Surface characterisation of spruce to understand the effects of natural weathering

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The weathering is the process causing degradation of the biobased fibres by the weather conditions (e.g. solar radiation, temperature and moisture). The rate of weathering is affected by the wood species, specific climatic conditions and the pre-treatment of the material. Weathering affects the material state through degradation of the surface. The breakage of the fibres leads to further penetration of the weather agents into the deeper layers, resulting increase of the surface roughness, change of colour and decrease of glossiness. In consequence the aesthetic value of the material is reduced. The objective of this work, undertaken under a STSM within COST action FP1303, was to understand the weathering mechanism and kinetics that could lead to designing more effective preservation techniques. The other goal was to develop prediction model of aesthetic appearance that will be afterwards implemented for computation of the bio-materials' service life period, including maintenance/renovation scheduling.

Norway spruce samples, obtained from the same piece of wood to minimise variability, had been exposed to natural weathering at 18 sites across Europe for a weathering duration of 12 months (Round Robin test, of the COST Action FP1006 and FP1303) – Figure 1. Every month one sample was collected and stored in a climatic chamber protected from light in order to avoid further degradation. Samples were characterized by means of several techniques in order to understand different mechanisms which occur in wood surface during weathering. Following tests were performed:

- Aesthetical changes
    - Colour
    - Imaging
    - Visual grading
    - Glossiness
- Chemical changes
    - FT-IR
    - FT-NIR
    - UV-VIS-NIR
    - Micro NIR
    - XRF
- Morphological changes

- Laser displacement sensor
- Laser line
- Focus depth measurement

This study proved that the weathering effect is strongly influenced by the exposure location. The weathering kinetics showed similar trend in various magnitude among the different locations concerning the colour effect. The highest colour changes (ΔE) occurred in Turkey, the lowest in UK. It was confirmed by analysis of the NIR spectra, which showed that the spectral shape in both locations were different. This might be a result of diverse intensity of the degradation processes, like hydrolysis and photo degradation, related to the specific weather conditions.

Figure 1: Map of the location that the samples were exposed.

Similar conclusions were drawn from MicroNIR data analysis by means of PARAFAC method. Furthermore, it was possible to accurately model the NIR spectral changes along the exposure duration and location (Figure 2a).

Additionally, performed visual grading showed that the human perception of weathered wood is related to various factors like colour, glossiness and surface roughness. By means of Multiplicative Linear Regression (MLR) analysis (Figure 2b) it was possible to identify that the dominant factor that affects the human perception of wood degradation state is predominantly the colour. Roughness and glossiness of the surface had lower influence. MLR model might be therefore used as support for prediction of the consumer aesthetic perspective and acceptance.

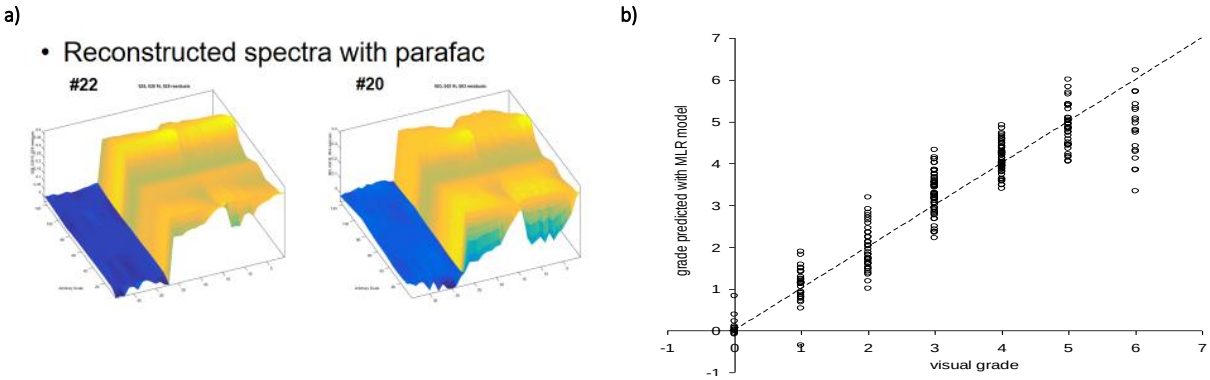

Figure 2: a) PARAFAC model of micro NIR results, b) MLR model of morphological characteristics and weather degradation visual grading

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