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Influence of varnish materials on the spatial and time-dependent moisture sorption dynamics of wood used for musical instruments studied by neutron imaging

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The hygroscopicity of wood influences wooden musical instruments in various ways. On the one hand, the moisture content (MC) affects mechanical and acoustical properties via density, stiffness and damping. On the other hand, changes in MC result in swelling and shrinkage. Moreover, spatial MC gradients can lead to high internal stresses, which may result in cracks and fracture.

Varnishes act as a retarding barrier for moisture diffusion. Hitherto, the effect of varnish has been noted in terms of structural deformations (i.e. board cupping due to the one-sided varnish application) or as altered mass changes. However, more detailed studies on the impact of varnishes on the dynamics of the spatial MC distribution are scarce. Furthermore, old instruments commonly show a typical wear pattern. Areas that are regularly exposed to contact, sweat and/or breath, suffer from varnish deterioration. This raises the question whether the remaining varnish in worn off areas, mainly consisting of grounding or sealer materials, can still effectively protect against humidity changes.

Neutron imaging has proven to be a suitable technique to investigate moisture transport in wood. As neutrons are very sensitive to hydrogen, it is possible to determine and localise MC changes. In order to assess and characterize the moisture barrier performance of various varnish materials as well as worn off and intact varnish systems, an investigation with differently varnished wood samples was conducted.

The study was performed at the thermal neutron imaging beamline NEUTRA at the PSI. Imitating the conditions of musical instruments, the lateral sides were sealed, thus allowing sorption only at the upper and lower surfaces. The samples were preconditioned (35% RH and 20°C), ensuring equilibrated and known reference conditions. In total, 80 samples (10 runs with 8 samples each) were investigated, enabling a five-time repetition of 16 different wood and varnish material combinations. The samples were put in a climate chamber, allowing for an in-situ measurement of the MC changes while controlling temperature and RH. Based on a comparison of the reference radiograph to the radiographs taken over time, the spatial MC distribution and its time evolution were determined. For the time span studied (5h at high and low RH), no moisture sorption was observed for the completely varnished surfaces. The results revealed that the sorption occurs homogenously across the surfaces and that pretreatments decelerate the moisture uptake. Interestingly, a grounding consisting of clear oil varnish and pumice powder displays a low barrier and a pretreatment mainly consisting of albumen and gum arabic did not lead to a protection at all.

The study has proven the applicability of neutron imaging for the investigation of spatial and time dependent changes in wood MC, enabling the examination of varnish influences. The results reveal the effectiveness of different varnishes and allow for an assessment of their influences on dimensional and acoustical properties of wooden musical instruments. The results can likewise be used for validations of material and sorption models, being relevant for e.g. coatings on wood in general (i.e. wood as building material) or in wood conservation science.

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