UNIVERSITY OF WEST HUNGARY
SIMONYI KÁROLY FACULTY OF ENGINEERING, WOOD SCIENCES AND APPLIED ARTS

SORPTION PROPERTIES OF WOOD BARK AND PHLOEM

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Performance Testing and
Testing Methodologies of
Non-wood Biobased Materials
Joint COST ACTION FP1303 & FP 1404 Workshop
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Introduction

- Traditionally, bark is burned to generate heat and energy
- Products with high added value are rare
- ~10 % of a tree stem's volume is bark
- 1.6 billion m^3 global logging harvest, → bark volume of 160 million m^3 worldwide annually (Xing et al. 2006: For Prod J, 56(3):64–69)

http://www.rolite.eu/en/korgist-soojustus/

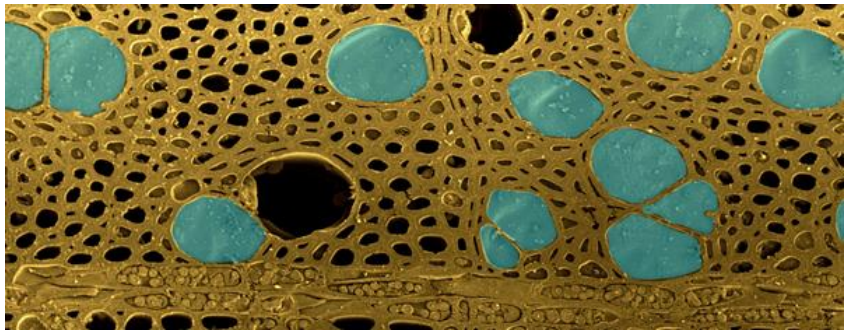
Introduction

- Building owners are increasingly interested in using biomaterials as construction elements
- An important factor during the building of living houses is the heat insulation
- The utilization of bark as insulation boards is a promising possibility to reach the goal of good heat insulation with a biomaterial

http://www.rolite.eu/en/corkoco/

Introduction

- However, building materials are in contact with air humidity in all utilization fields
- It is important to know the sorption and diffusion properties of these materials to be able to understand the expected moisture transport processes during utilization
- Sorption properties of wood and bark are strongly dependent on wood species
- Properties of bark are strongly dependent on tree age



https://www.sciencenews.org/article/trees-worldwide-sip-away-dehydration?mode=magazine&context=4542

Introduction

- Sorption can be decreased by heat treatment
- The characteristic of heat-treated lignocellulosic materials' sorption behaviour usually includes slower reaction to relative humidity changes compared to the untreated ones
- The phenomenon of modification is even more complicated, as all of the treatment parameters have influence on the sorption behaviour

http://www.waterdamagerestorationtpa.com

Introduction

- During the service life of a product the surrounding climate is regularly changing, thus the EMC, and therefore the dimensions, are changing too
- The goal → determine sorption behaviour of wood bark and phloem with and without heat treatment

http://ruach.files.wordpress.com/2009/09/water-on-wood-high-res.jpg

http://kiwikku.deviantart.com/art/Bark-Water-120542784

Materials and methods

Sorption test

- Wood species:
  - Softwoods: **scots pine, larch** (douglas fir, spruce, black pine)
  - Hardwoods: **oak, beech** (poplar, maple, birch, lime, hornbeam, ash, turkey oak, black locust)
- Two age groups were investigated:
  - Young (age between 5-15 years, from thinning cuts)
  - Old (above typical cutting age of the species)

Sampling of *Populus tremula*

Materials and methods

Sorption test

- Particle size: ~2mm×5-10mm×5-10mm (radial×tangential×longitudinal)
- ~2 g of particles for each species with and without HT
- Investigated wooden parts:
  - **Outer bark**
  - **Phloem**
  - (Sapwood)
- Climatic conditions:
  - T= 20°C; ϕ=20 – 35 – 50 – 65 – 80 – 95%
- Moisture content change: 0% → 95% → 0%

Larch phloem (left) and bark (right) samples

Materials and methods

Heat-treatment parameters:

Heat-Treatment (HT):

Applied media:

- air

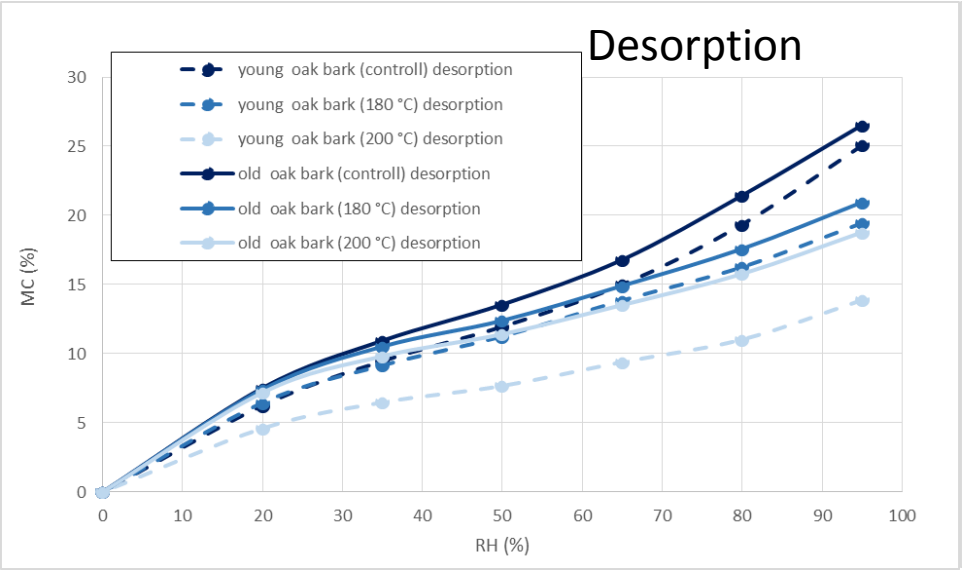
Temperature: 180 and 200 °C

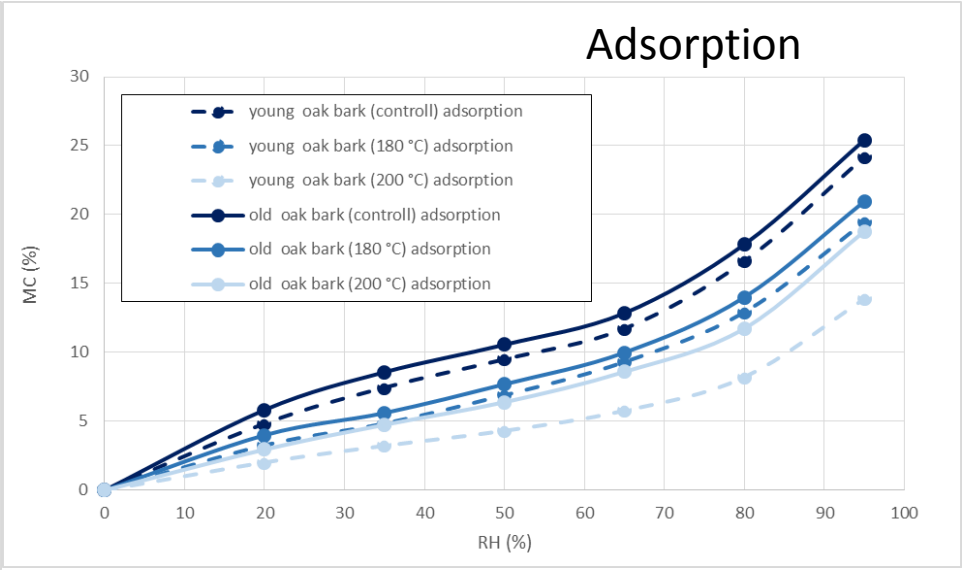
Treatment time: 3 hours

+ untreated samples

Results

- Oak bark desorption and adsorption

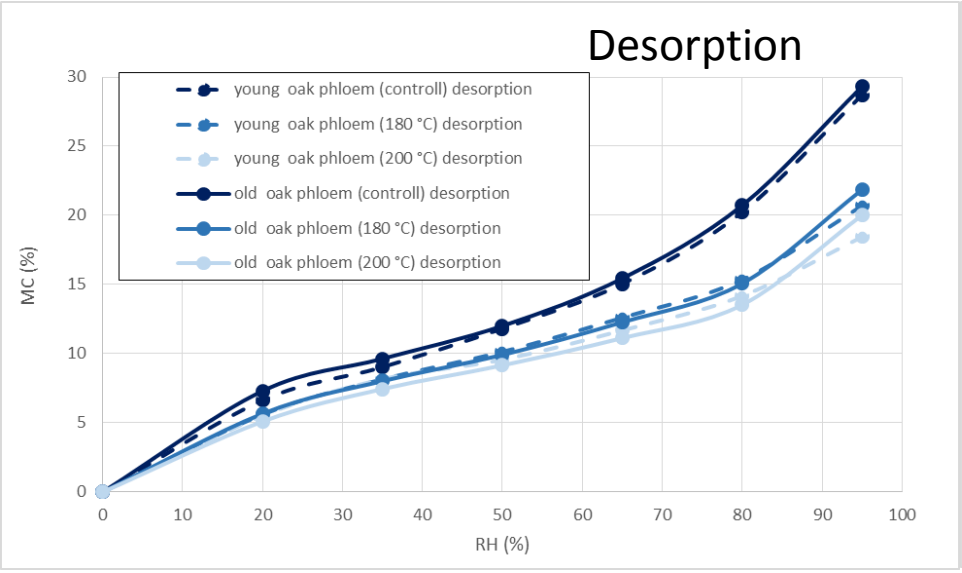


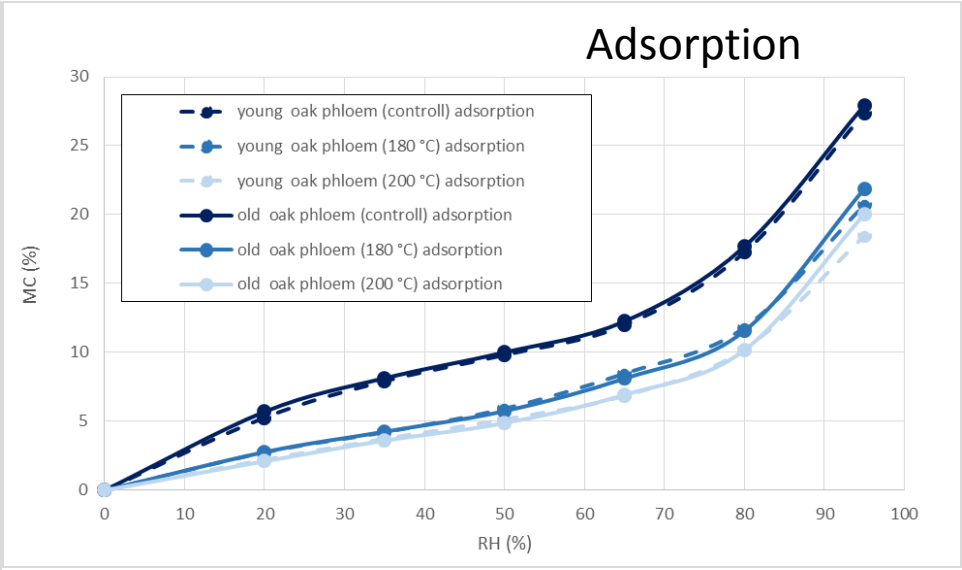


- Higher EMC for old
- Clear effect of HT temperature

Results

- Oak phloem desorption and adsorption

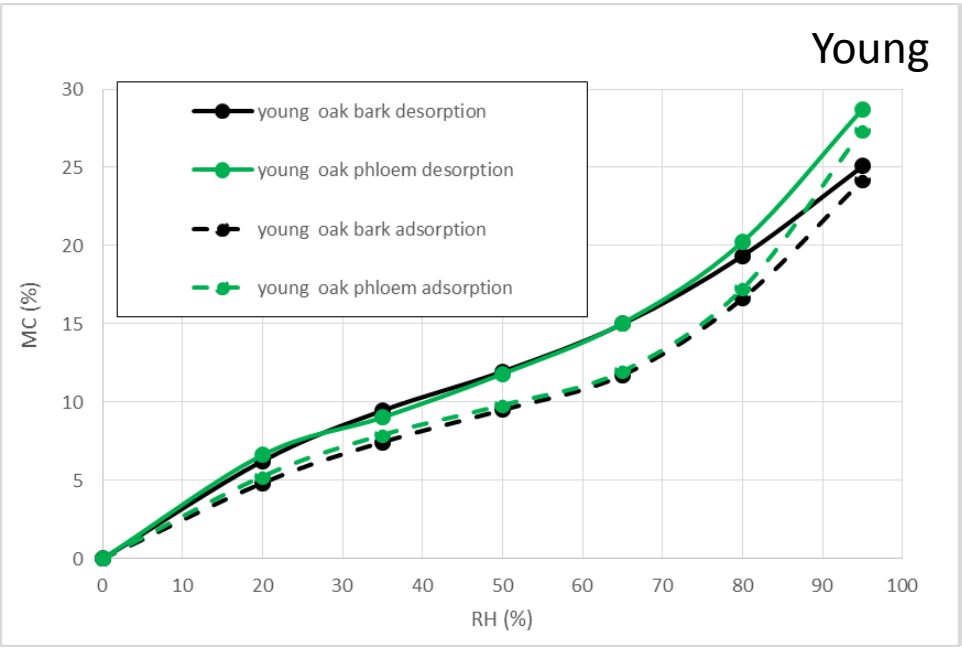


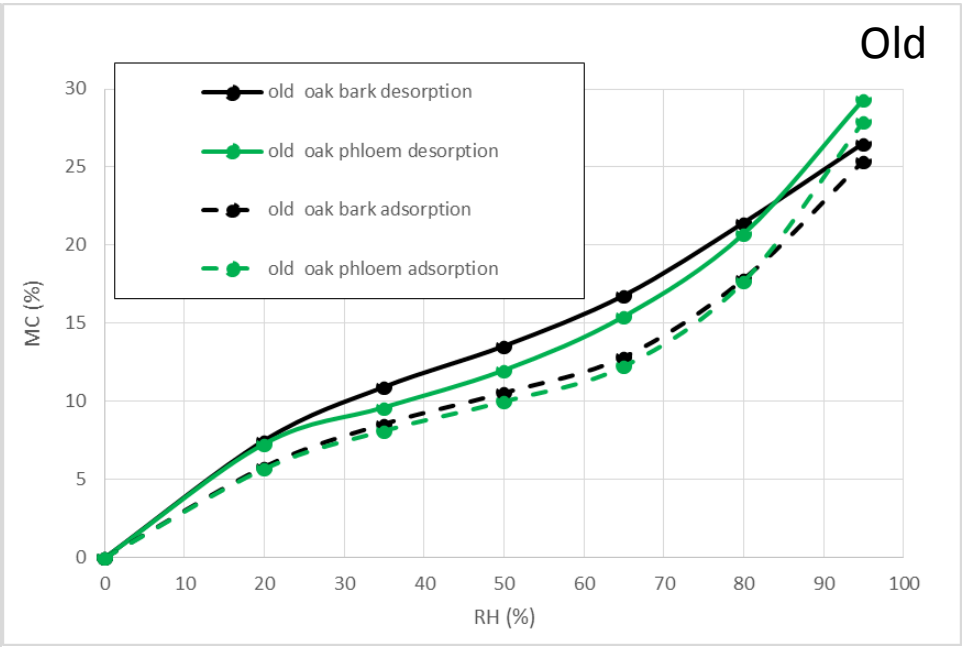


- No significant difference between old and young
- Clear effect of HT temperature

Results

- Oak hysteresis

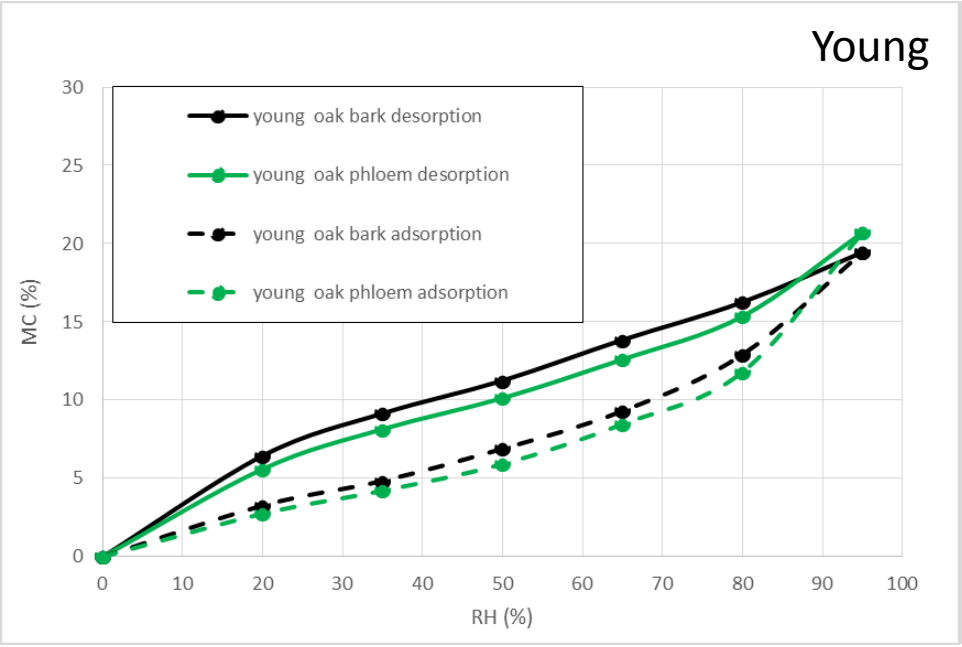


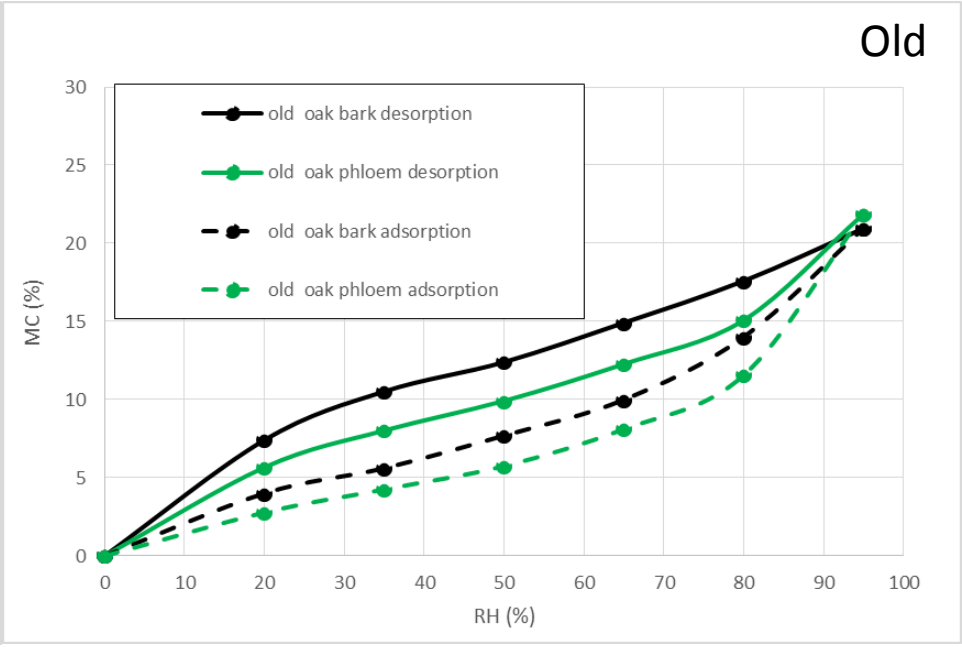


- Sorption of bark and phloem is only different at higher RH ranges

Results

- Oak hysteresis (180°)

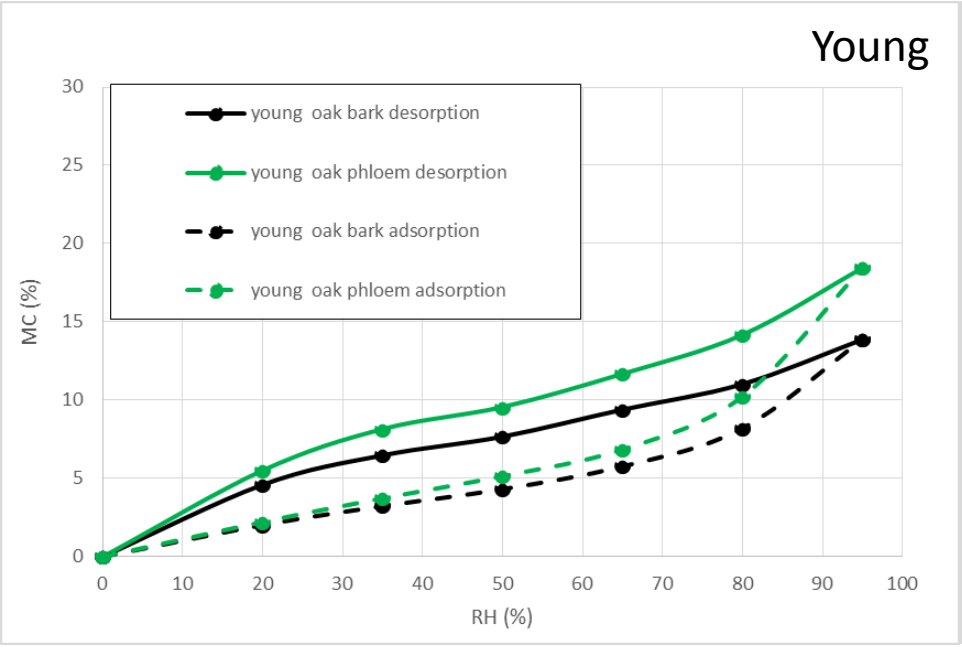


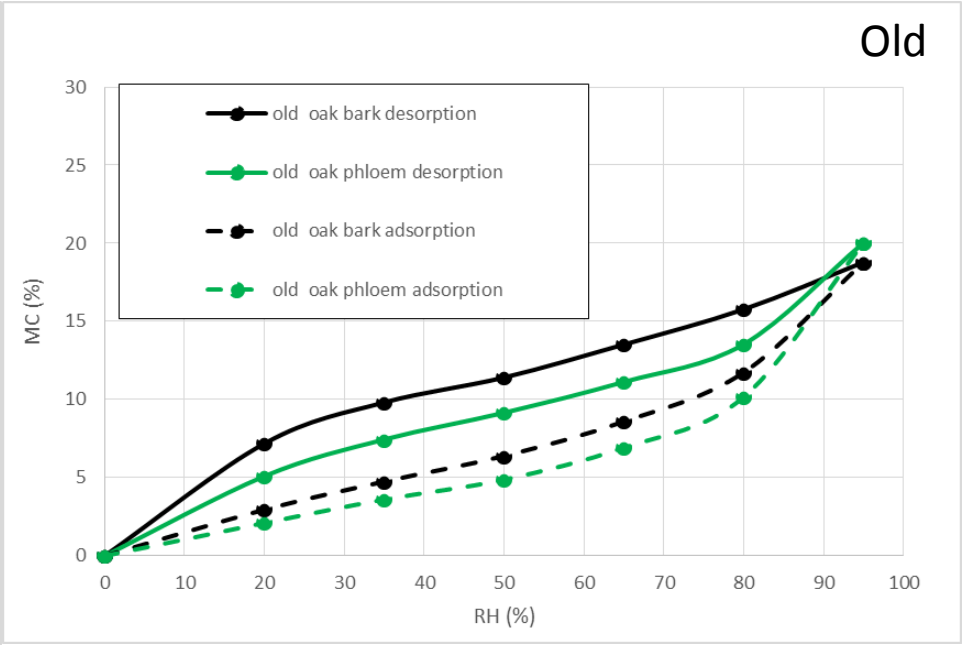


- Lower EMC-s in general, especially at higher RH ranges
- Different behaviour after 180° HT → lower EMC-s for phloem and larger hysteresis

Results

- Oak hysteresis (200°)

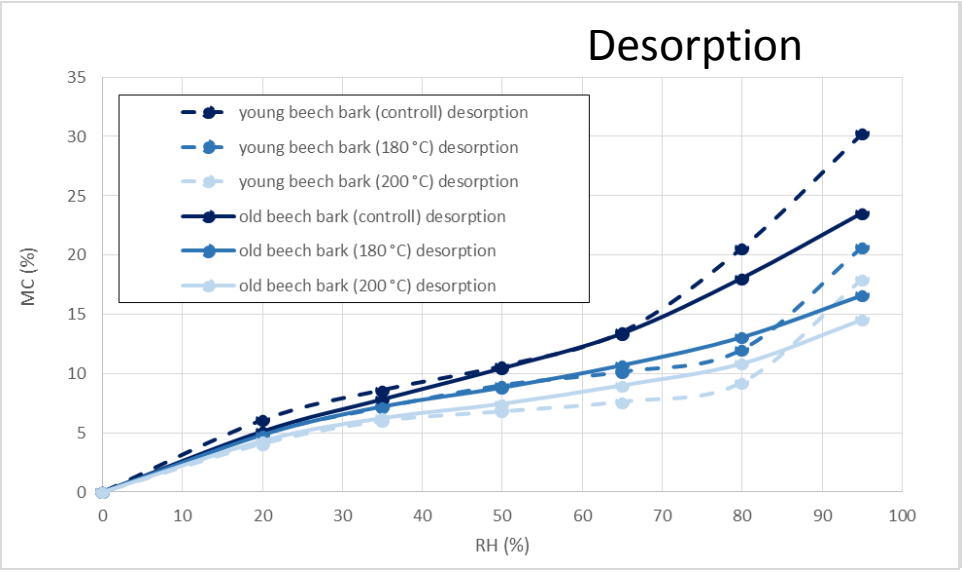


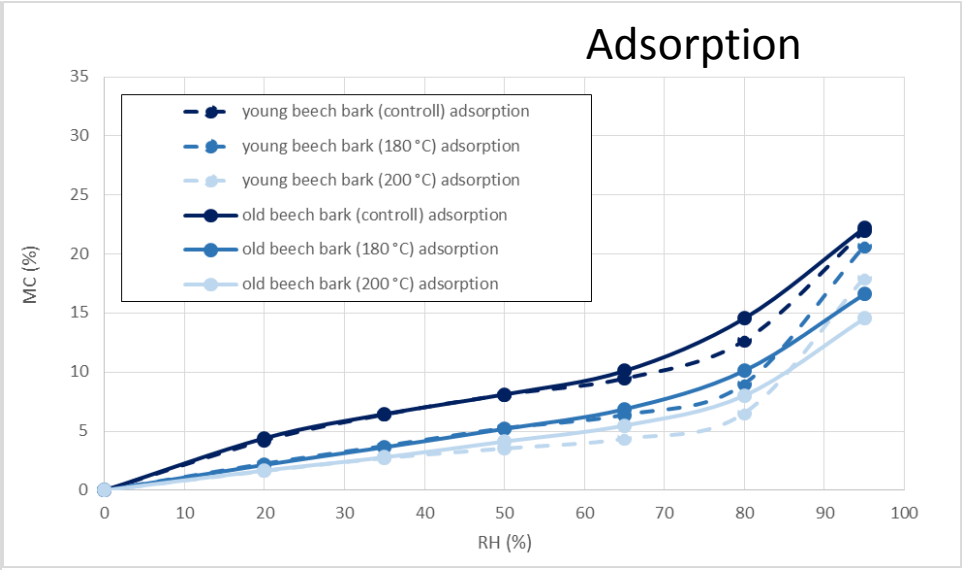


- Lowest EMC-s in general
- Different behaviour after 200° HT → significant differences between young and old bark
- Stronger effect of HT on the young bark, however no significant differences between the sorption behaviour of phloem after 200° HT

Results

- Beech bark desorption and adsorption

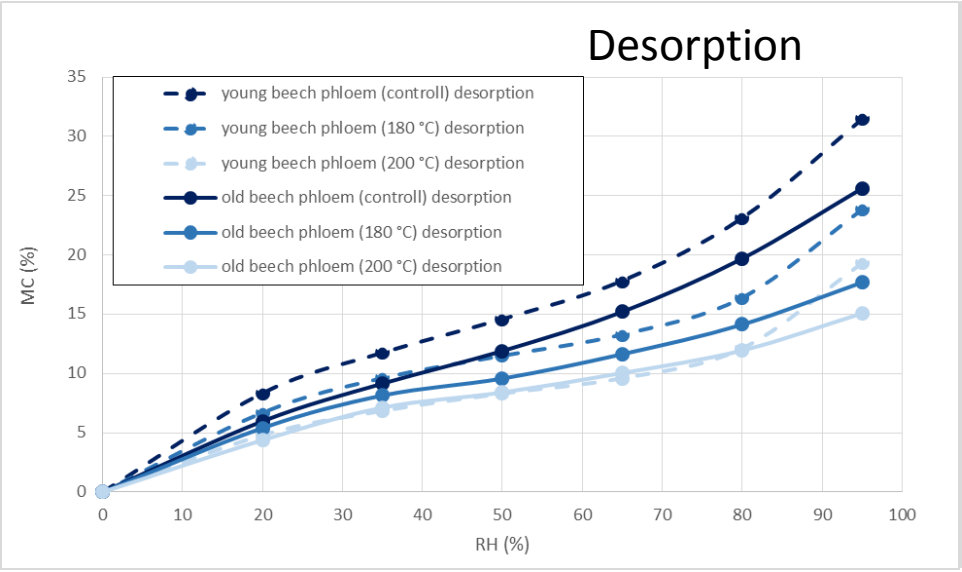


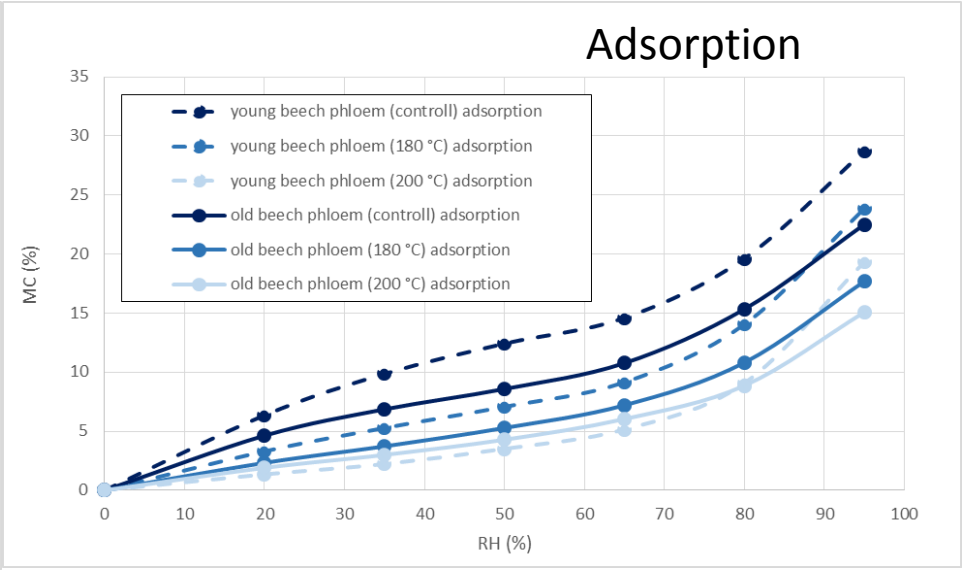


- Different EMC-s at higher RH ranges between young and old bark
- Clear effect of HT temperature

Results

- Beech phloem desorption and adsorption

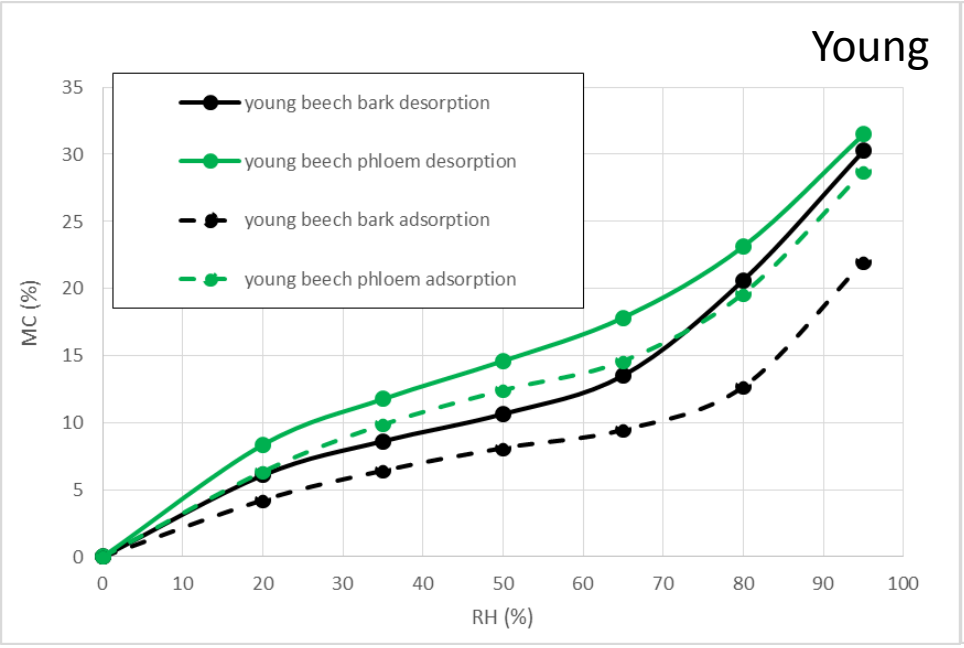


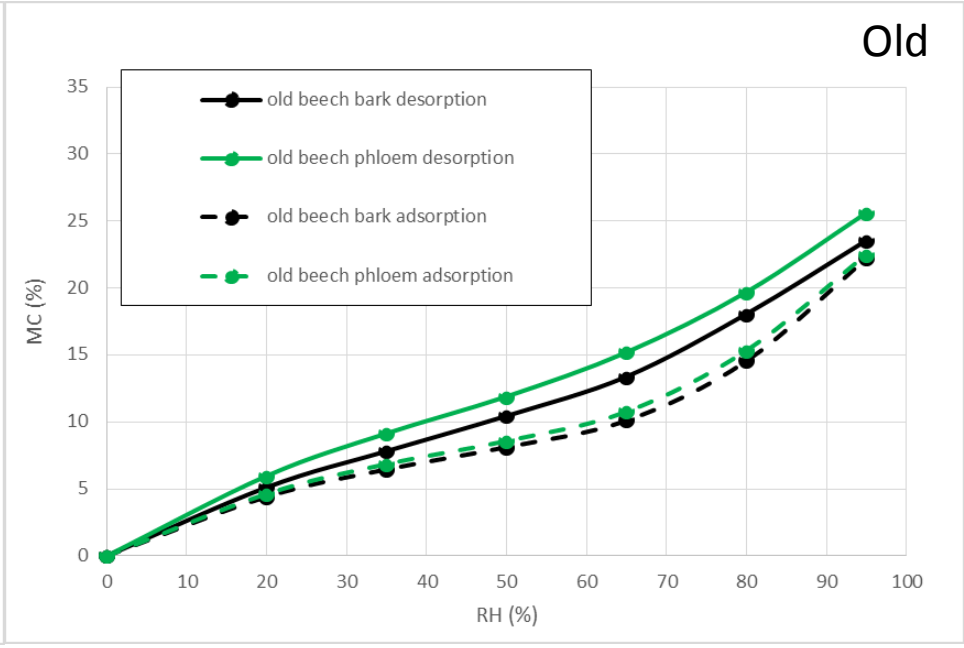


- Significant difference between old and young phloem → higher EMC-s for young
- Clear effect of HT temperature

Results

- Beech hysteresis



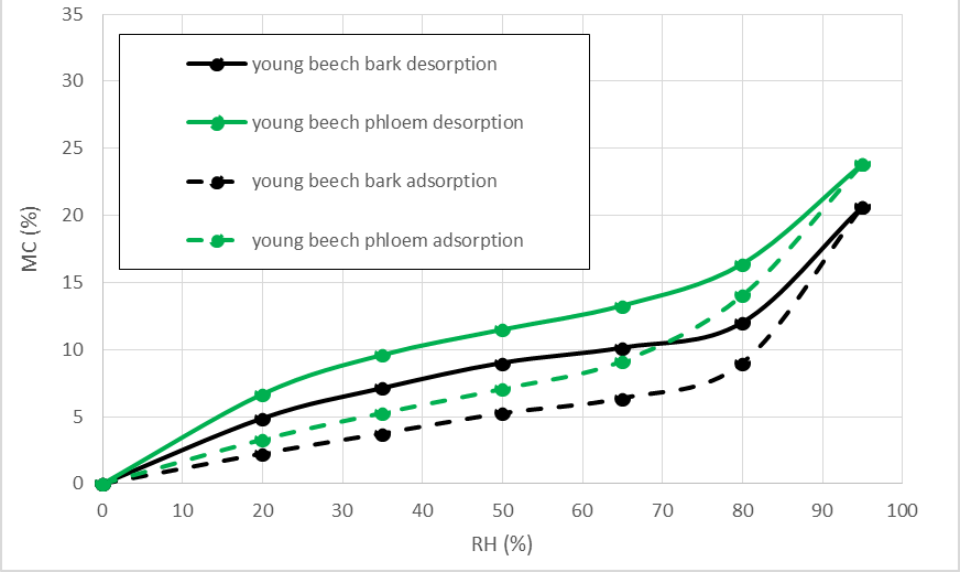


- Only the sorption of young bark and phloem is different, no significant differences in case of old samples

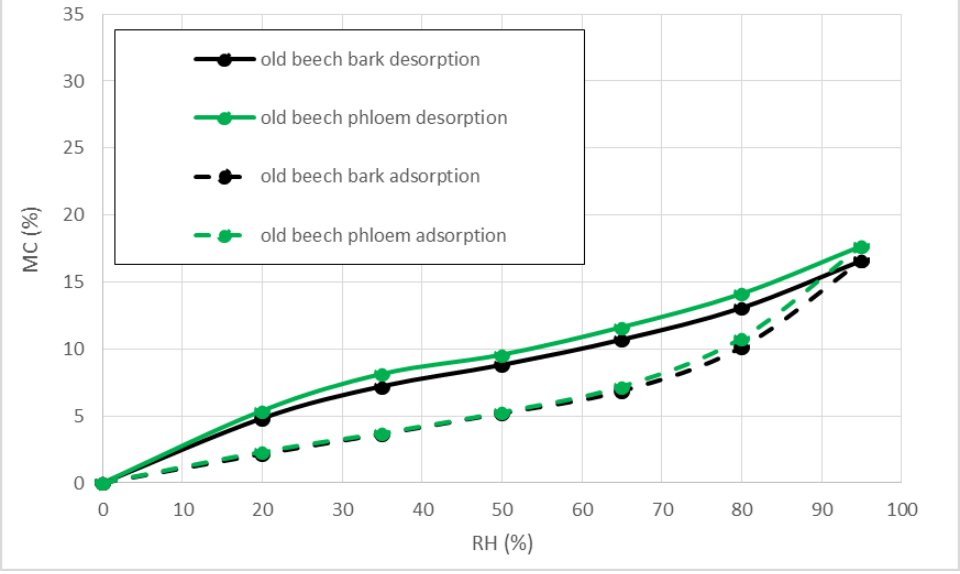
Results

- Beech hysteresis (180°C)

Young



Old

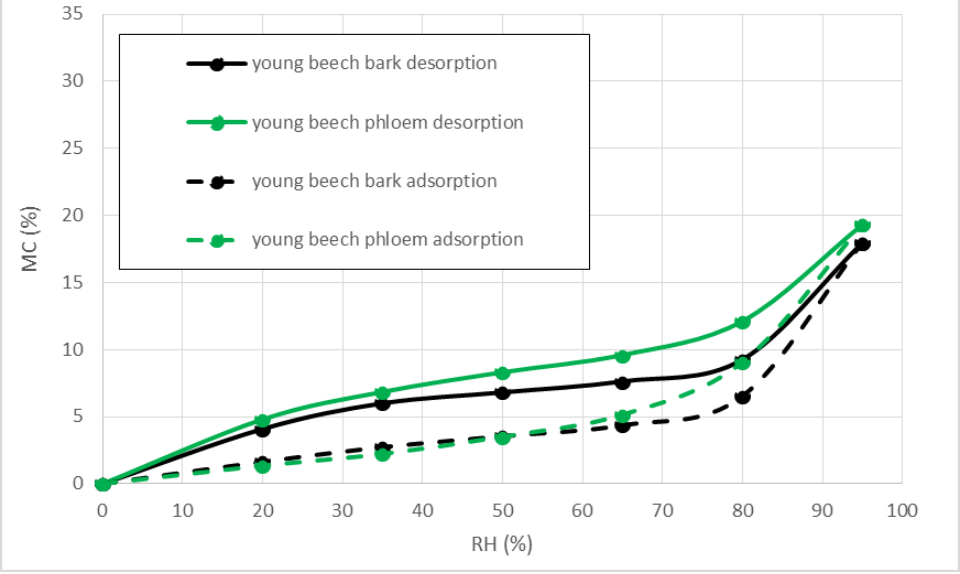


- Lower EMC-s in general, especially at higher RH ranges
- Similar behaviour after 180° HT → Only the sorption of young bark and phloem is different, no significant differences in case of old samples
- Larger hysteresis compared to the untreated

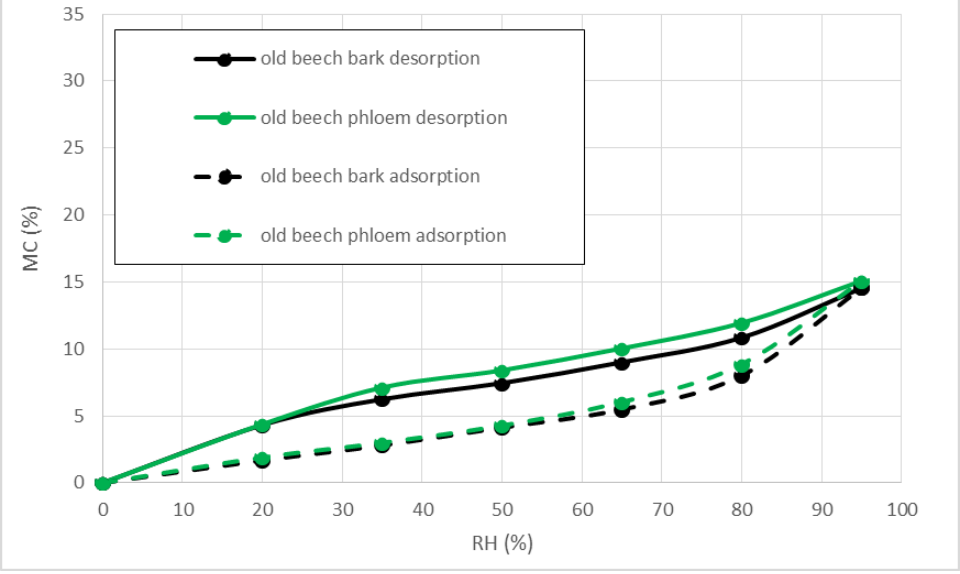
Results

- Beech hysteresis (200°C)

Young



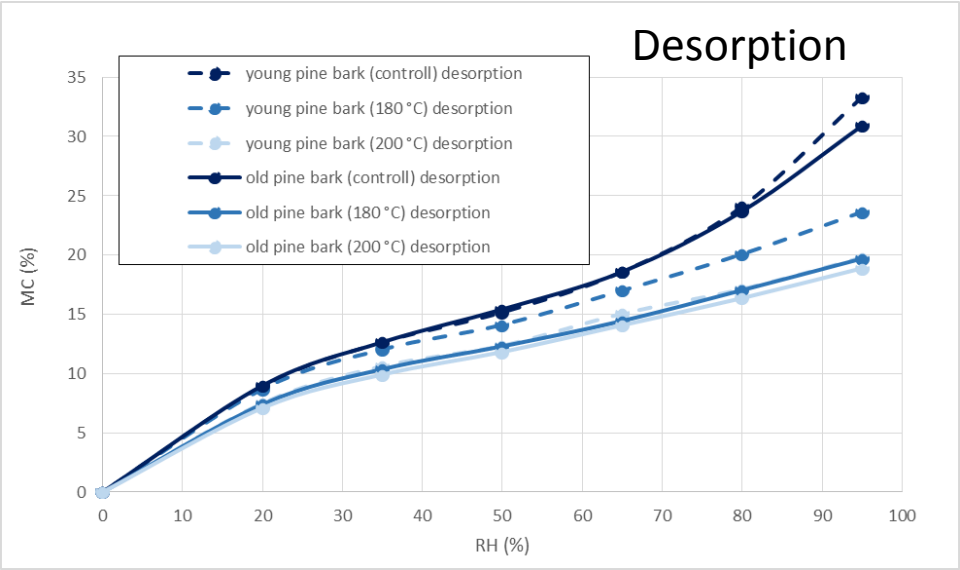
Old

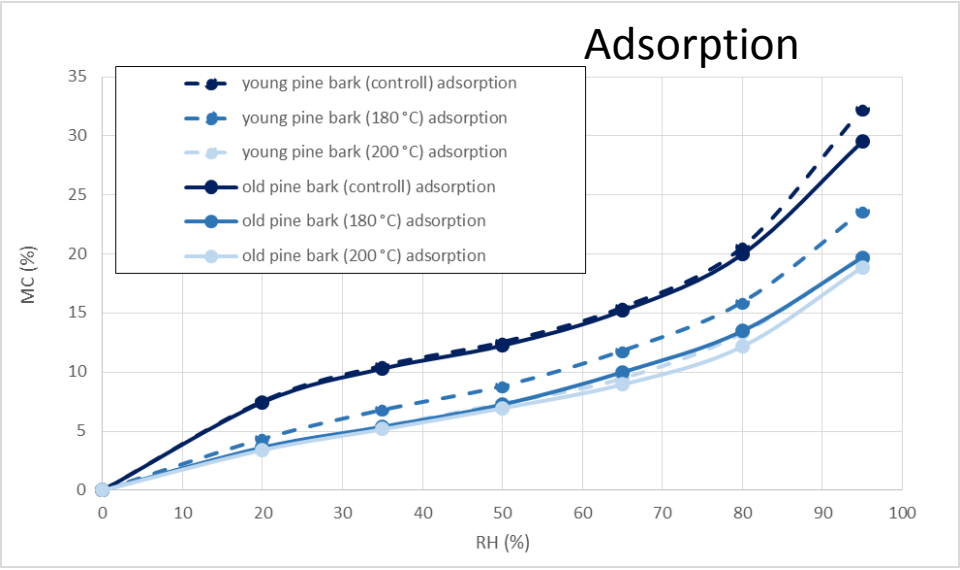


- Lowest EMC-s in general
- Significant differences between young and old bark
- Differences between the sorption behaviour of young bark and phloem were diminished after 200° HT

Results

- Pine bark desorption and adsorption

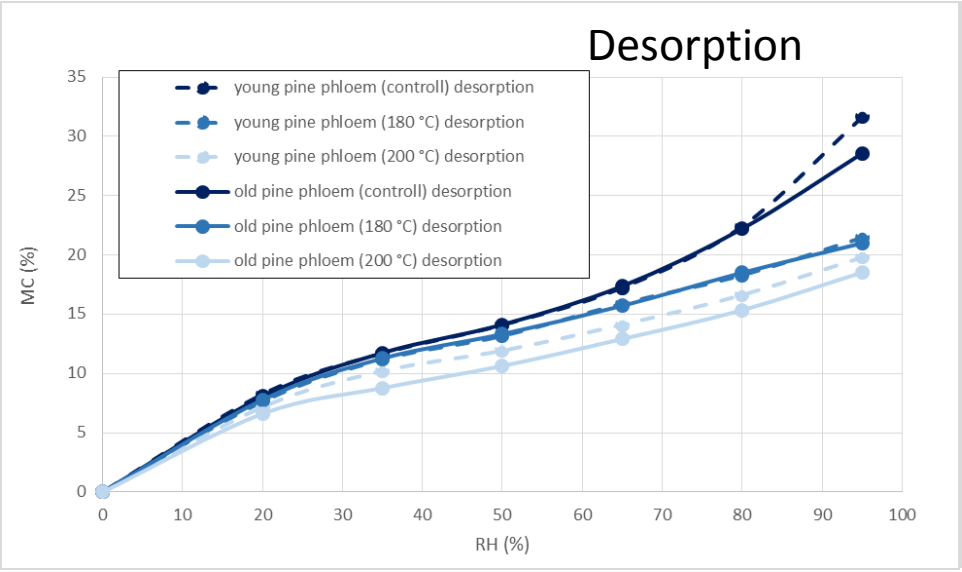


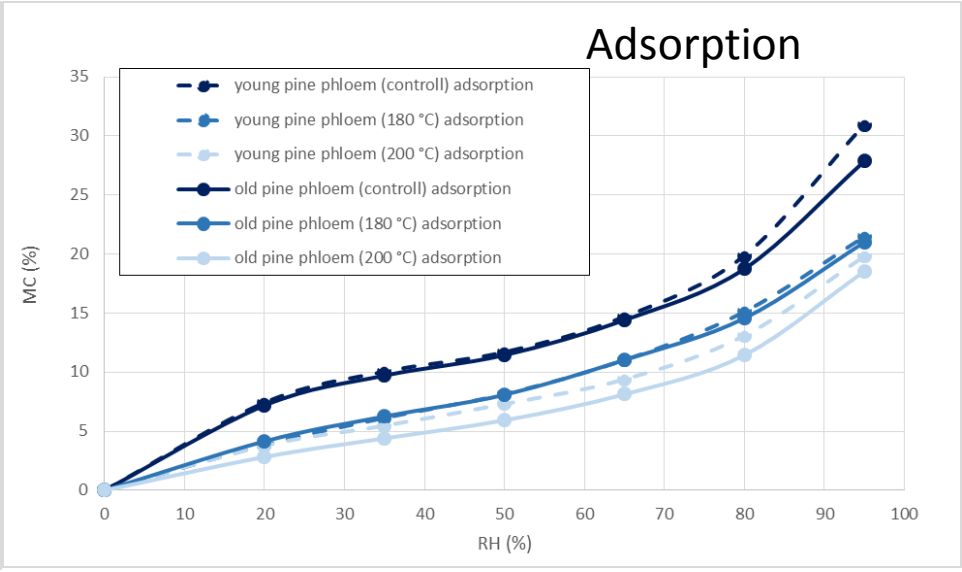


- Different EMC-s at higher RH ranges between young and old bark
- Clear effect of HT temperature in case of young bark, however, no differences in case of old bark

Results

- Pine phloem desorption and adsorption

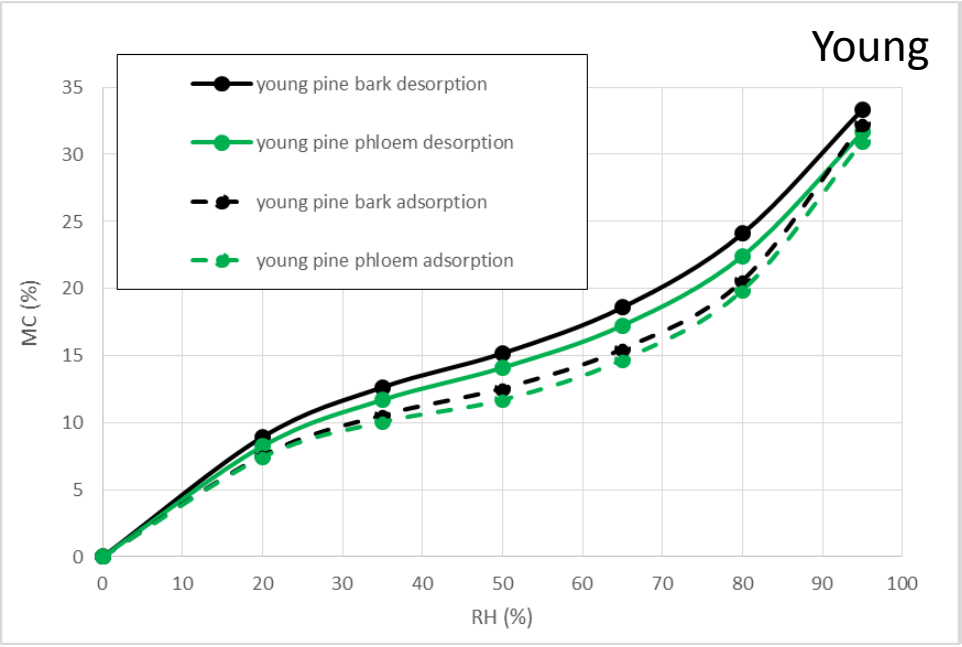


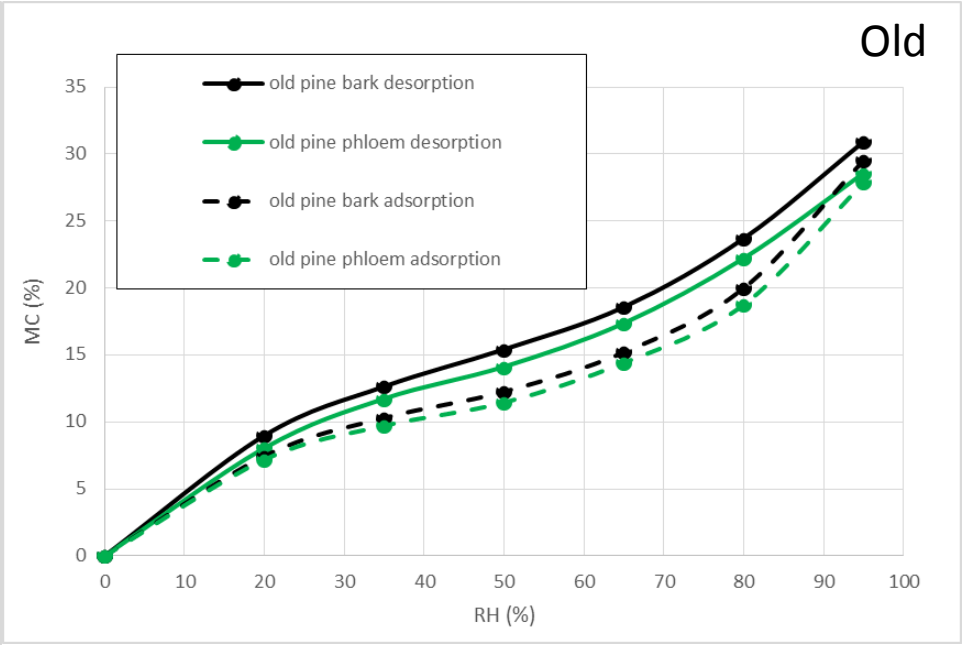


- No significant difference between old and young phloem → only at higher RH ranges
- Clear effect of HT temperature

Results

- Pine hysteresis

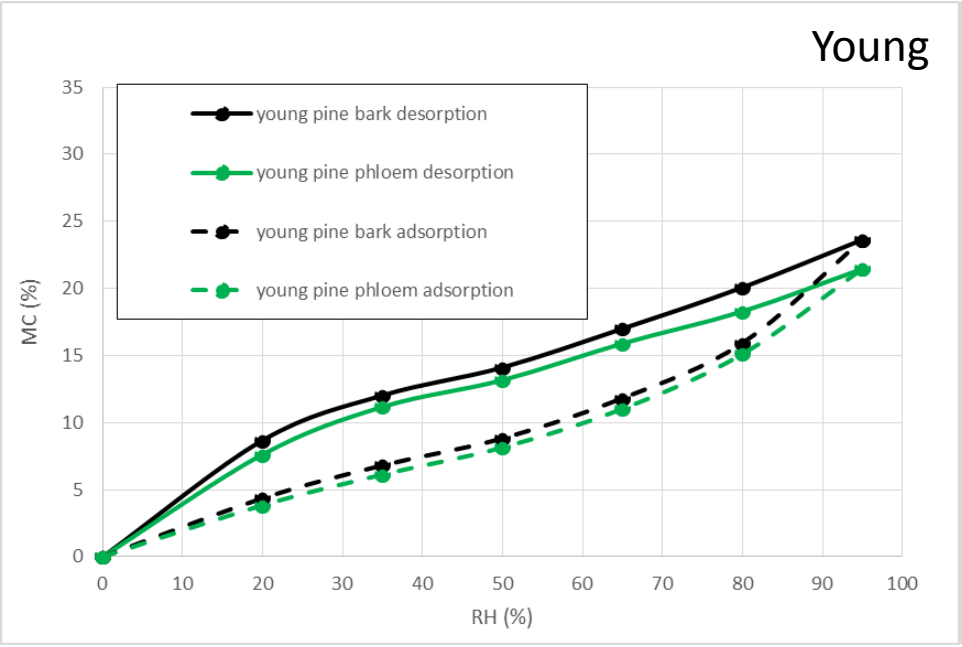


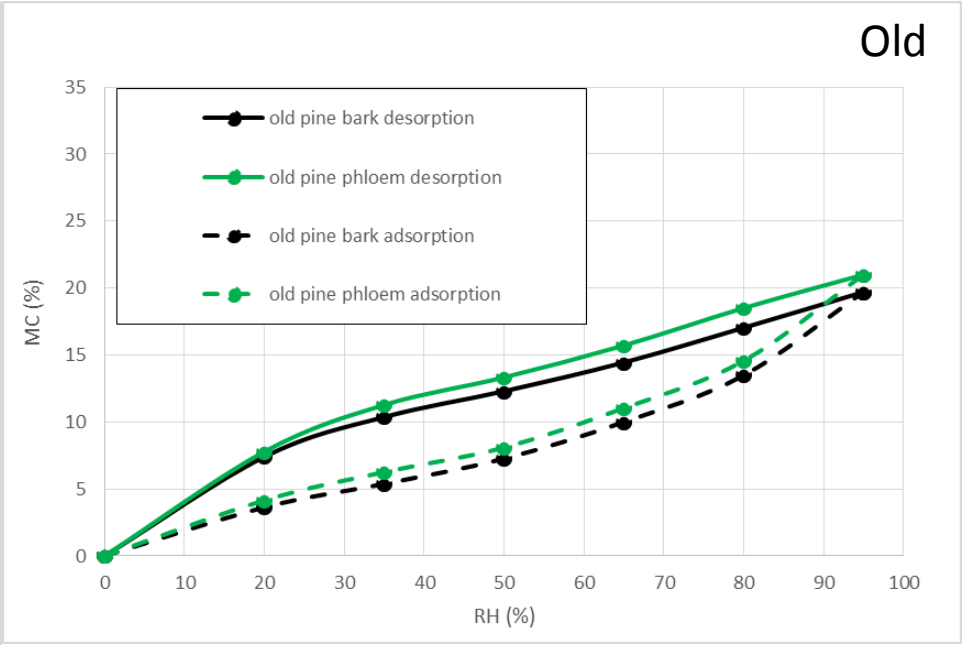


- Only slight differences between the sorption behaviour of bark and phloem
- Slight differences between old and young samples

Results

- Pine hysteresis (180°C)

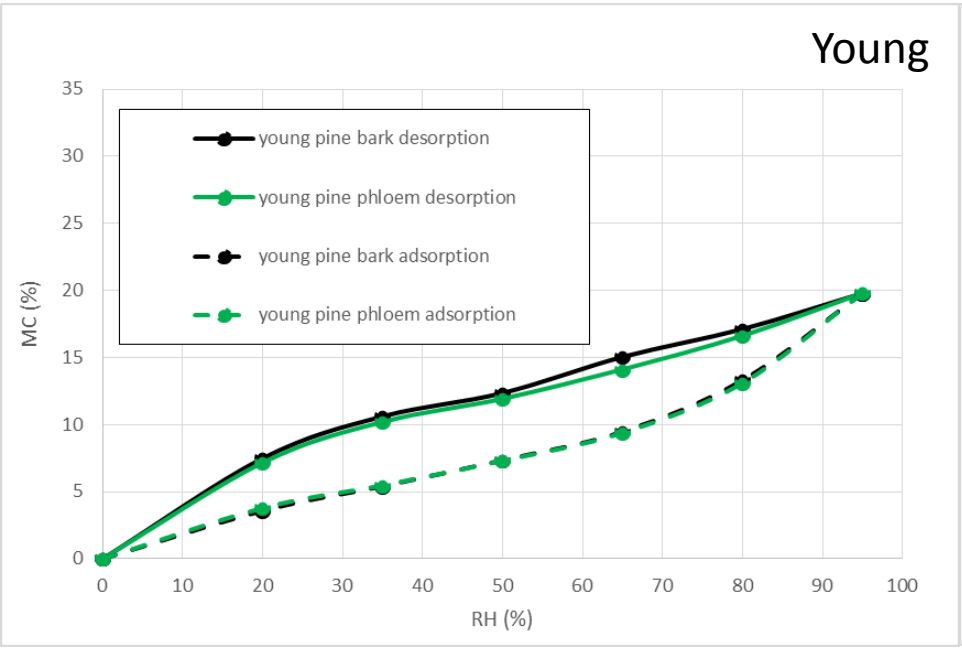


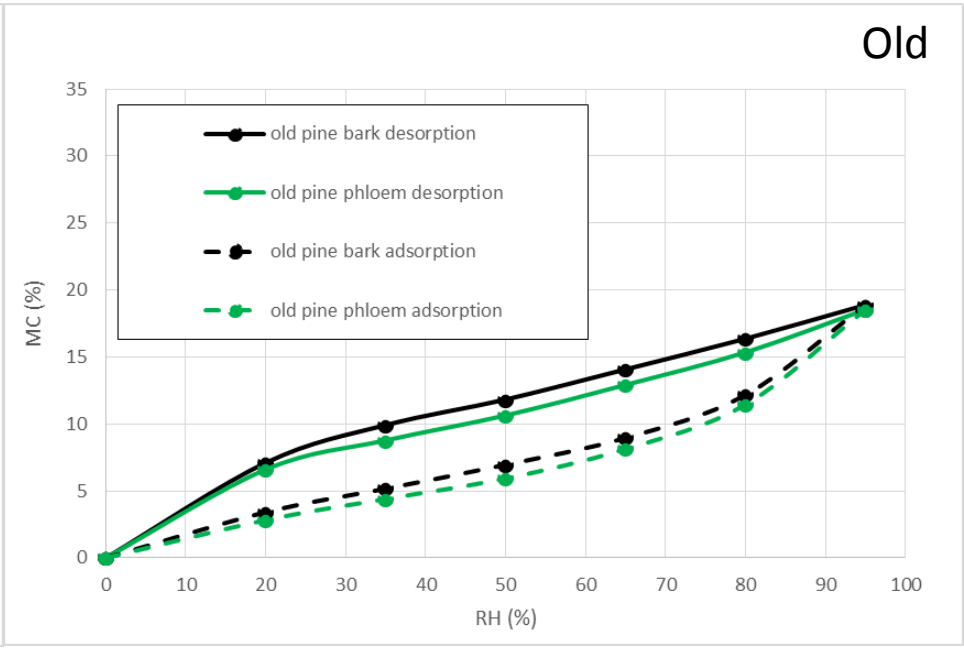


- Lower EMC-s in general, especially at higher RH ranges
- Similar behaviour after 180° HT → Only slight differences between bark and phloem
- Larger hysteresis compared to the untreated

Results

- Pine hysteresis (200°C)

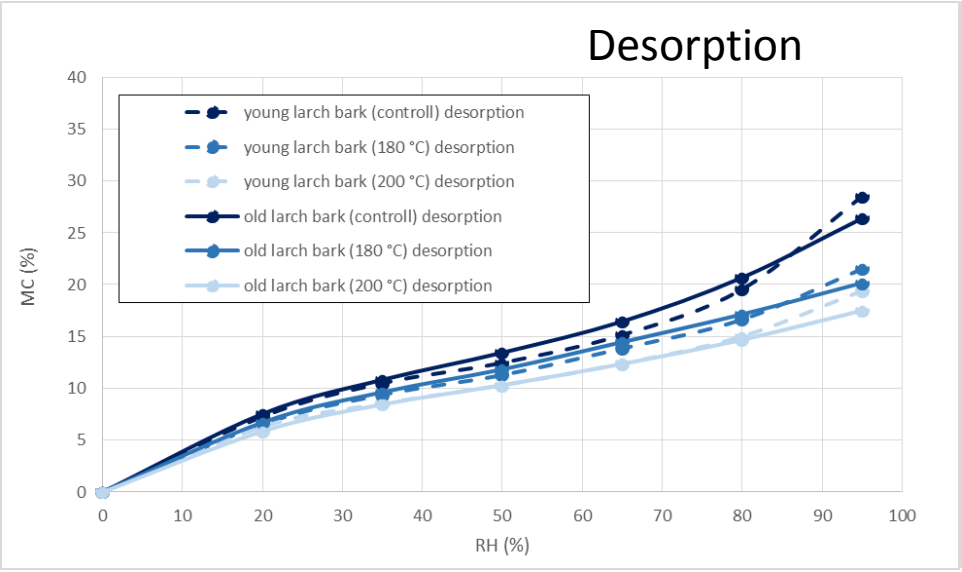


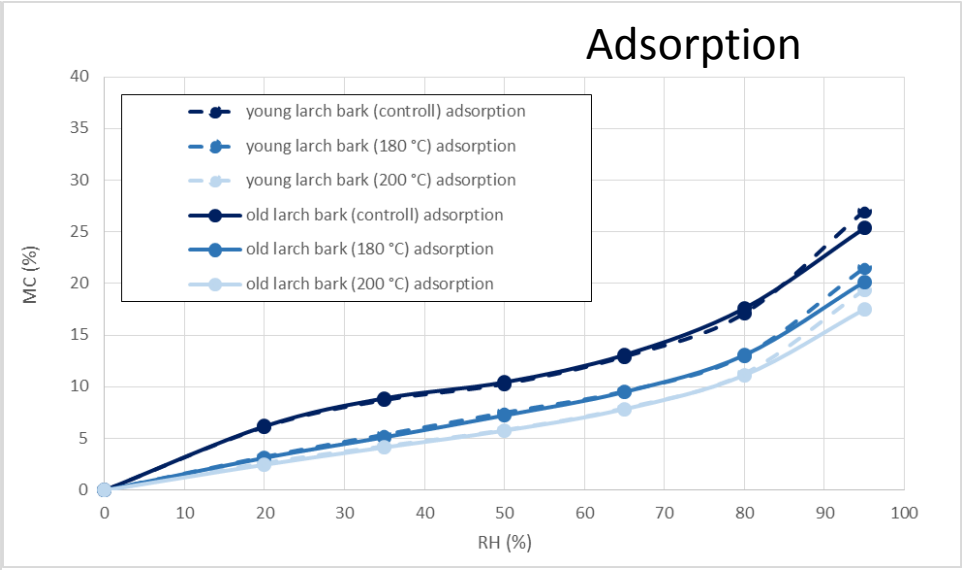


- Lowest EMC-s in general
- No significant differences between young and old
- Differences between the sorption behaviour of bark and phloem were diminished after 200° HT

Results

- Larch bark desorption and adsorption

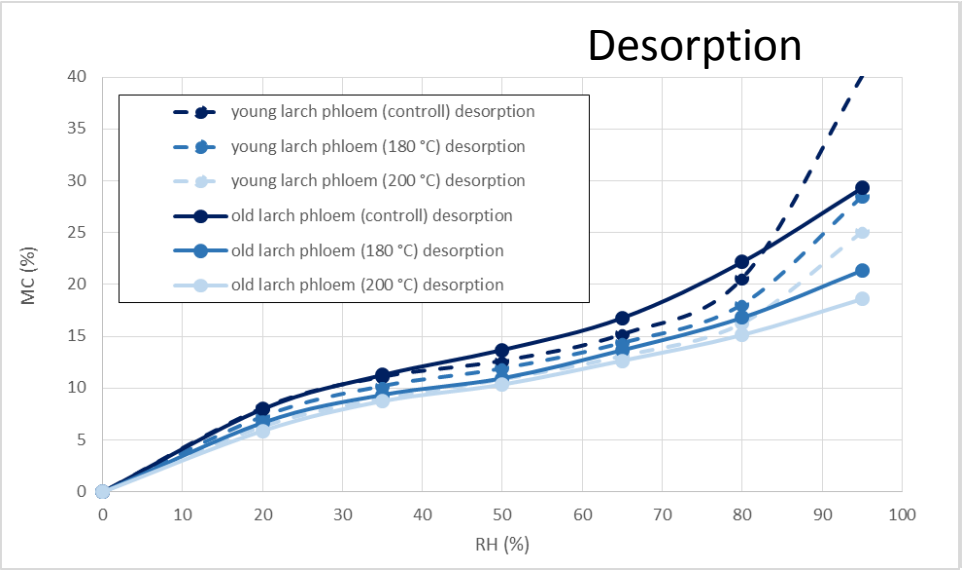


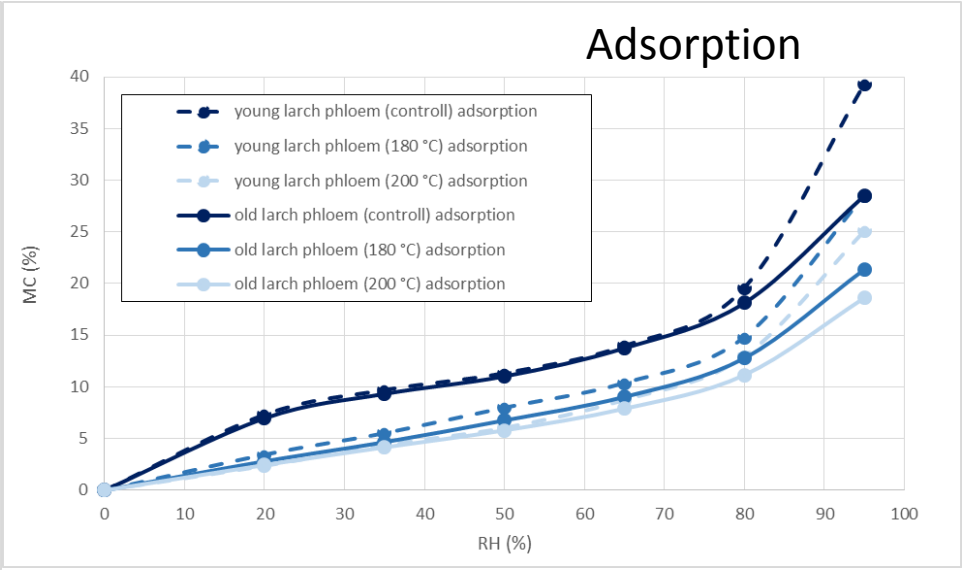


- Different EMC-s near the FSP between young and old bark
- Clear effect of HT temperature

Results

- Larch phloem desorption and adsorption

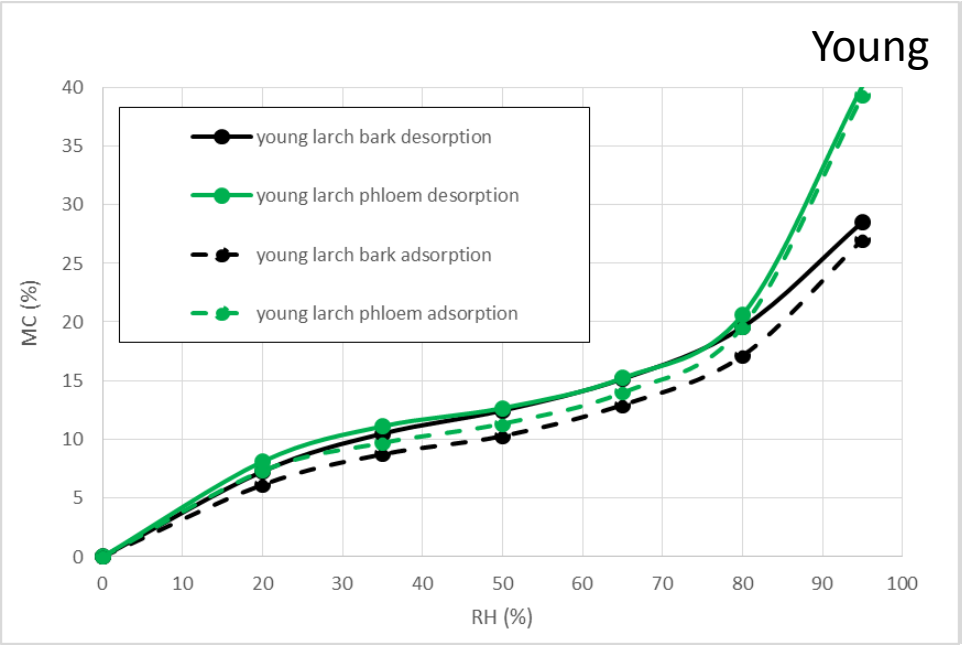


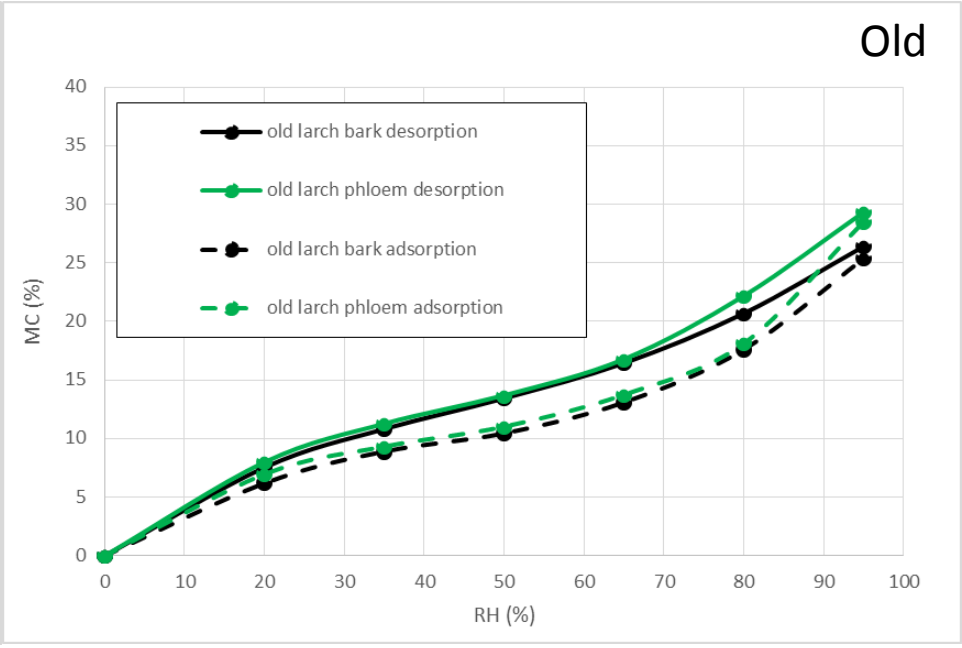


- Different EMC-s near the FSP between young and old phloem as well
- Clear effect of HT temperature

Results

- Larch hysteresis



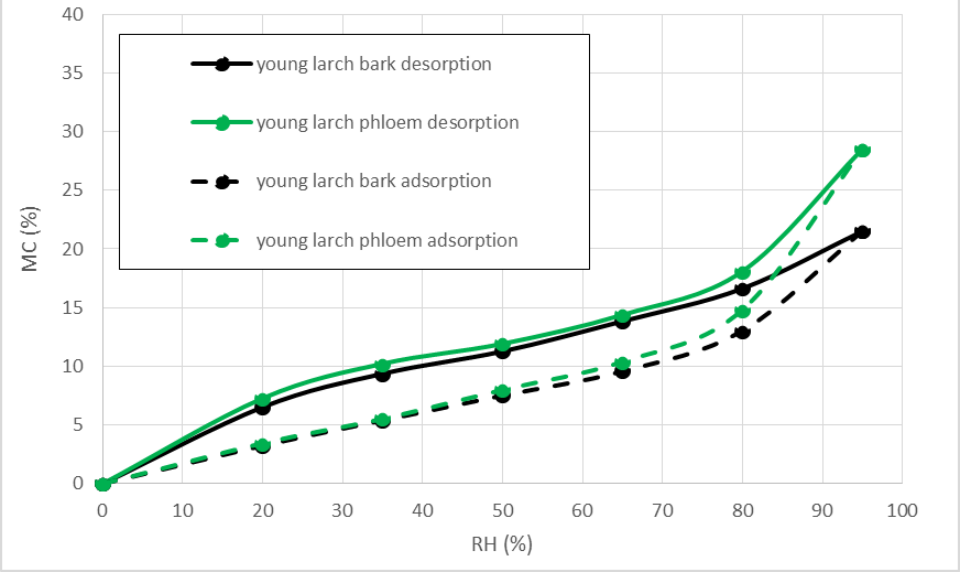


- Only slight differences between the sorption behaviour of bark and phloem and only at higher RH ranges
- Very small hysteresis in case of young bark and phloem

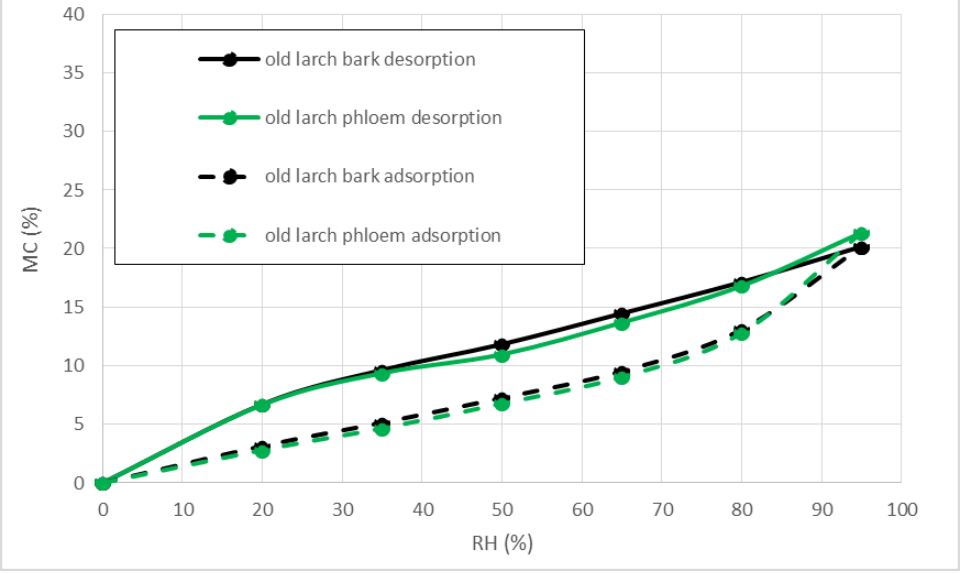
Results

- Larch hysteresis (180°C)

Young



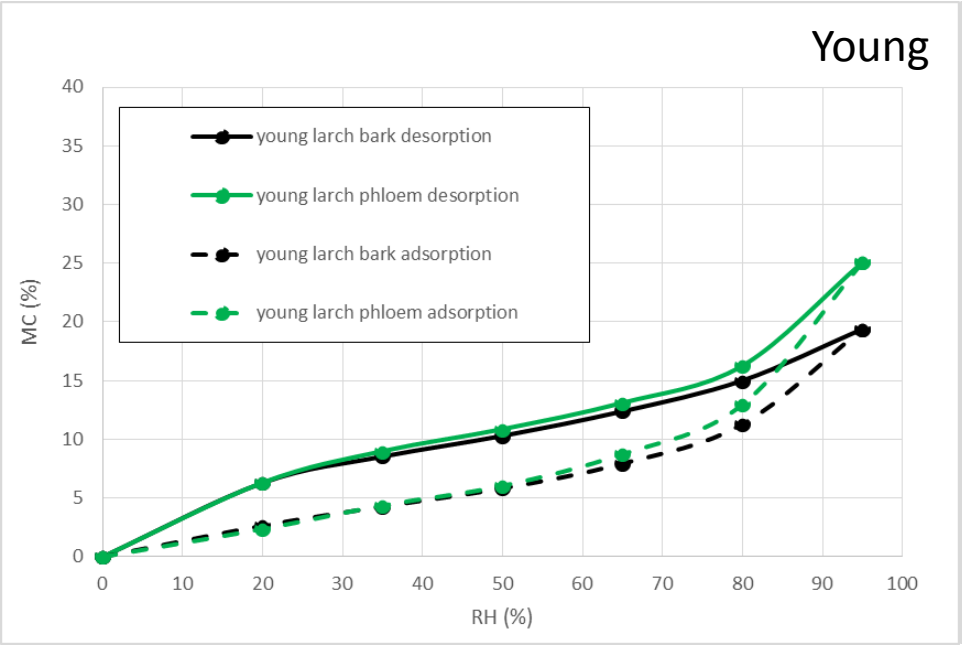
Old

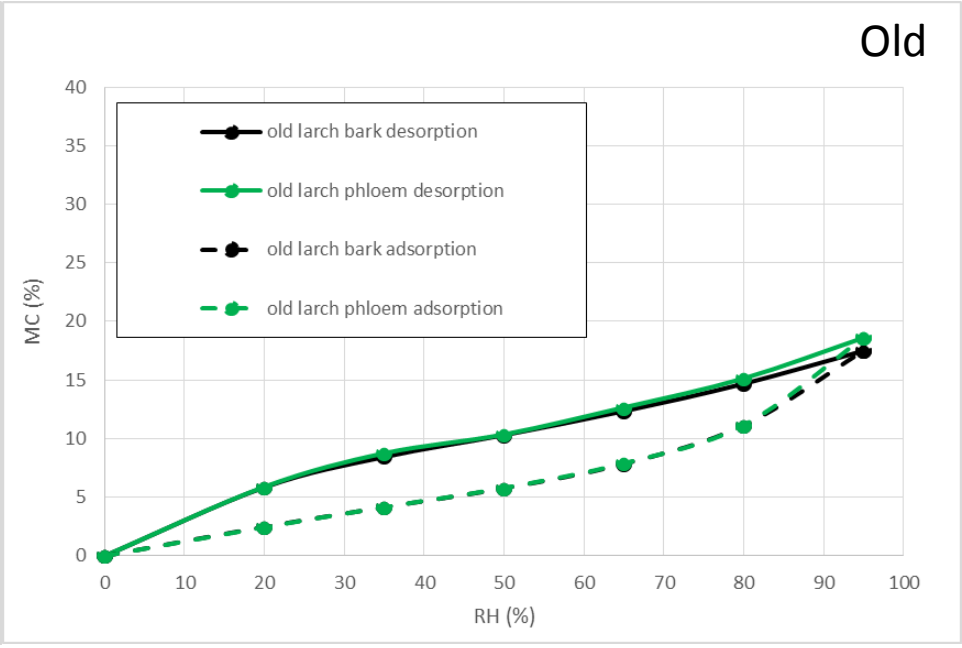


- Lower EMC-s in general, especially at higher RH ranges
- Similar behaviour after 180° HT → Only slight differences between bark and phloem, excepting the higher RH ranges with large differences
- Larger hysteresis compared to the untreated

Results

- Larch hysteresis (200°C)





- Lowest EMC-s in general
- Significant differences between young and old only near the FSP
- Differences between the sorption behaviour of bark and phloem were diminished after 200° HT, significant differences only between young bark and phloem near the FSP

Conclusions

- The effect of species is very strong on the sorption behaviour
- Differences in sorption behaviour between bark and phloem are depending on wood species
- Differences between old and young bark or phloem are also strongly dependent on the species
- In general, EMC-s of young and old bark or phloem are similar, or young parts have higher EMC-s → exception is e.g. oak
- Sorption behaviour near the FSP is often different compared to lower MC-s → trends turn to the opposit in this range between young/old or bark/phloem

Conclusions

- Effect of heat treatment is very clear, as EMC-s at all RH ranges decreased
- Effect of the treatment temperature is in most cases clear, as 200°C treatment resulted in the lowest EMC-s at all RH ranges
- EMC decreased the most at higher RH ranges (>80%) as a result of heat treatment
- Hysteresis increased as a result of heat treatment in all cases → this result is the opposit as known from the literature for wood material

Conclusions

- Very inhomogeneous material in terms of sorption
- Different structures, cell types and chemical composition
- Use as a mixture of different species in an insulation board should be avoided
- A lot of other questions to be cleared: diffusion properties, heat insulation/conductivity, glueability, etc.

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Thank you for your attention!