Modification of Beech by Drying Oils and Microwaves for Outdoor Use in Gardening and Landscaping

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Initial Situation and Objective

The alternative wood preservation concept of "hydrophobing" has more and more intensively been worked on in recent years. The hydrophobing agents previously investigated also include vegetable oils (linseed, poppyseed, tung oil) with a tendency towards oxidative polymerisation (drying). However, they only partially cure after full impregnation. As a consequence, there are oily or sticky spots on the wood surfaces, which can be grown over by bacteria and algae, which, in their turn, will cause black discolouration.

The project aimed at picking up on the concept of hydrophobing and removing the existing and principal shortcomings.

Hence, it was the objective to develop a new procedure of hydrophobing wood with the help of radically polymerisable natural oils or oil derivates, which the previously existing drawbacks of incomplete polymerisation was unable to render. Hydrophobing as a biocide-free alternative to treatment with chemical protective agents was thus expected to be decisively improved and made fit for the market.

These hydrophobing agents were to be introduced into the cell walls by means of a pressure procedure (empty-cell impregnation) and cured there. However, full-cell impregnation by filling the lumina was not intended.

Then, the curing process was to be initiated by microwave treatment down into the inner layers of the wood, which allowed to expect an enhanced property profile, as compared to simple oil impregnations, also with a view to biological resistence, physical-mechanical parameters and reduced tendency towards swelling and shrinking. Well impregnable beech was intended to be made fit for permanent outdoor use by way of the aspired biocide-free hydrophobing procedure.

Results

As a result of the project, a commercially producible, well impregnable recipe on the basis of a polymerised fatty acid ester was developed from a multitude of possible oils, which was tested at temperatures of 70 °C in a vacuum pressure procedure for fully impregnating wood of cross-sections of up to 100 mm and lengths of 500 mm. The empty-cell impregnation procedure developed for that purpose, in which excess oil was removed again from the cell walls by applying microwaves and vacuum, permitted, depending on the duration and intensity of the microwave treatment, to determine degrees of loading of between 150 kg/m^3 and 400 kg/m^3. The oil removed thereby could be re-used up to three times. Storage time of the oil is at least six months.

The isolene oil applied is able to cure inside wood also without any siccative. However, this process may take several weeks when the samples are air-dried (Fig. 1).

For that reason, a procedure was tested on a laboratory scale for curing by means of oxygen, by which full curing of the oil could be achieved within 24 hours, also inside the samples. The completeness of curing was proven by FTIR-spectroscopic investigations, extraction by organic solvents and physical pressing tests.

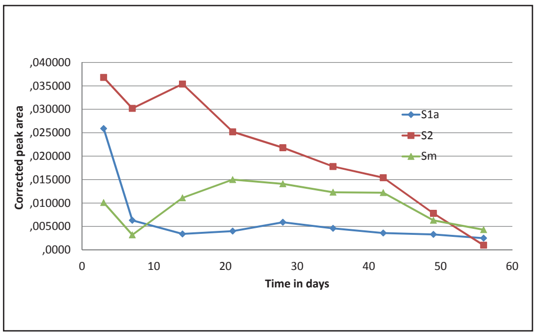

Fig. 1: Temporal course of the bands at 3010 cm^{-1} (cis DB) in beech-wood bricks after impregnation with a siccative impregnation oil (MH) (A = outer surface, S1a = 1 mm, S2 = 5 mm, Sm = centre of the sample)

The addition of siccatives, such as cobalt or manganese, even led – on average – to boosting the polymerisation process and, therefore, to enhancing the product properties, especially showing in a clearly increased resistance towards wood-destroying fungi. The oil treatment resulted in delayed water absorption by the samples as compared to wood in its natural state. The effects occurred to be of varying intensity, depending on the hydrophobing agent and the degree of siccativation (Fig. 2).

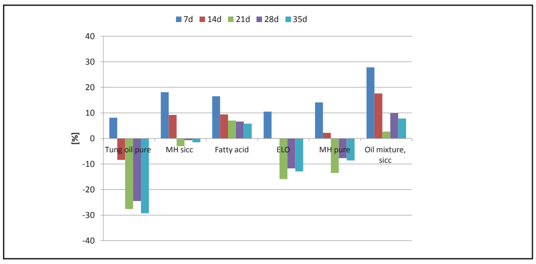

Fig. 2: Moisture exclusion capacity of several impregnators compared to beechwood in % after five weeks of storage at 20 °C / 65 % relative humidity

After a longer period of exposure to a moist climate or after several days of soaking in water, the amount of water absorbed, related to the share of wood, by the oil-treated samples of all variants was yet as high as by the natural wood samples. The expectation that, by oil treatment and subsequent curing, the swelling of the samples would be reduced was not fulfilled either. The differential swelling values of the oil-treated samples were, regardless of the degree of loading, on average above those of natural beech.
The oil treatment had its largest impact on the biological resistance of the samples. So, for example, after leaching and testing under the influence of the wood-destroying basidiomycetes Coniophora puteana and Trametes versicolour acc.to EN 113, a significant reduction in mass loss, as contrasted to natural beech, could be achieved. In this respect, the siccative variant proved to be especially effective. However, the mass losses obtained, showed a wide spread. The maximum limit of 3 % to 5 % in mass loss was achieved in single cases to allow being graded as Hazard Class (HC) 3. Resistance testing against soft rot fungi yielded a comparable result. There, mass loss could be reduced by oil treatment from 21 m% to minimum 6 m% (Fig. 3).

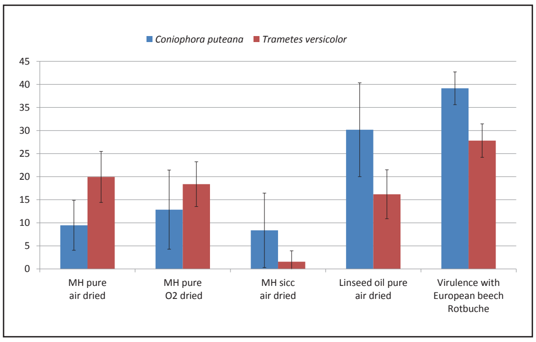

Fig. 3: Mass loss after the strain of leaching (acc. to EN 84) of several oil variants in beech samples (EN 113) as compared to native beech variants

Mass loss of 6 m% ranges close to the limit that is required to be accepted to be HC 3 and 4, and it should be worthwhile continuing the work by further modifications of the recipe in order to still meet the goal.
A clearly fungicidal effect of the hydrophobing agent with and without siccativation occurred, as contrasted to soft rot fungi, with a medium mass loss (due to fungal and bacterial attacks) of 6.1 m% in comparison to 22.3 m% in untreated test samples. Also, moisture was reduced in wood in ground contact from about 68 % in untreated samples to 35 % and to about 38 % in samples treated with a hydrophobing agent.

Conclusion

Significant property enhancement of beechwood was attained in the project by applying oxidatively curing oils in empty-cell impregnation, especially with a view to surface properties and resistance towards soft rot.
However, in order to still accomplish the intended goal of the project, i.e., application of the so treated beechwood in areas of Hazard Class 3 or 4, requires further development effort focusing on an improvement of the hydrophobing effect and better attachment of the hydrophobing agent to the cell walls.