4	18.3	16.9
gloss	2.8	5.4	5.0	5.2	5.1	5.4

Fig. 6.12 Technical characteristics of thermally modified pine

10. Thermally modified frake (*Terminalia superba*)

MATERIAL DESCRIPTION:
exotic wood species from sustainable plantation, heat treated in saturated steam

AVALIABLE ON THE MARKET: ✓

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	44.7	58.8	65.9	72.3	66.8	67.2
CIE a*	9.8	7.8	5.4	4.2	4.9	4.1
CIE b*	20.0	19.8	14.9	12.8	14.5	11.3
gloss	4.3	3.6	3.7	6.9	4.0	5.

Fig. 6.13 Technical characteristics of thermally modified frake

11. Thermally modified poplar (*Populus tremula*)

MATERIAL DESCRIPTION:
under utilized hardwood, modified thermally

AVALIABLE ON THE MARKET: ✓

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	39.7	59.3	63.3	65.2	64.8	64.3
CIE a*	9.7	6.1	5.0	5.3	5.5	5.2
CIE b*	17.5	17.4	15.3	15.8	15.6	15.0
gloss	2.3	7.1	6.2	7.3	7.2	6.9

Fig. 6.14 Technical characteristics of thermally modified poplar

12. Thermally modified Sessile oak (*Quercus petraea*)

MATERIAL DESCRIPTION:
common hardwood modified thermally in vacuum

AVALIABLE ON THE MARKET: ✗ ✓

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	55.4	61.5	67.2	69.8	70.6	72.0
CIE a*	6.3	8.1	7.0	5.7	5.5	4.8
CIE b*	17.5	22.1	21.4	19.9	18.9	15.6
gloss	3.7	4.7	5.0	5.0	5.1	4.8

Fig. 6.15 Technical characteristics of thermally modified oak

13. Acetylated alder (*Alnus glutinosa*)

MATERIAL DESCRIPTION:
under utilized hardwood, modified with acetyl anhydrite

AVALIABLE ON THE MARKET: ✗ ✓

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	57.1	82.8	85.6	85.2	84.5	78.9
CIE a*	7.8	3.5	2.8	2.0	1.4	1.6
CIE b*	19.7	21.9	17.0	14.6	11.6	9.6
gloss	3.4	6.5	6.8	7.9	6.8	7.5

Fig. 6.16 Technical characteristics of acetylated alder

14. Acetylated beech (*Fagus sylvatica*)

MATERIAL DESCRIPTION:
common non-durable hardwood, modified with acetyl anhydrite

AVALIABLE ON THE MARKET:

COST:

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	54.6	80.7	81.1	81.3	79.5	68.3
CIE a*	6.9	3.4	3.0	2.4	1.6	1.5
CIE b*	17.7	19.9	17.7	16.0	12.6	9.0
gloss	2.9	4.9	5.0	5.0	4.8	3.9

Fig. 6.17 Technical characteristics of acetylated beech

15. Acetylated radiata pine (*Pinus radiata*)

MATERIAL DESCRIPTION:
softwood, modified with acetyl anhydrite

AVALIABLE ON THE MARKET:

COST:

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	72.0	79.8	81.1	79.8	79.3	76.6
CIE a*	6.3	3.9	2.4	2.2	1.3	1.1
CIE b*	24.1	25.5	16.6	15.5	13.5	9.4
gloss	4.2	5.3	4.7	4.6	6.0	4.9

Fig. 6.18 Technical characteristics of acetylated pine

16. Sessile oak (*Quercus petraea*) finished with wax

MATERIAL DESCRIPTION:
natural wood (hardwood), commonly available, finished with wax

AVALIABLE ON THE MARKET:

COST:

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	67.0	73.4	72.3	76.5	77.4	77.1
CIE a*	7.6	6.9	6.3	5.1	4.5	4.6
CIE b*	32.1	25.4	22.1	22.7	19.5	16.6
gloss	2.2	2.4	2.4	2.8	2.8	2.5

Fig. 6.19 Technical characteristics of oak finished with wax

17. Scots pine (*P. sylvestris*) coated with nanoparticles

MATERIAL DESCRIPTION:
common softwood coated with proprietary nanocoating (TiO_2) solution

AVALIABLE ON THE MARKET:

COST:

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	77.9	69.2	72.4	74.8	73.4	76.0
CIE a*	7.3	11.6	9.3	8.0	7.8	6.5
CIE b*	30.2	30.4	23.2	22.3	22.3	18.1
gloss	3.3	5.2	6.1	4.7	6.7	6.9

Fig. 6.20 Technical characteristics of pine finished with nanocoating

18. Carbonized surface of larch (*Larix* sp.)

MATERIAL DESCRIPTION:
durable softwood with the surfaces carbonized with fire, finished with oil

AVALIABLE ON THE MARKET:

COST:

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	24.8	23.5	26.8	33.2	36.1	32.5
CIE a*	0.1	0.2	0.7	1.5	1.8	1.2
CIE b*	0.3	-0.2	1.0	4.4	6.4	4.2
gloss	1.3	1.3	1.3	2.0	2.4	2.3

Fig. 6.21 Technical characteristics of larch with carbonized surface

19. Pine (*P. sylvestris*) coated with polyurethane paint

MATERIAL DESCRIPTION:
common softwood coated by hand with DIY polyurethane paint

AVALIABLE ON THE MARKET:

COST:

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	51.4	48.7	49.6	49.7	49.6	48.4
CIE a*	5.2	5.5	6.0	5.7	5.5	4.8
CIE b*	13.6	12.3	13.1	12.9	12.4	10.7
gloss	40.3	32.6	27.7	28.9	24.4	21.3

Fig. 6.22 Technical characteristics of pine coated with polyurethane paint

20. TM radiata pine + impregnation with oil

MATERIAL DESCRIPTION:
radiata pine modified thermally + water borne penetrating oil

AVALIABLE ON THE MARKET:

COST:

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	30.5	38.5	38.3	39.6	39.0	37.7
CIE a*	8.8	10.6	10.0	9.9	9.5	9.0
CIE b*	9.9	16.7	15.1	17.0	16.7	15.5
gloss	1.4	1.6	1.7	1.3	1.3	1.3

Fig. 6.23 Technical characteristics of TM pine impregnated with oil

21. TM radiata pine + impregnation with silicate

MATERIAL DESCRIPTION:
radiata pine modified thermally + a silicate treatment designed to silver off

AVALIABLE ON THE MARKET:

COST:

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	50.5	68.9	73.0	74.2	76.2	68.7
CIE a*	8.2	4.9	3.9	3.4	2.9	3.6
CIE b*	20.0	14.4	12.1	11.1	10.2	10.7
gloss	1.9	2.7	3.2	2.9	3.1	3.1

Fig. 6.24 Technical characteristics of TM pine impregnated with silicate

22. TM radiata pine + surface coating

MATERIAL DESCRIPTION:
radiata pine thermally treated and industrially coated

AVALIABLE ON THE MARKET: ✗ ✓

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

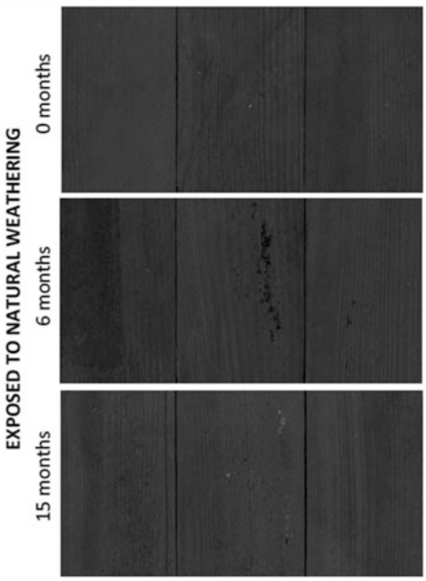
RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	42.6	51.3	50.8	52.9	52.9	53.4
CIE a*	12.4	13.2	13.2	13.1	12.9	13.0
CIE b*	19.5	27.3	26.3	27.6	27.1	28.0
gloss	15.0	13.3	13.3	14.3	14.3	16.5

Fig. 6.25 Technical characteristics of TM pine with coated surface

23. Biofinished Scots pine (*Pinus sylvestris*)



MATERIAL DESCRIPTION:
oil treated softwood, with a functional biofilm on the surface

AVALIABLE ON THE MARKET: ✗ ✓

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

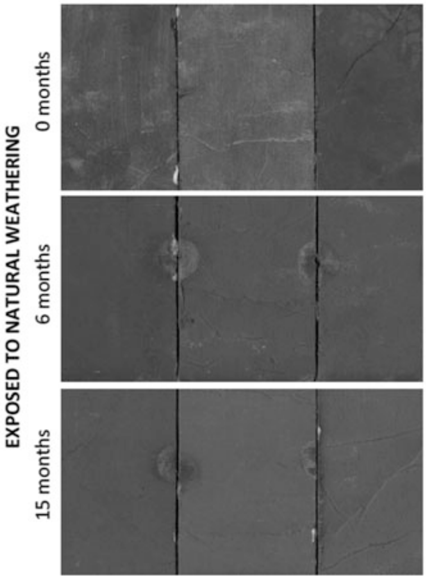
RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	23.4	24.0	23.1	23.5	23.2	23.1
CIE a*	0.6	0.3	0.3	0.4	0.5	0.4
CIE b*	1.4	0.2	0.4	1.0	0.4	0.6
gloss	1.2	1.7	1.6	1.0	1.4	1.0

Fig. 6.26 Technical characteristics of biofinished pine

24. Bio-based ceramics



MATERIAL DESCRIPTION:
proprietary composite based on bio-resin

AVALIABLE ON THE MARKET:

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	36.8	32.0	35.0	36.9	36.4	36.9
CIE a*	-0.3	-0.1	-0.2	-0.2	-0.1	-0.2
CIE b*	-1.0	-0.5	-0.9	-0.6	-0.5	-0.7
gloss	1.6	1.4	1.0	1.1	1.1	1.2

Fig. 6.27 Technical characteristics of bio-based ceramics

25. Fiberboard

MATERIAL DESCRIPTION:
composite board made of straw blended with waste silk fibres + green adhesive

AVALIABLE ON THE MARKET:

COST: €€€€€

DURABILITY:

FIRE RESISTANCE:

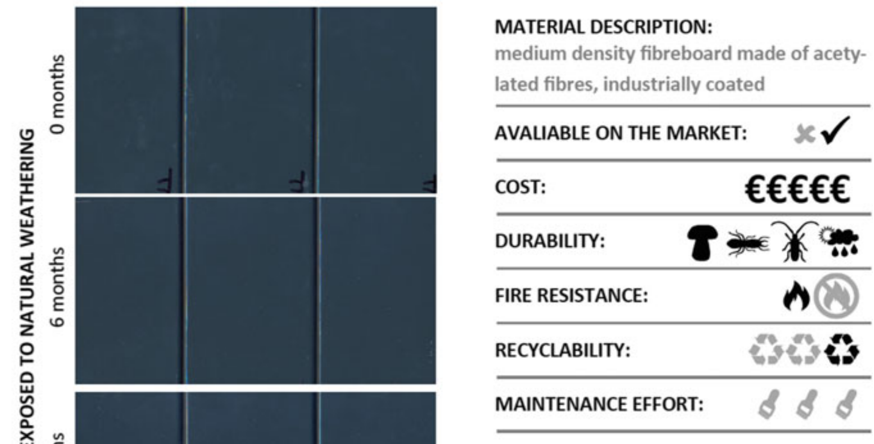
RECYCLABILITY:

MAINTENANCE EFFORT:

months	0	3	6	9	12	15
CIE L*	60.8	56.8	58.4	59.4	60.9	56.4
CIE a*	8.3	11.5	9.6	8.6	7.4	8.8
CIE b*	25.8	33.2	30.2	28.2	26.2	26.9
gloss	2.2	1.9	1.7	1.7	1.6	1.3

Fig. 6.28 Technical characteristics of non-wood fibreboard

26. Fibreboard made of acetylated fibres



months	0	3	6	9	12	15
CIE L*	34.4	34.4	34.5	34.6	34.6	34.4
CIE a*	-2.9	-2.9	-2.9	-2.9	-2.8	-2.8
CIE b*	-2.7	-2.7	-2.7	-2.7	-2.8	-2.7
gloss	80.5	76.3	79.9	80.3	79.3	78.8

Fig. 6.29 Technical characteristics of fibreboard made of acetylated fibres

27. Wood-plastic composite

months	0	3	6	9	12	15
CIE L*	50.6	53.4	53.4	54.3	53.0	53.0
CIE a*	-0.4	0.0	0.2	0.2	0.2	0.3
CIE b*	2.2	0.7	0.7	0.7	0.7	0.7
gloss	2.1	2.0	1.8	1.7	1.5	1.6

Fig. 6.30 Technical characteristics of wood–plastic composite

Table 6.2 Explanation of symbols used for sample description

Characteristic	Availability on the market	Cost	Fire resistance	Recyclability potential	Maintenance effort
High (positive)	✓	•••••			
Low (negative)	✗	•••••			

Table 6.3 Explanation of symbols used for assessment of sample durability

Characteristic	Durability			
	Fungi	Termites	Beetles	Weathering
High (positive)				
Low (negative)				

Symbols presented in black mean that material possesses a particular property (e.g., black symbol for termites means that material is termite resistant). Higher number of black symbols in case of cost means that material is more expensive. Similarly, higher number of black symbols in case of recycling means that material has higher recycling potential and can be recycled/reused in several ways.

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