Linseed oil-based coating for retarding mould growth on wood

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Background

Wood finishing with coatings can have protective, aesthetic, or both functions depending on the intended application. Reduction of the adverse effects of water and photodegradation is the most common idea behind the use of protective coatings. However, additional benefits including antimicrobial resistance can be provided by tailoring the coating formulations. It is well established that a certain period of favourable environmental conditions is detrimental to the initiation of mould growth (Viitanen (1997), Kuka *et al.* (2022)). Therefore, ensuring that germination and growth are inhibited may allow sufficient time to prevent conditions that favour mould growth and thus avoid the problem. Not only wood as a renewable resource, but also bio-based coatings are becoming increasingly important in light of environmental concerns and the risk of depletion of fossil resources. Linseed oil has a long tradition and is still the predominantly used natural oil for wood applications in Europe (Arminger *et al*. (2020)). The present study investigated the possibility of retarding mould growth on wood surfaces by using a linseed oil-based emulsion without and with antimicrobial additives incorporated into the formulation.

Keywords: wood, linseed oil, anti-microbial coating

Experimental

Specimens of birch (*Betula* spp.) and pine (*Pinus sylvestris* L.) sapwood measuring 30 mm × 70 mm × 5 mm were used as a wood substrate for testing coating formulations that differed in antimicrobial additives. Ten replicates, each prepared from a different board, were used in all experiments. The base formulation was a linseed oil (55 %) emulsion which was used without or with antimicrobial additives – nano zinc oxide (ZnO), nano titanium dioxide (TiO_2), and ionic silver (Ag). An equal additive concentration (w/w) of 1 % was incorporated in all formulations. Uncoated wood was used as a control. The coating was applied on conditioned specimens in two layers, which ensured that no film was formed on the wood surface. The average consumption was 107 ± 3 g for pine wood and 92 ± 9 g for birch wood. After the coating dried, the specimens were exposed to controlled conditions (relative humidity(%)/temperature(°C)) in climate chambers. The climate conditions used were: 97/30 and 93/30. The study did not involve spraying with a fungal suspension, but natural inoculation was used allowing fungi present in the air and on the non-sterile wood to colonise the surface during incubation, which is considered more appropriate approach by some researchers when a particular strain of fungus is not of interest (Thomson and Walker (2014)). The coated surfaces were regularly examined using a light microscope at 20× magnification to evaluate mould development.

Results and discussion

As expected, considerably faster mould development was observed in the experiments performed at RH 97%. The time (days) needed to reach two stages of mould growth are presented in Figure 1: initial growth with mould occupying up to 10 % of the coated surface and intense growth with the coverage of hyphae more than 50 % of the coated surface.

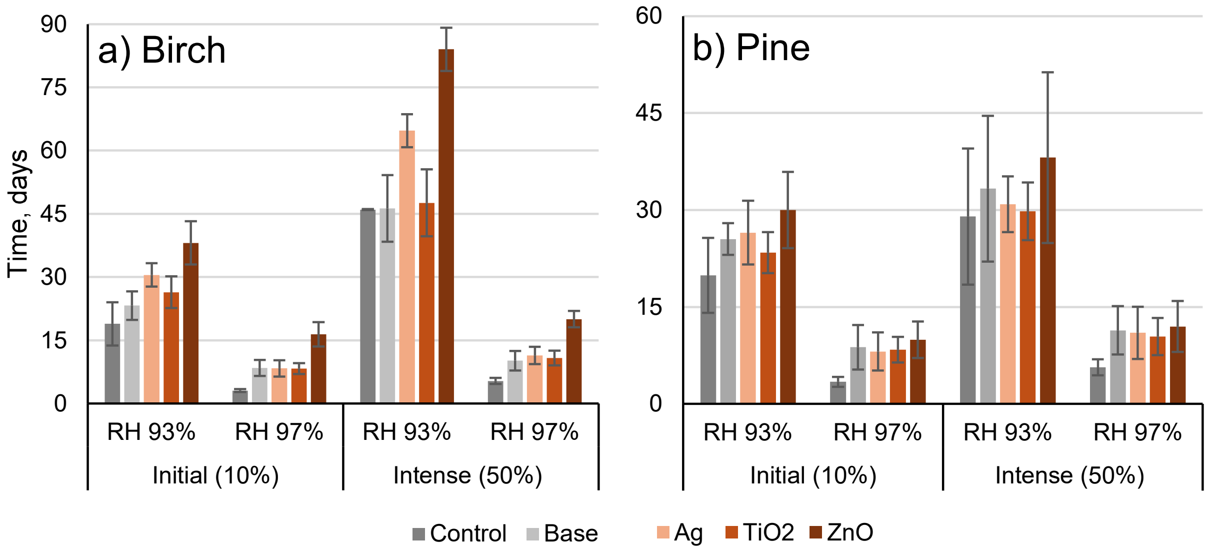

Figure 1: Mould development: a) birch, b) pine

For both species, a similar tendency to render some inhibitory effect against mould growth was observed for the base formulation of the linseed oil emulsion even without any antimicrobial additives. It was especially pronounced for the initial stage of mould growth. Although the delay was observed for the same number of days in the experiments carried out at both relative humidities, the samples coated with the base formulation required two times more days to reach 10% hyphal coverage than the control at 97% relative humidity, when mould development is a very rapid process. Such delay can be sufficient to normalise conditions and avoid the spry of mould in a real-life indoor scenario. Delaying of mould growth by coating both unmodified and thermally modified wood with linseed oil was also observed by Vidholdová *et al.* (2021). This could be related to the antiadhesive effect of linseed oil on certain mould fungi reported by Bennouna *et al.* (2022).

All tested antimicrobial additives showed some inhibiting effect only in the case of birch wood. For the pine wood, Ag and TiO_2 did not improve the performance of the base formulation while the addition of ZnO delayed mould development, especially in the initial stage. ZnO showed also the highest efficiency for birch wood when a remarkable improvement was observed for both the inhibition of initial and intense growth stages compared to other formulations.

Conclusions

The results show that the linseed oil emulsion when used as a non-film-forming coating, allowing for maintaining the natural appearance of the wood surface, can hinder mould development. The performance of the formulation can be improved by antimicrobial additives. ZnO was the most effective between the tested additives. However, to finalize the formulation, further work is needed to assess the optimal concentrations and to test the potential synergistic effect of ZnO and Ag, which were the two more effective additives.

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References

Arminger B, Jaxel J, Bacher M, Gindl-Altmutter W, Hansmann C. (2020) On the drying behavior of natural oils used for solid wood finishing. Progress in Organic Coatings 148(June):105831.

Bennouna F, Sadiki M, Elabed S, Ibnsouda Koraichi S, Lachkar M. (2022) The effect of different vegetable oils on cedar wood surface energy: Theoretical and experimental fungal adhesion. International Journal of Biomaterials 2022:9923079.

Kuka E, Cirule D, Andersone I, Andersons B, Fridrihsone V. (2022) Conditions influencing mould growth for effective prevention of wood deterioration indoors. Applied Sciences 12(3):975.

Thomson A, Walker P. (2014) Durability characteristics of straw bales in building envelopes. Construction and Building Materials 68(2014):135-141.

Vidholdová Z, Slabejová G, Šmidriaková M. (2021) Quality of oil-and wax-based surface finishes on thermally modified oak wood. Coatings 11(2):1–17.

Viitanen HA (1997) Modelling the time factor in the development of mould fungi — the effect of critical humidity and temperature conditions on pine and spruce sapwood. Holzforschung 51:6–14.