Mid infrared spectra of four green and remoistened wood species

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4th International Symposium of Indonesian Wood Research Society

Makassar, Indonesia

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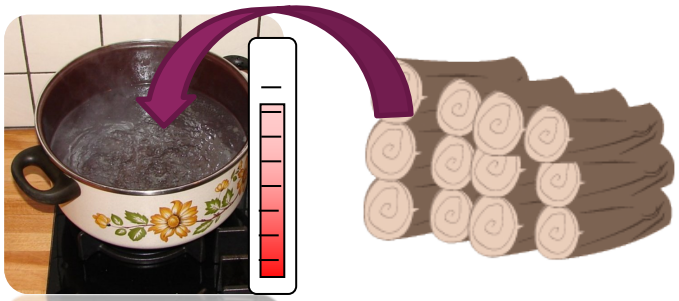
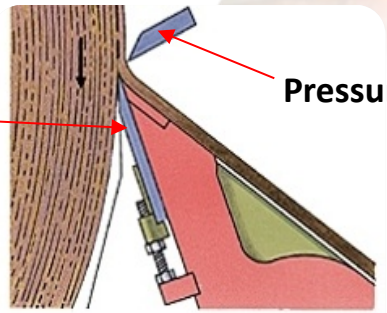
Peeling process: veneer production

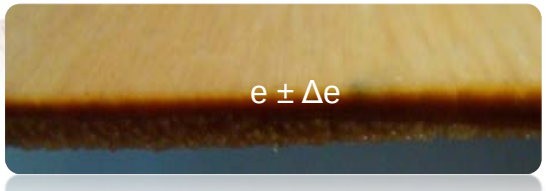
Soaking



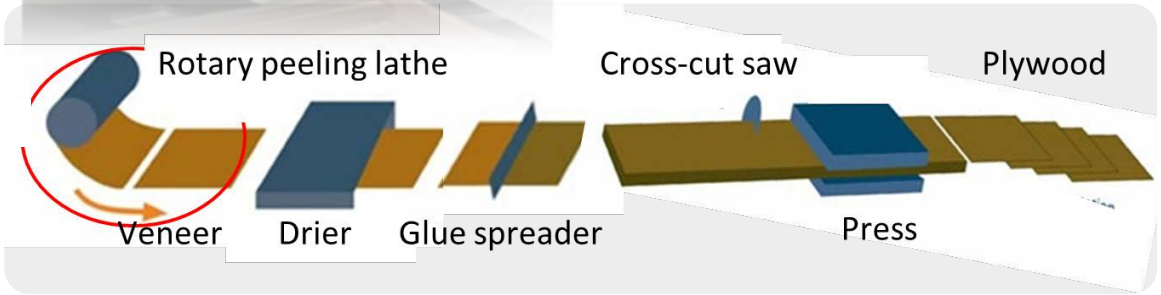
Peeling



Veneer



Plywood



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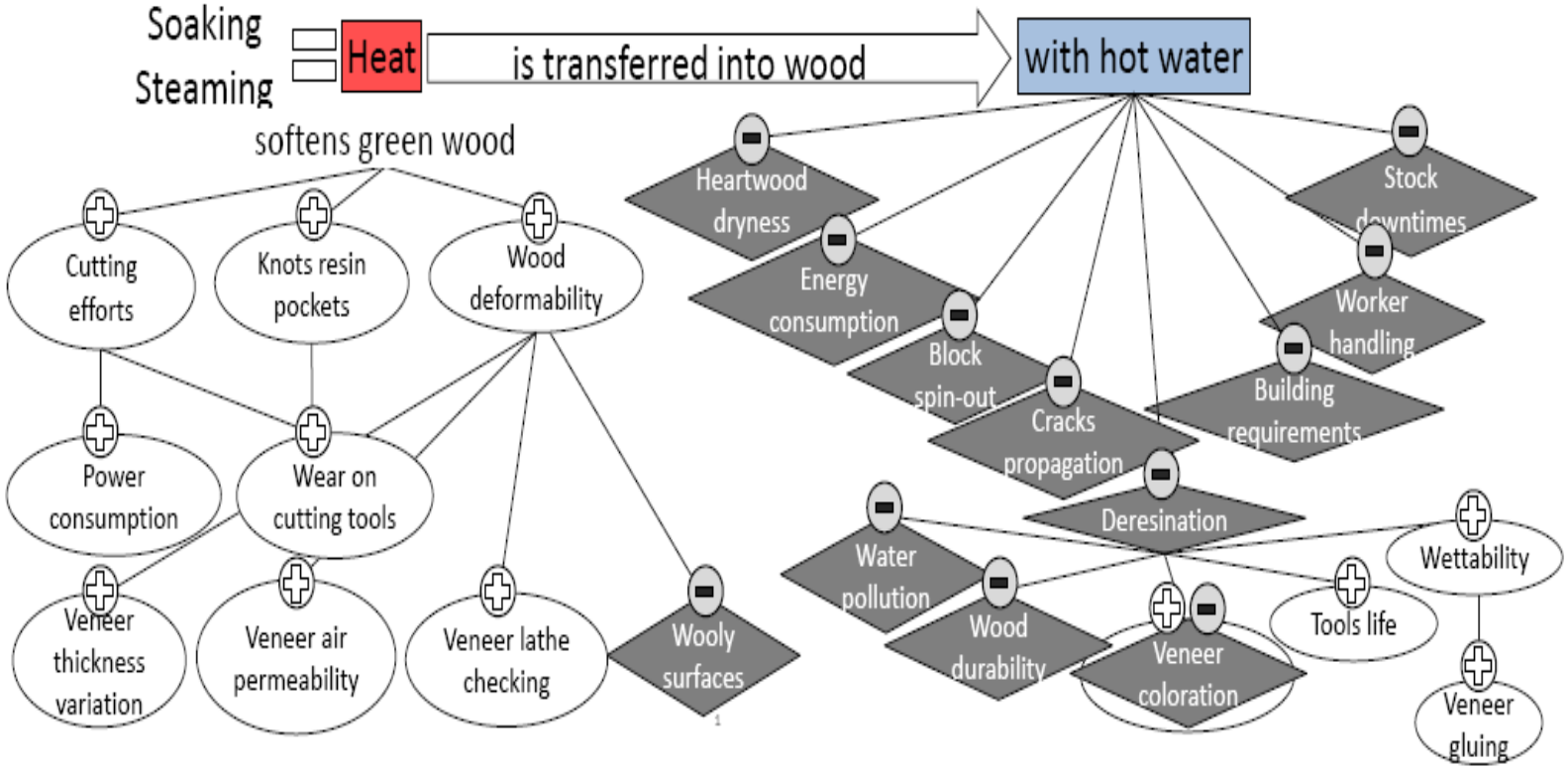
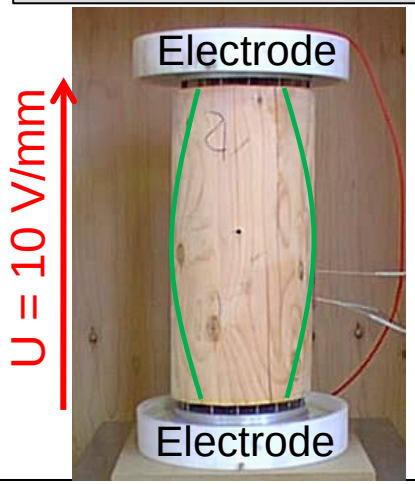
Why soaking?



Alternative methods to heating wood

Volume heating

Electric ohmic heating

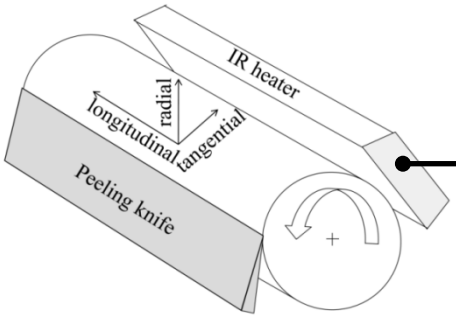


Microwave heating

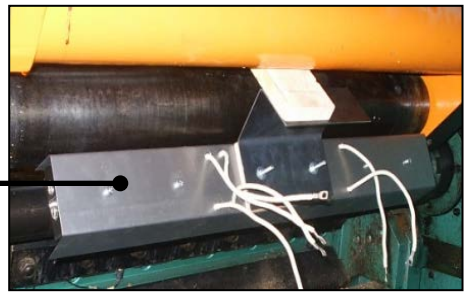
Because wood does not need to be cooked for a long duration, cell wall has to be brought rapidly to the required medium-range temperature

Surface heating

Infrared heating (IR)



Infrared heater



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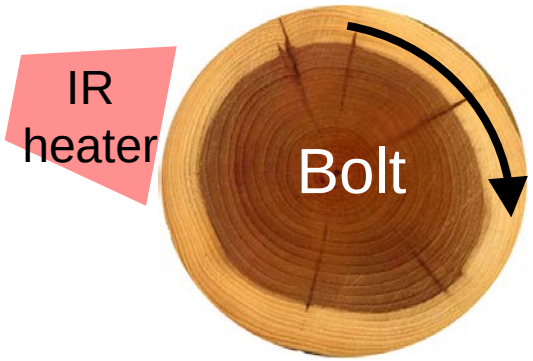
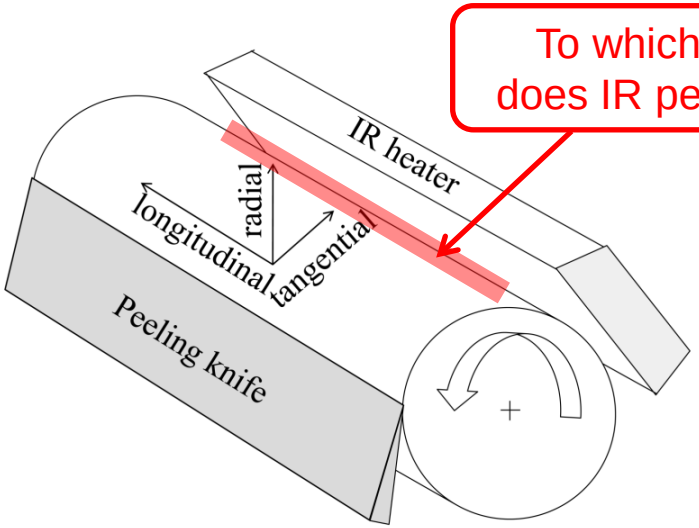
Penetration depth of IR in green wood





Do we have to integrate IR volumic Beer- Lamberts absorption law in heat transfer equations?

(1) $\rho C_p \frac{\partial T}{\partial t} = \nabla(k \nabla T) + \beta I_0 e^{-\beta r}$ with $I_0 = \sigma T_{ext}^4$ and $\beta = \frac{4\pi\kappa}{\lambda}$

(2) $Q_{rad} = h(T_{ext} - T) - \varepsilon\sigma T^4$

The answer is given by

Characterisation of optical properties of green and moisturized wood under IR radiation

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The samples

- Wavenumbersfrom 550 cm^{-1} to 5500 cm^{-1} i.e. from 18 µm to 1.8 µm
- 4 wood species: beech, birch, douglas-fir and spruce and from ambient moisture content to saturate state – either green or remoisturized wood
- Samples were cut from the veneers in the form of 30 mm diameter discs using a circular cutter

- Sample thicknesses varied from 0.2 to 3.1 mm (0.2 mm, 0.3 mm, 0.5 mm, 0.7 mm, 0.9 mm, 1.1 mm, 1.2 mm, 1.6 mm, 2.0 mm, 2.1 mm, 2.2 mm, 2.3 mm, 3.0 mm, 3.1 mm)
- Green samples that had never been dried were kept wrapped in plastic bags just after peeling to prevent moisture loss.

Other samples were “re-moisturised” from previously air-dried veneers by soaking in cold water.

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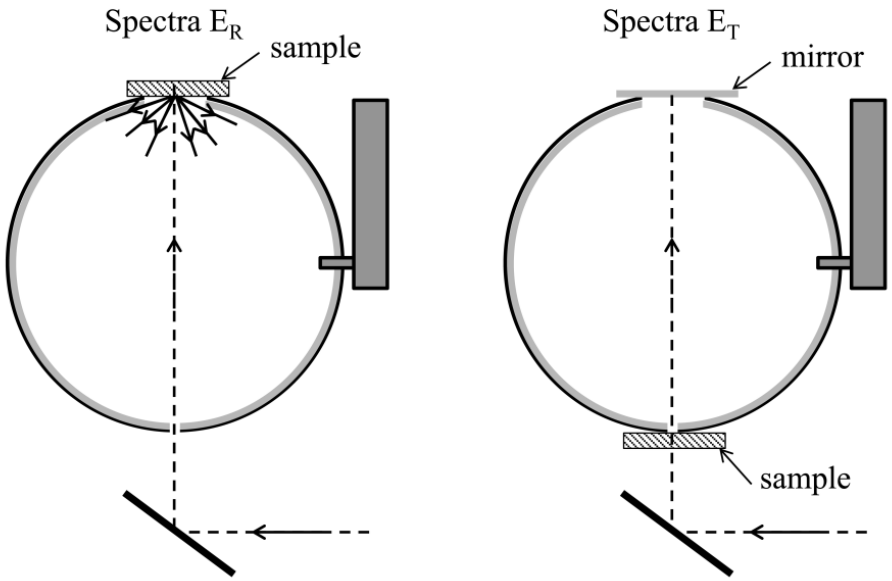
Spectrometer equipped with an integrating sphere



- The amount of energy absorbed by the material (absorptivity A) is given by:
  $A = 1 - R - T$

With R = reflectivity
T = transmittivity

Measured

- Transmission spectra (T) > IR penetration depth

i.e. how deep the IR radiation penetrated into the wood

- Reflection spectra (R) > amount of energy accumulated within wood

i.e. measure the efficiency of the energy to transfer between the source and the material

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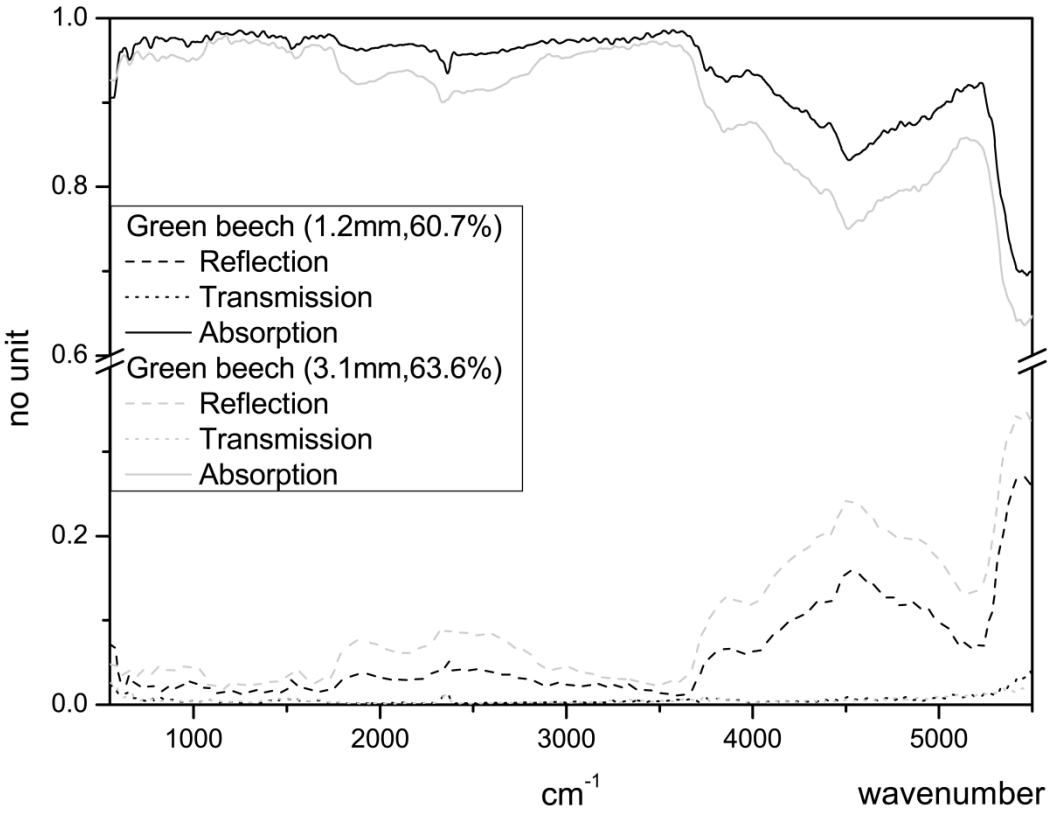
Interpretation of the spectra

- T and R increase with higher frequencies i.e. at shorter wavelengths: A is more significant at higher wavelengths than at shorter wavelengths
- T remains weak and could be neglected: there is no radiation transmitted through the sample and 70 to 98% of all incident IR radiation is absorbed by the samples. But how deep is IR absorbed?



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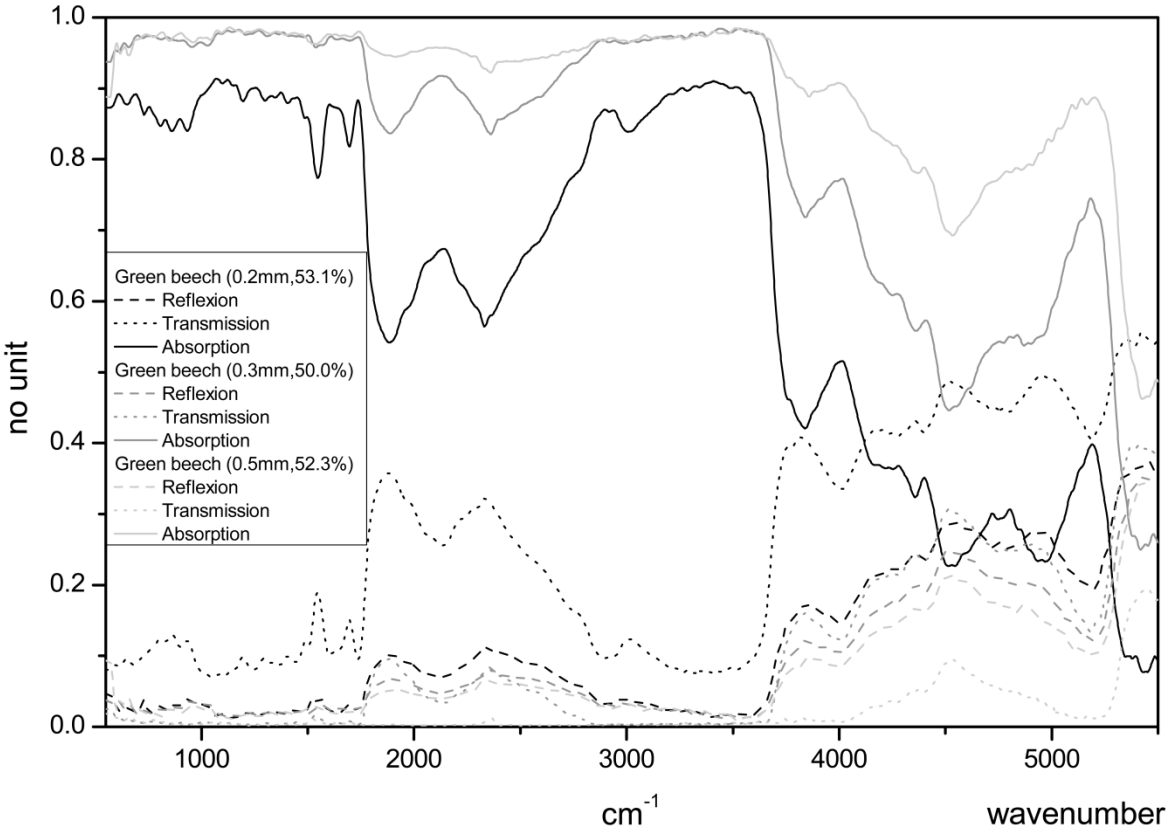
IR penetration depth

- Samples of 0.2 mm and 0.3 mm transmit energy: around 0.1 for 0.3 mm thick samples
- It is possible to accumulate around 90% of the incident energy emanating from a source emitting at between 550 cm^{-1} and 4000 cm^{-1} to a depth of 0.3 mm



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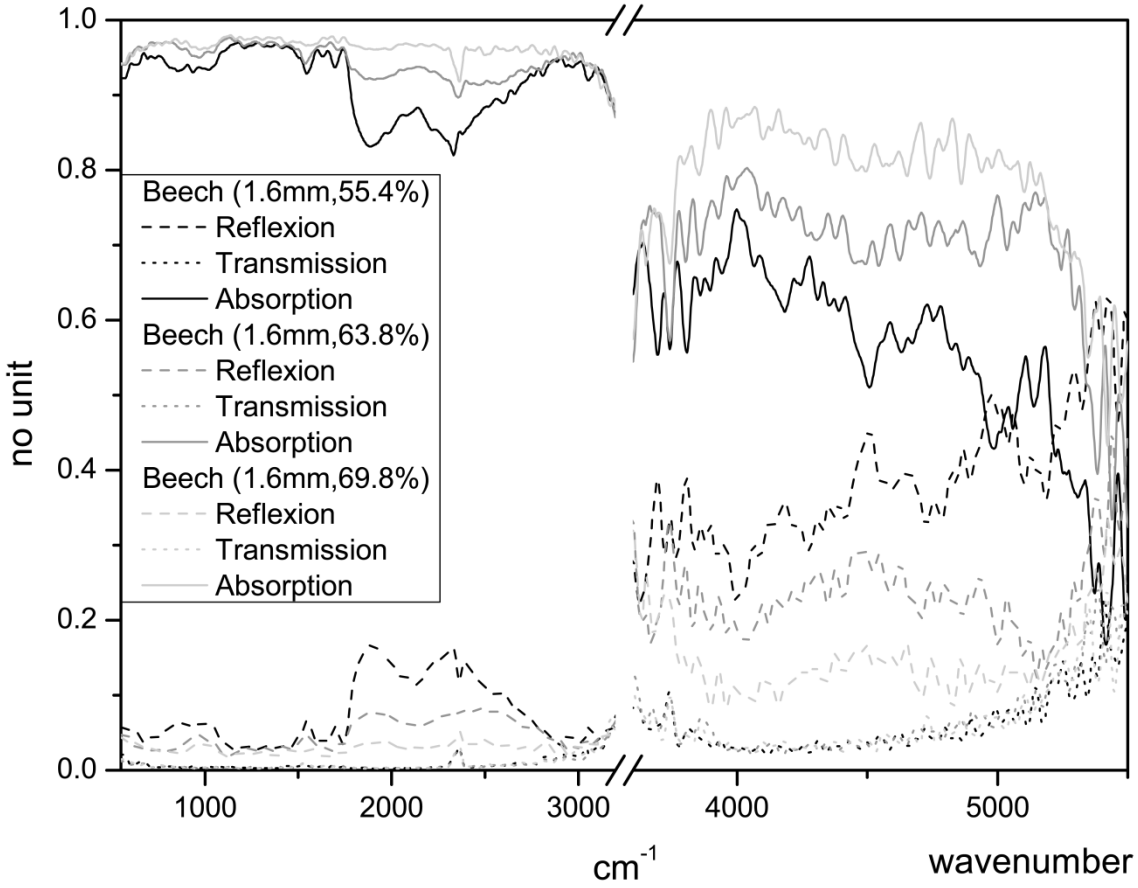
Influence of MC

- The most significant amount of absorbed radiation occurs in wetter wood. However, if this substantial increase serves to heat the water present in wood, it is of no interest for the purpose investigated herein, namely to heat wood with IR radiation.



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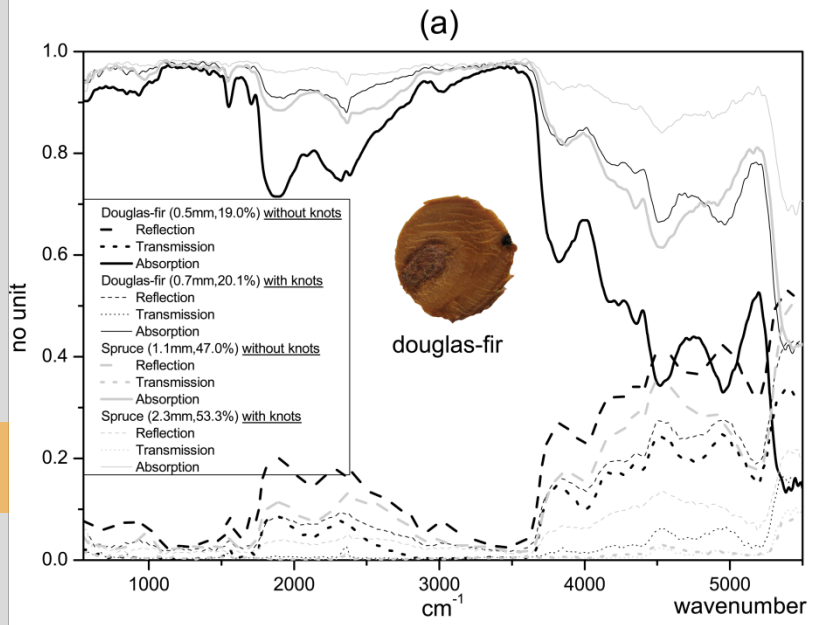
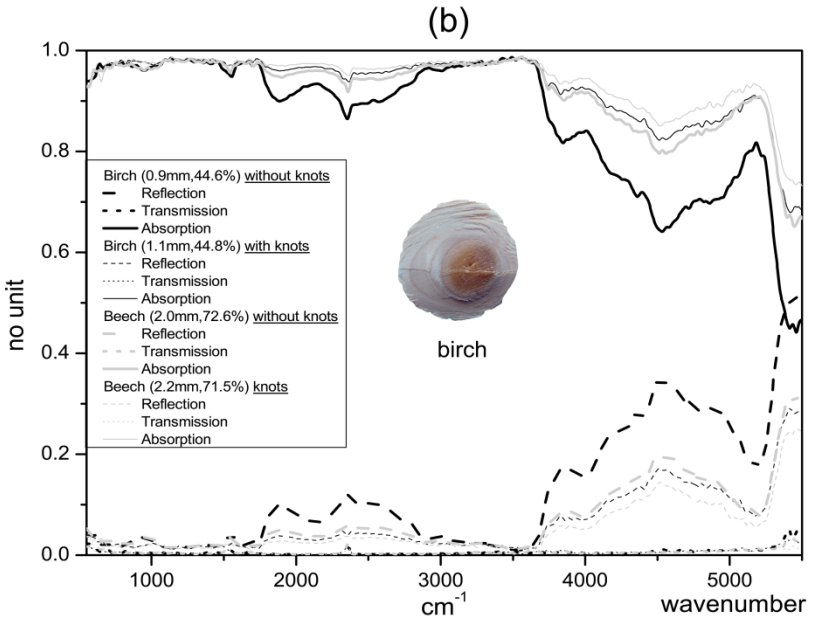
Influence of knots

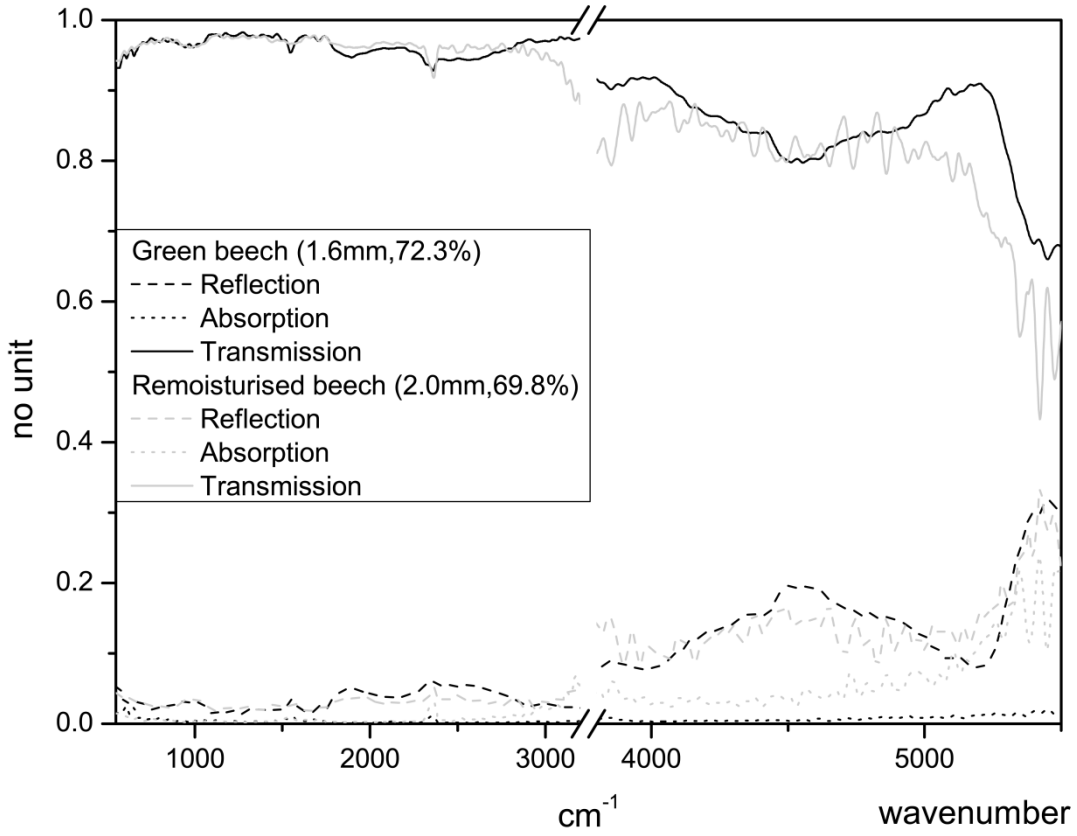
- Knots increase absorption. A possible explanation is that the denser parts of wood, such as may be found in knots, feature a relatively greater number of molecules able to absorb energy.





Remoisturised vs green wood

- Whilst green and re-moisturised wood are structurally different due to irreversible loss of hydroxyl groups during hornification (re-moisturising wood does not liberate all hydroxyl groups “lost” during initial drying from the green state), they interact in the same way with IR radiation



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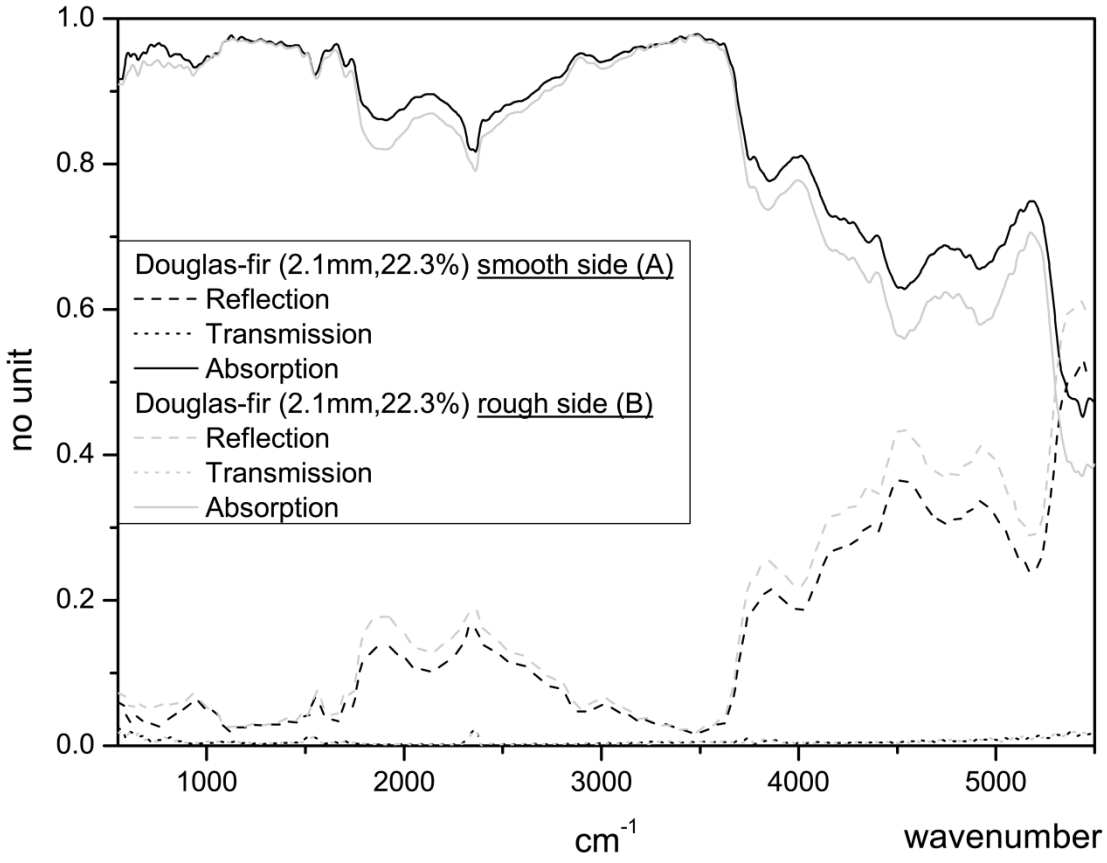
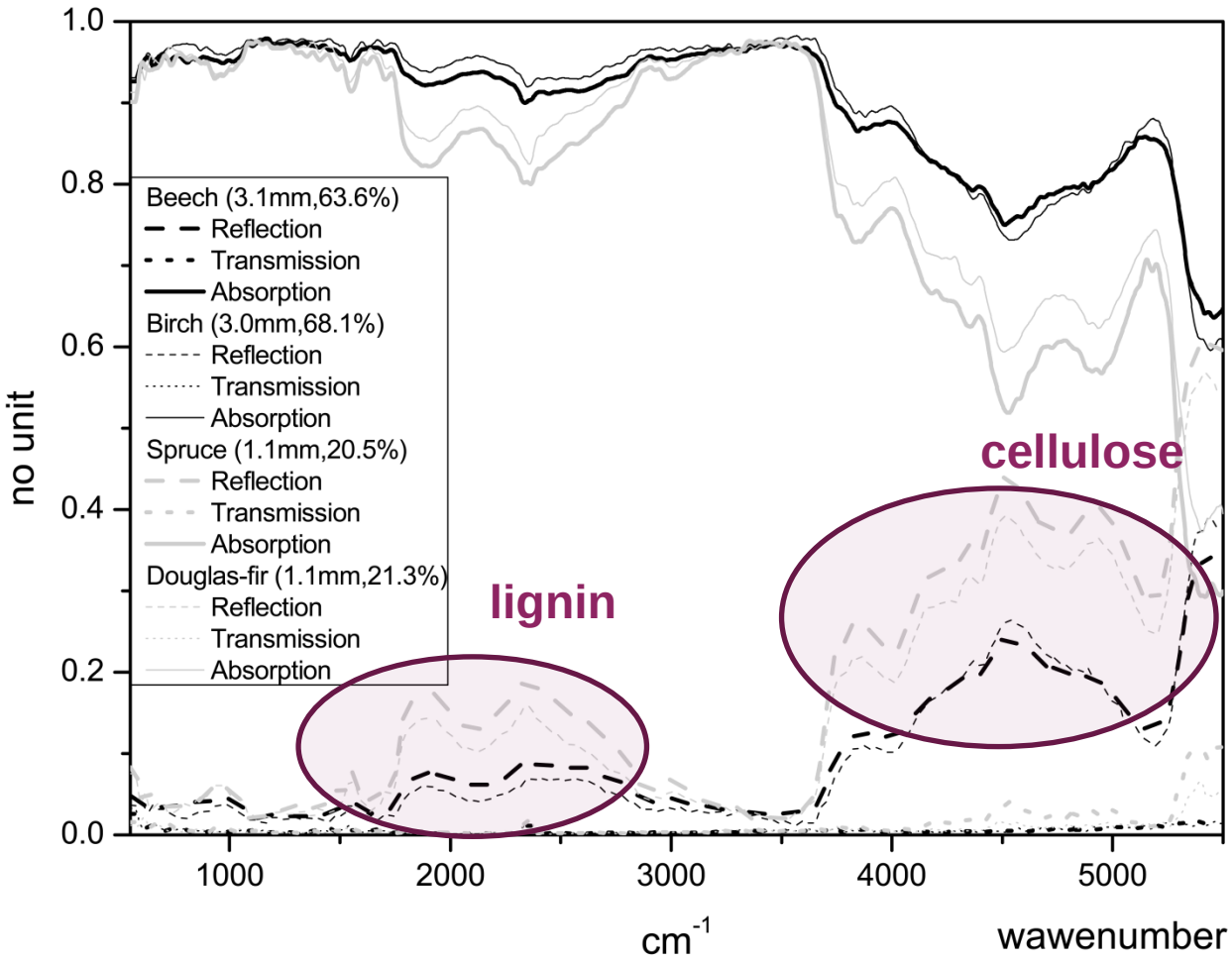
Effect of surface quality

- The rougher the surface (the loose side, side B), the greater the reflection and the less absorption. In case of a rough surface, the incident IR radiation hitting surface irregularities is more likely to be reflected out of the sample and has less chance of penetrating the material than on an even surface



Effect of species

- Variability between softwoods and hardwoods is explained by specific chemical bonds



- The thinner the sample, the more radiation transmitted through it and the thicker the sample, the more reflected and absorbed radiation
  - ➢ relatively low penetration depth of 0.3 mm
- The presence of water in wood is beneficial to IR penetration into wood because it increases the amount of absorbed energy
- Knots increase absorption (denser parts)
- Similar interaction with IR between green and re-moisturised wood
- Modifying the veneer surface quality influences wood absorption
- Softwoods spectra exhibit similarities that differ from those of hardwoods
- Variability between softwoods and hardwoods is explained by specific chemical bonds

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Thank you for your attention.