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WATCHING WOOD DRY: CHARACTERISING WATER IN WOOD BASED ON DESORPTION OR SCANNING ISOTHERMS?

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MOTIVATION

Water plays an important role in degradation processes of wood and influences physical wood properties such as dimensional stability and mechanical behaviour. The interaction between water and wood has therefore been widely studied and this is commonly done by determining sorption isotherms. Sorption isotherms show the relation between the equilibrium moisture content and the ambient relative humidity (RH). The equilibrium moisture content is however not only dependent on the ambient climate, but also on the moisture history of the sample; the moisture content is higher if equilibrium is reached by desorption than if equilibrium is reached by absorption (Pidgeon and Maass 1930). This is called sorption hysteresis and is observed in most porous materials. It is thus important to consider the moisture history of the specimen when determining sorption isotherms. After the introduction of automated sorption balances (Williams 1995), it has become common to determine sorption isotherms by initially drying the sample and then measure the absorption isotherm up to a high RH, typically 95% RH, see e.g. (Hill et al. 2009; Ceylan et al. 2014; Himmel and Mai 2015). Thereafter, desorption is initiated from this high RH and the sample is dried in steps back to 0% RH again. This procedure of measurement does however not yield desorption isotherms, but scanning isotherms. In the present study, the consequences of this procedure of measurement on the obtained sorption isotherms and the evaluated sorption hysteresis are shown.

EXPERIMENTAL

Sorption isotherms were determined for Norway spruce (*Picea abies* (L.) Karst.) in a sorption balance (DVS Advantage, Surface Measurement Systems Ltd., London). All measurements started with specimens that had been vacuum saturated with water. A specimen was placed in the sorption balance and the desorption isotherm was determined by exposing the specimen to the following relative humidity levels: 95-80-65-50-35-0%. The absorption isotherm up to 95% RH was then determined followed by a scanning desorption isotherm from 95% RH, both using the same RH levels as for desorption. This measurement was repeated twice. For two other specimens, the desorption isotherm was determined as described above, but the absorption isotherms were determined up to 80% RH and scanning desorption was subsequently initiated from 80% RH. For more details, see Fredriksson and Thybring (2018). Sorption isotherms and sorption hysteresis were evaluated. The latter was evaluated as absolute difference in moisture content between the absorption isotherm and the desorption and scanning isotherms respectively.

RESULTS & DISCUSSION

The average sorption isotherms and absolute sorption hysteresis are shown in Figure 1. As expected, the desorption isotherm was higher than the scanning isotherms initiated from 95% and 80% RH reached by absorption. To clarify the reasons for this, the hygroscopic sorption isotherms are placed in the context of the full sorption isotherm for Norway spruce in Figure 2. Here it is seen that for the wood to follow the desorption isotherm, an initial moisture content substantially higher than the equilibrium moisture content at 95% RH reached by absorption is needed due to the large sorption hysteresis. From Figure 1 it is also seen that when sorption hysteresis was evaluated from desorption and absorption isotherms, the hysteresis was linear unlike when hysteresis was evaluated from absorption and scanning isotherms. The shape of the hysteresis curve consequently depends on the moisture content from which desorption was initiated. This needs to be considered when interpreting the underlying mechanisms of sorption hysteresis based on hysteresis curves.

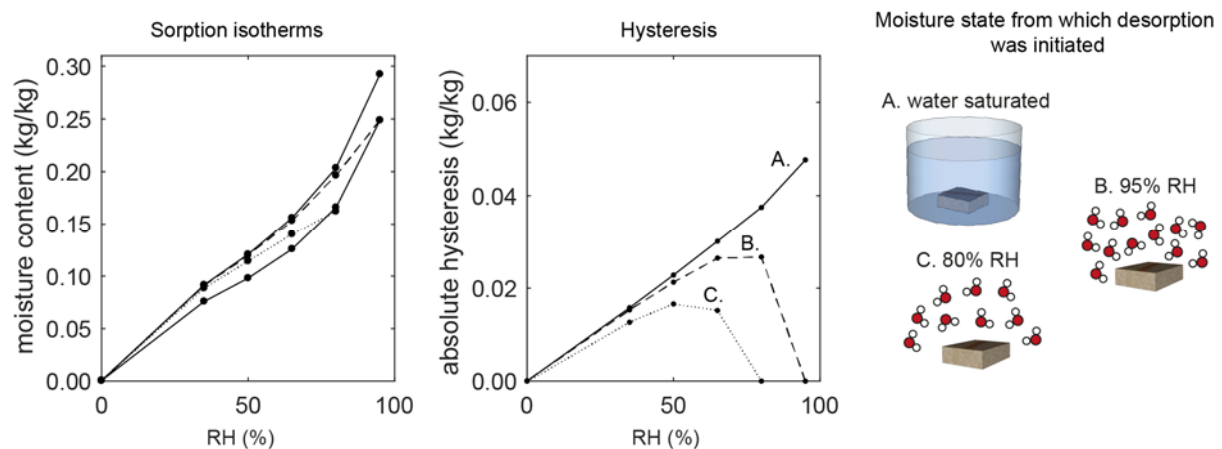


Figure 1. Average sorption isotherms and absolute sorption hysteresis evaluated from absorption and desorption isotherms (A), absorption and scanning isotherm from 95% RH (B) and absorption and scanning isotherms from 80% RH (C).

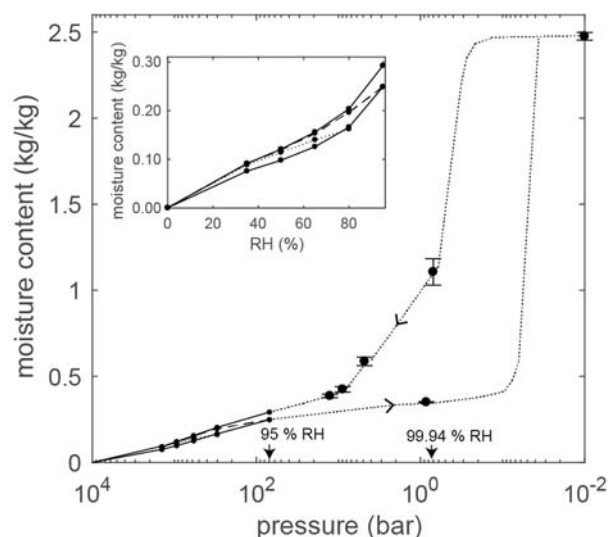


Figure 2. Full sorption isotherm for Norway spruce (*Picea abies* L. Karst.), over-hygroscopic sorption isotherm data from Fredriksson and Johansson (2016).

CONCLUSIONS

Determination of true desorption isotherms require initially water saturated specimens; desorption initiated from all other moisture states will generate scanning isotherms. The currently most common procedure of measurement thus underestimates the desorption isotherm. In addition, the initial moisture state of the specimen is important to consider when studying sorption hysteresis since more complex hysteresis patterns are obtained when using scanning isotherms instead of desorption isotherms which may make the interpretation of underlying mechanisms of sorption hysteresis more challenging.

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