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Improving the mechanical properties of thermally modified wood by a prior chemical treatment

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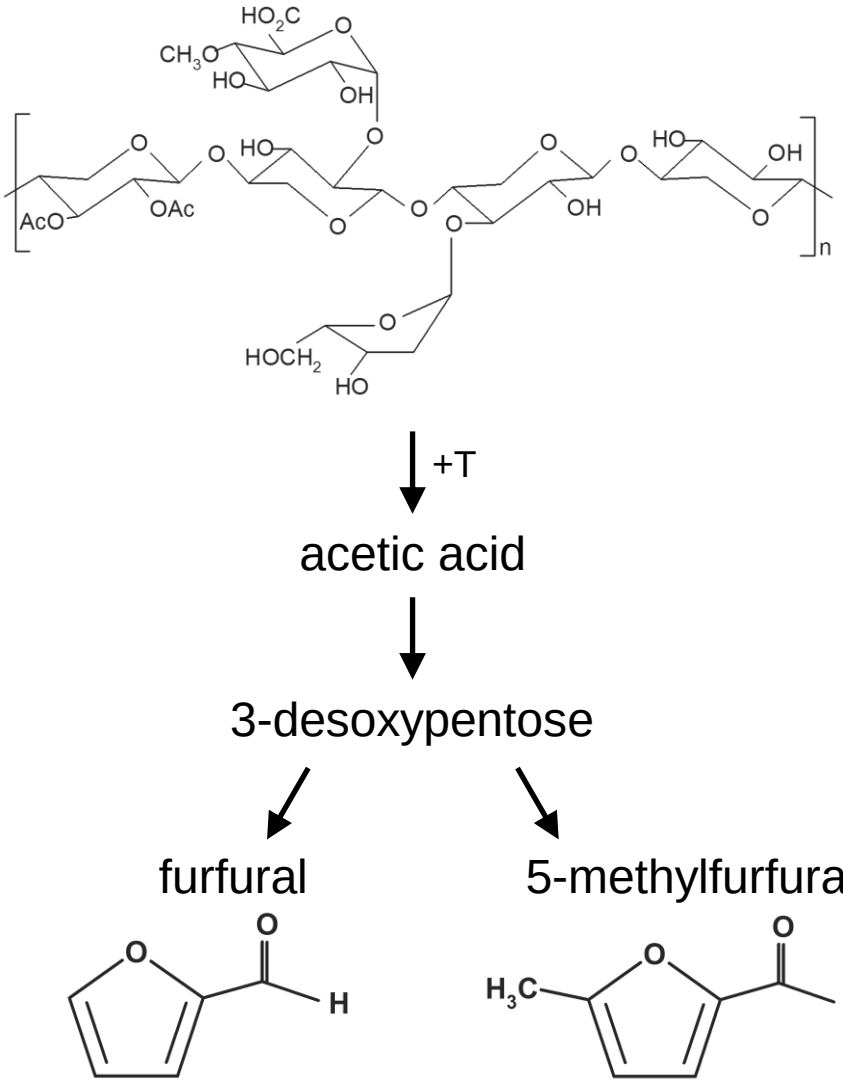
BACKGROUND AND OBJECTIVE

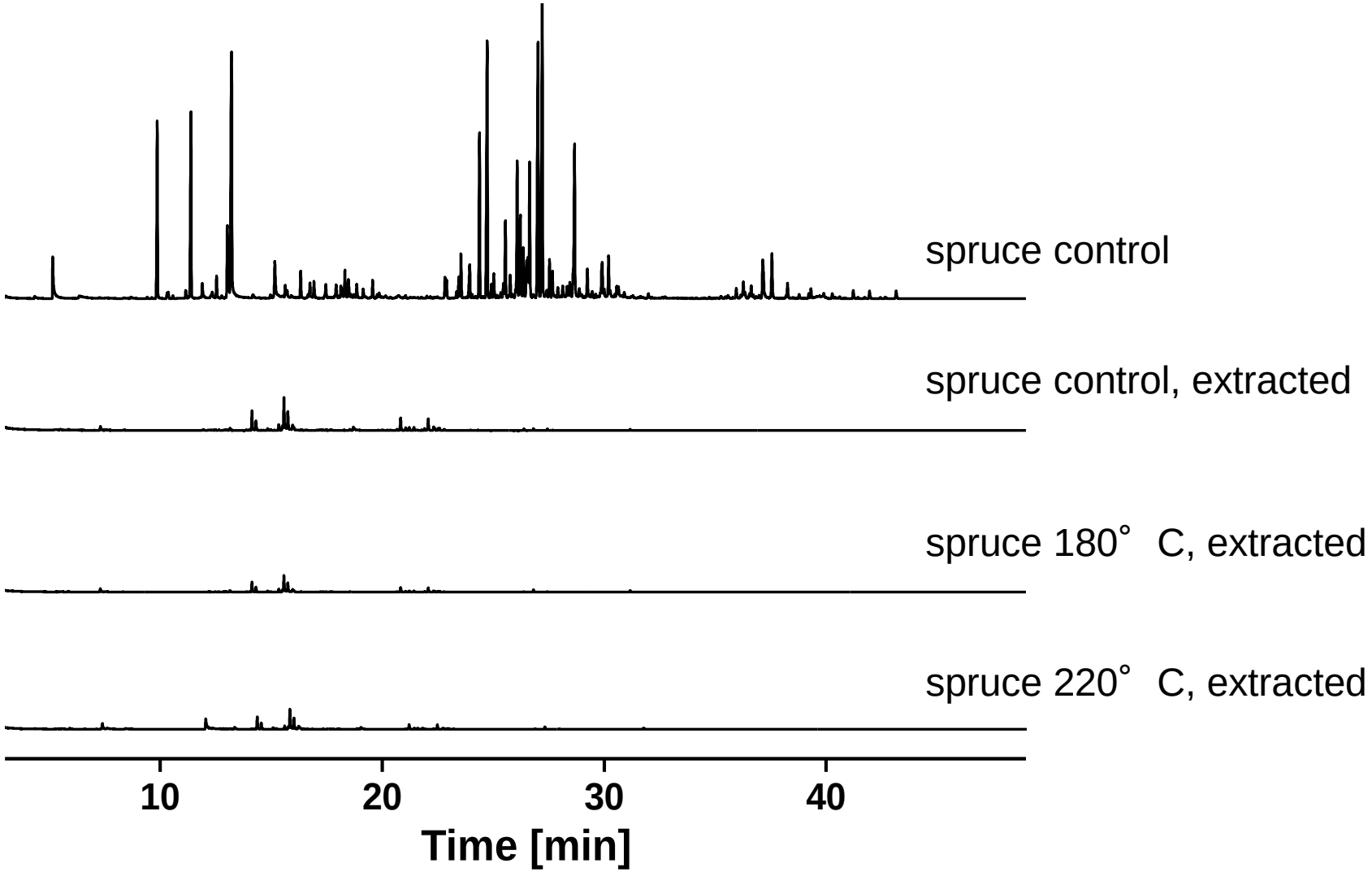
BACKGROUND

- Modification at temperatures in the range of **160 to 240° C** in **reduced oxygen atmosphere** provoke a permanent change in substantial wood properties over the whole profile
- Modification duration and temperature determine the degree of change

THERMAL MODIFICATION



GC/MS ANALYSES OF EMISSIONS FROM SPRUCE BEFORE AND AFTER EXTRACTION



OBJECTIVE OF THIS PROJECT

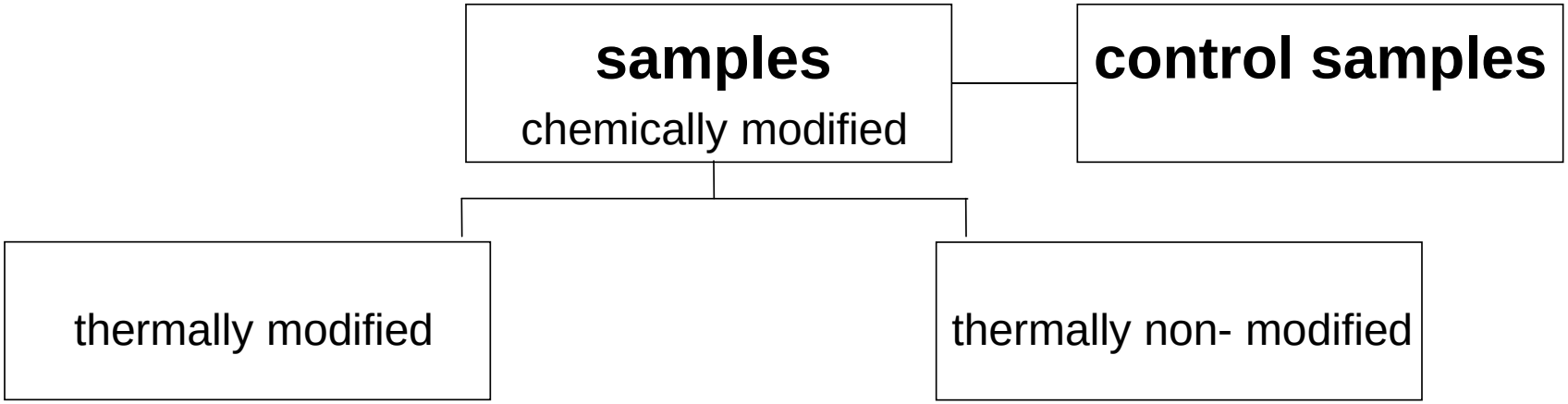
Elimination of hazardous emissions of thermally modified wood by chemical impregnation prior to the thermal treatment with **improvement** of positive characteristics and **minimization** of negative impacts at the same time.

EXPERIMENTAL SET-UP

SAMPLES

- heartwood (*Acer spec.)*
- dimensions:
  140 mm (longitudinal) * 10 mm (radial) * 10 mm (tangential)
- chemicals:
  urea (1; 0.5; 0.25 M)

EXPERIMENTAL SET-UP



- FT-IR spectroscopy
- Raman spectroscopy
- HS-SPME GC/MS
- three- point bending test
- raw and kiln- dried density
- Anti- Swelling- Efficiency

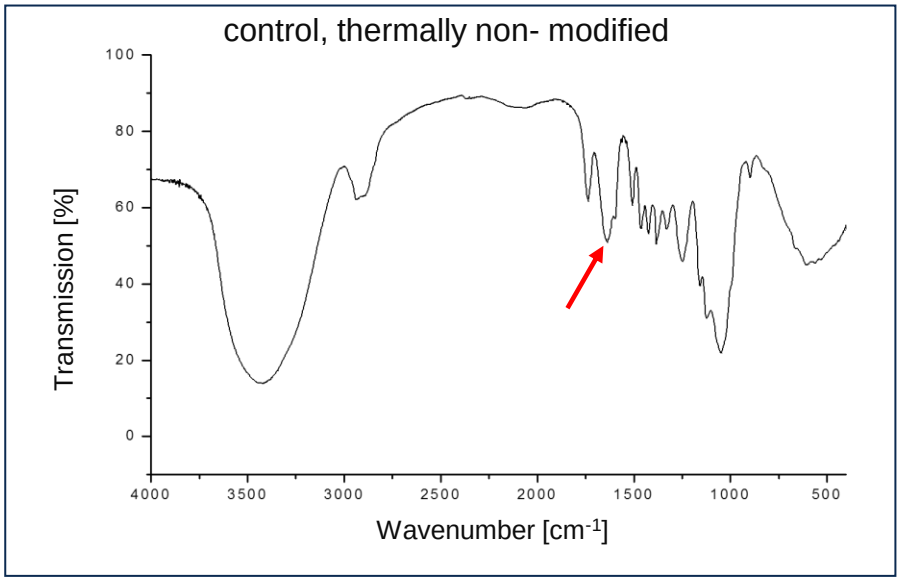
- FT-IR spectroscopy
- Raman spectroscopy
- HS-SPME GC/MS
- raw and kiln- dried density

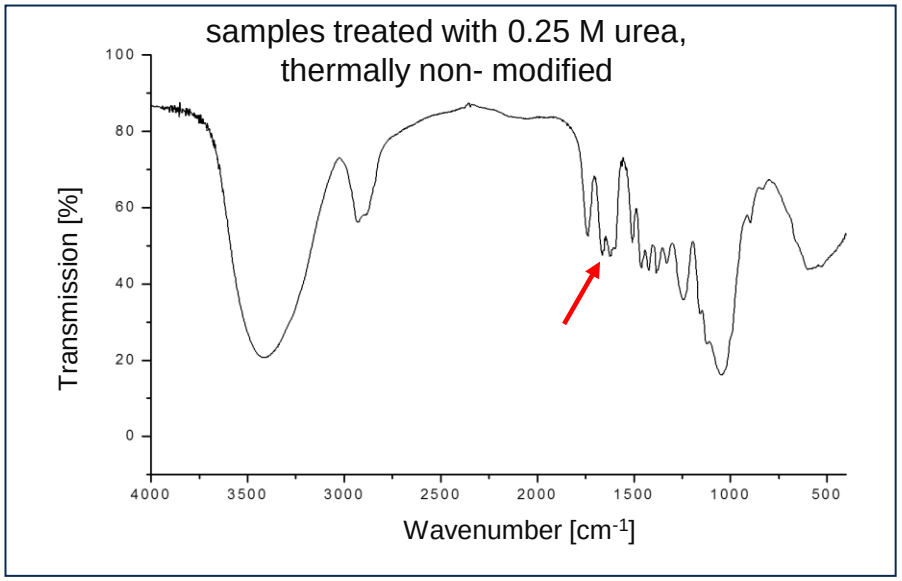
METHODS AND RESULTS

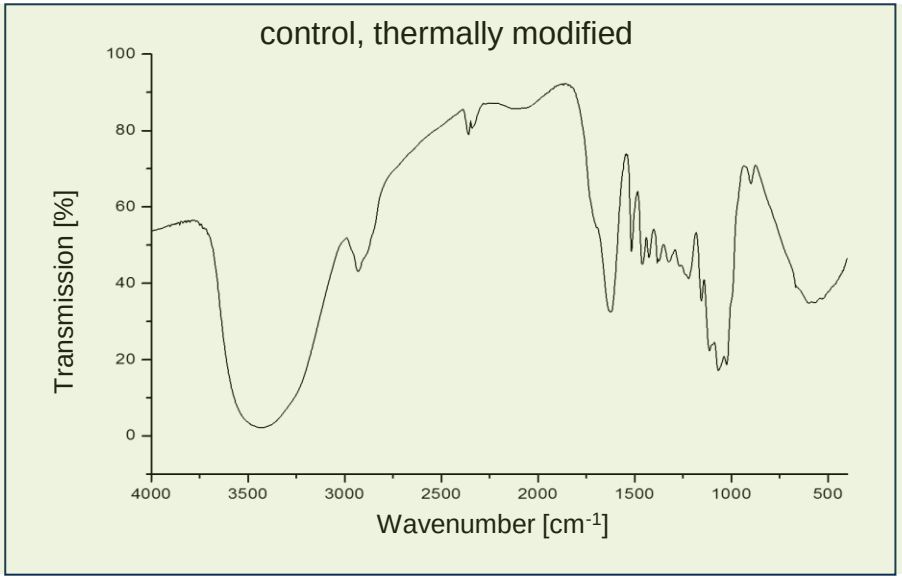
FT-IR- AND RAMAN-SPECTROSCOPY

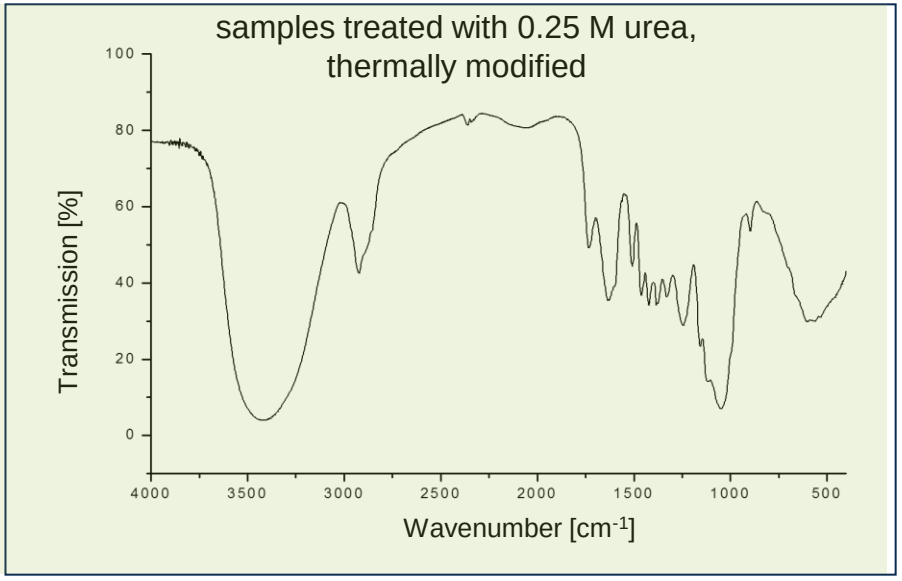
- Raman- and FT-IR spectroscopy for complementary determination of changed vibrations in wood due to chemical and thermal modification

FT-IR-SPECTROSCOPY

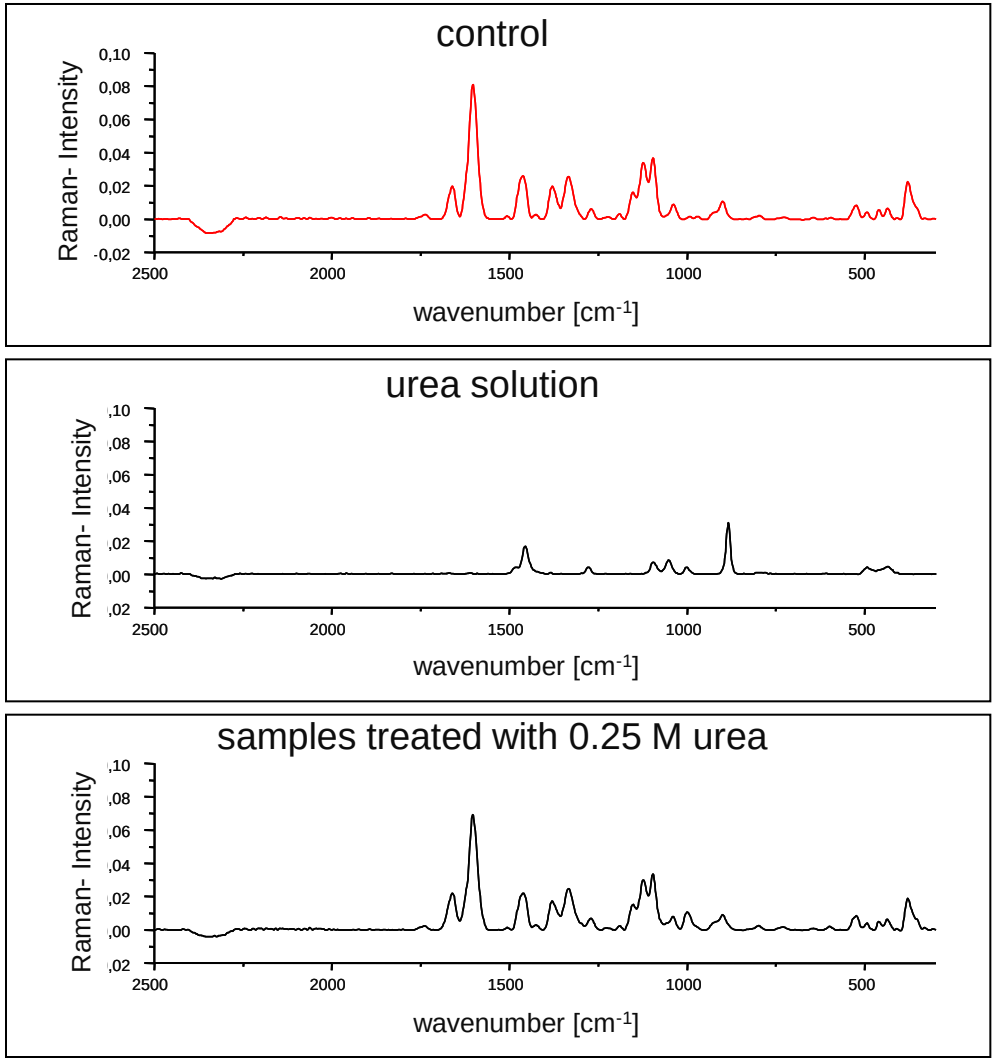








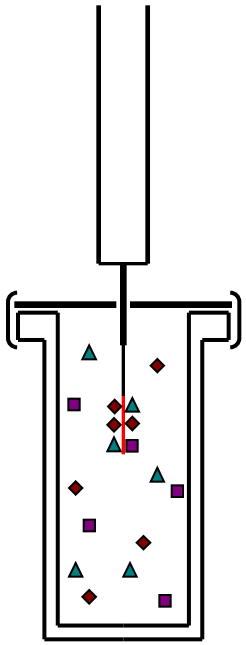
RAMAN- SPECTROSCOPY



HS-SPME GC/MS (Headspace gas chromatography/ mass spectrometry, combined with solid-phase microextraction)

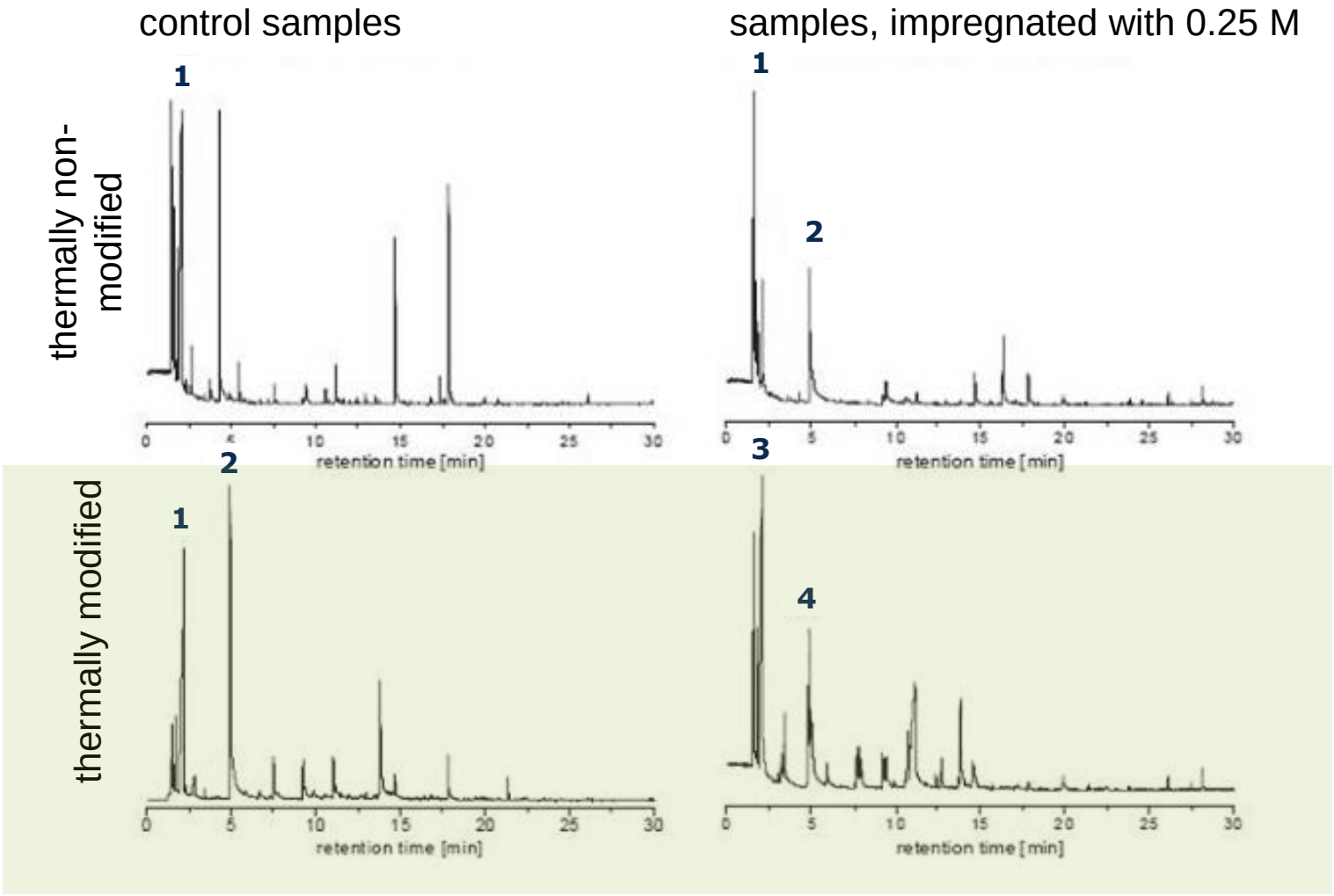
Isolation and characterisation of odorous and volatile emissions from chemically and thermally modified wood with GC/MS

- enrichment of volatiles by ***solid-phase microextraction (SPME)***
- conditions for enrichment:
  elevated temperature (70° C) over a defined period (1h)
- analysis by GC/MS:
  identification of substances by analysis of individual mass spectra and comparison with library or reference substances



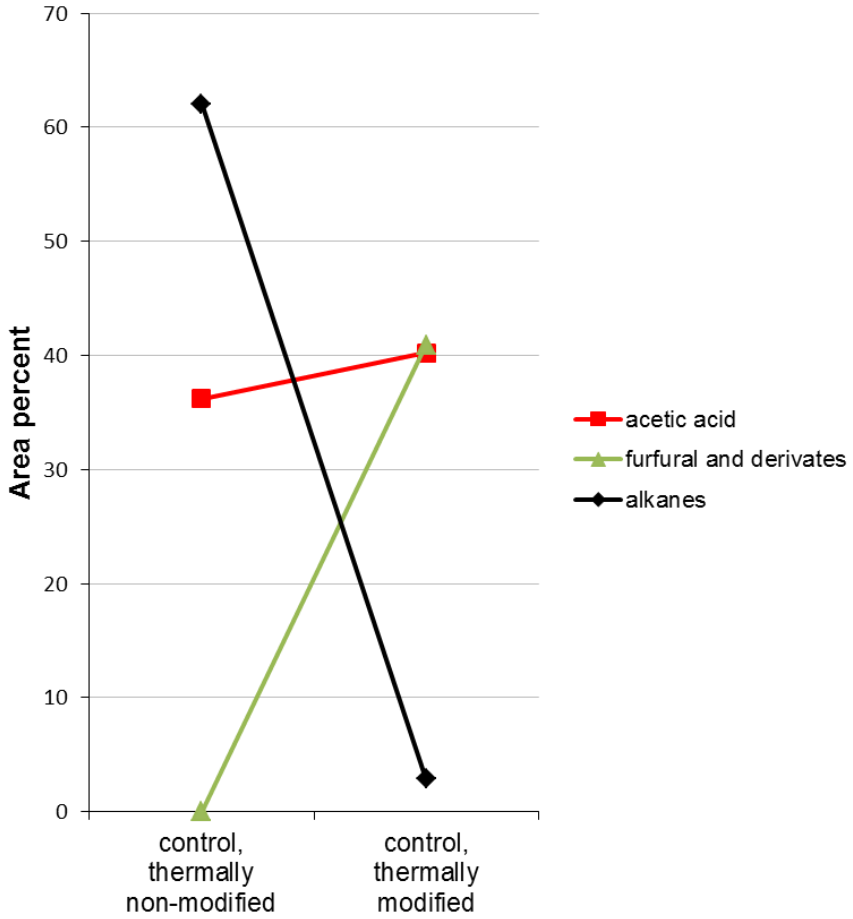
Sampling with SPME

SPME-GC/MS

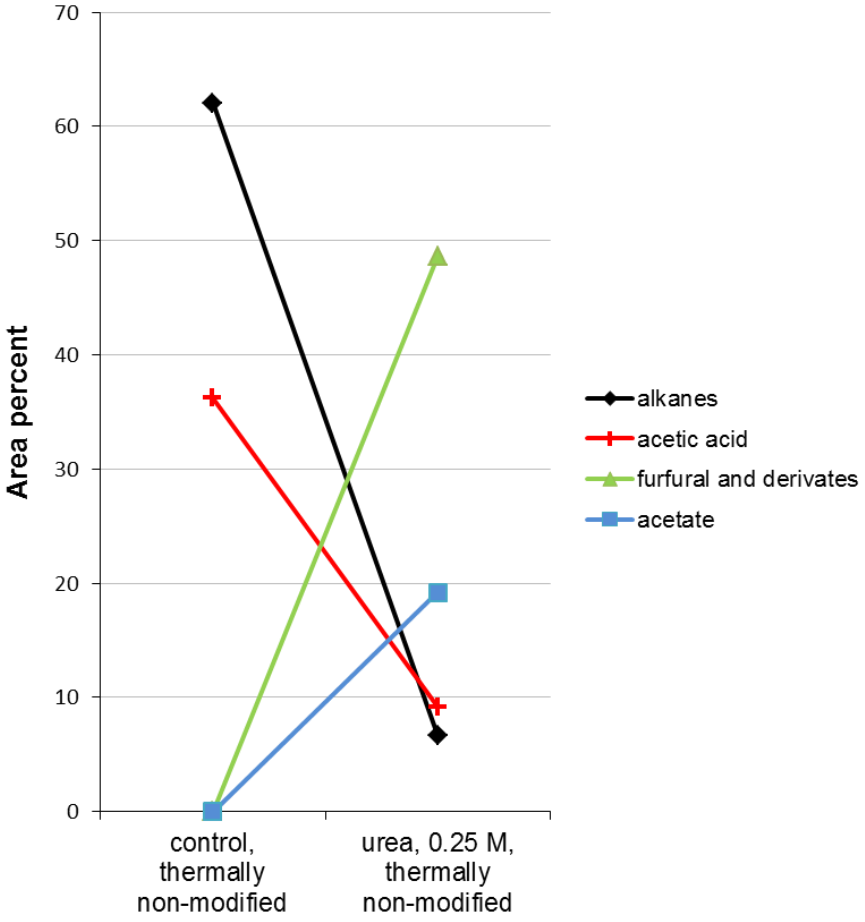


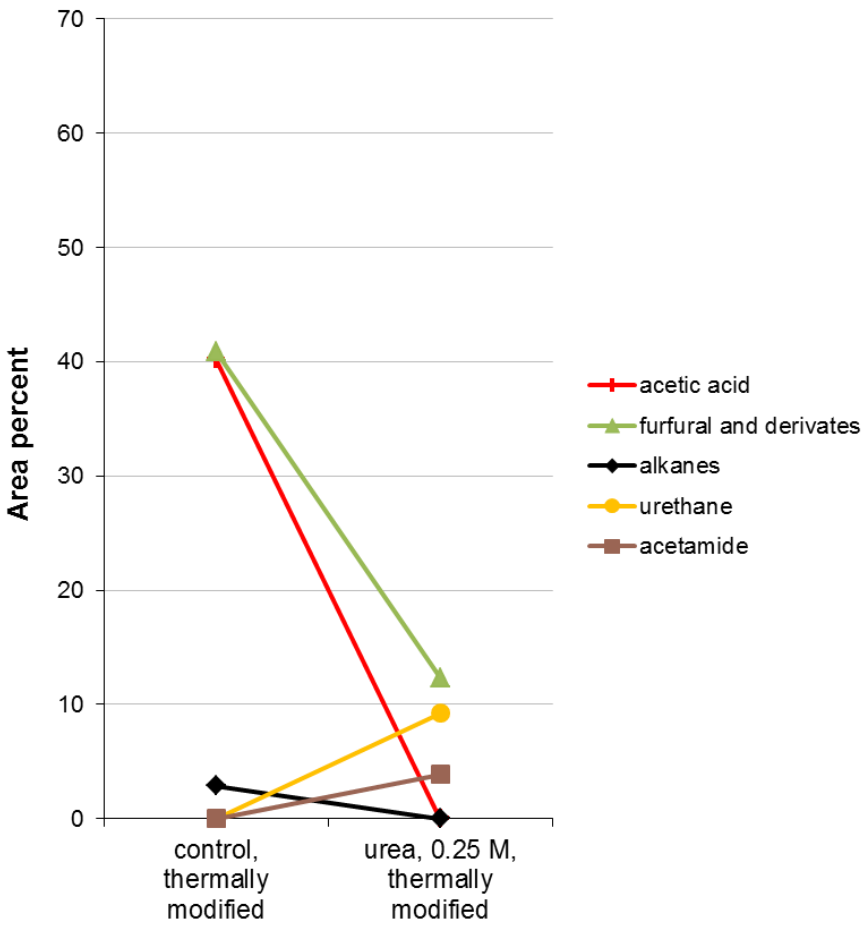
1: acetic acid, 2: furfural, 3: ethyl acetate, 4: urethane

SPME-GC/MS

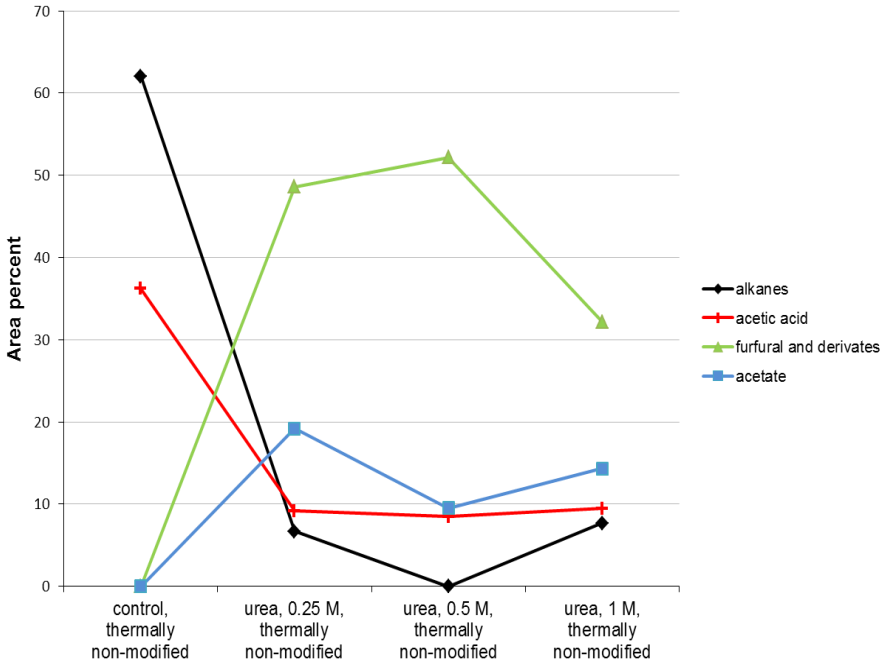

70
60
50
40
30
20
10
0
Area percent
control, thermally non-modified
control, thermally modified
acetic acid
furfural and derivates
alkanes

SPME-GC/MS


70
60
50
40
30
20
10
0
Area percent
control, thermally non-modified
urea, 0.25 M, thermally non-modified
alkanes
acetic acid
furfural and derivates
acetate


70
60
50
40
30
20
10
0
Area percent
control, thermally modified
urea, 0.25 M, thermally modified
acetic acid
furfural and derivates
alkanes
urethane
acetamide

SPME-GC/MS


Area percent
70
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30
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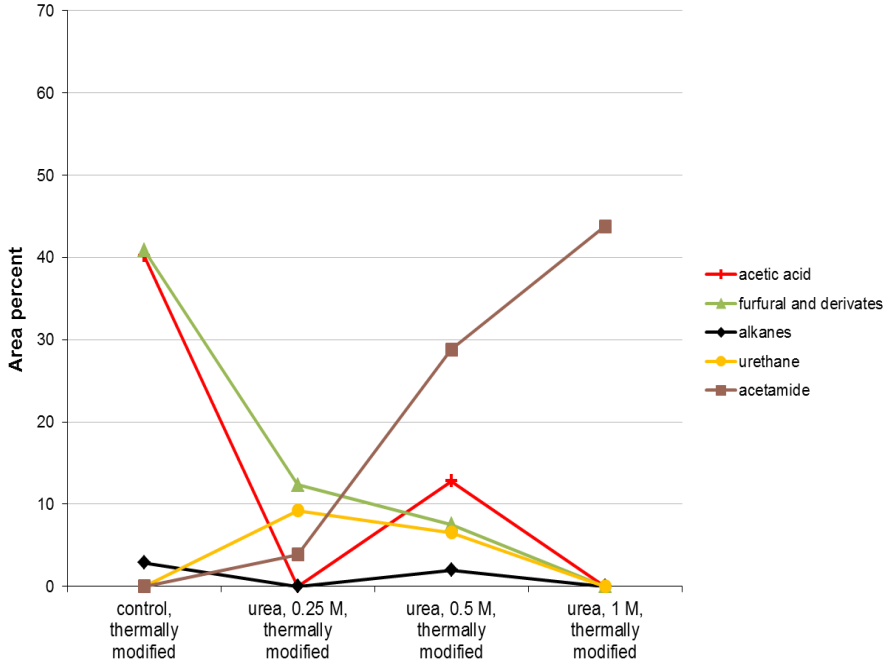
0
control, thermally non-modified
urea, 0.25 M, thermally non-modified
urea, 0.5 M, thermally non-modified
urea, 1 M, thermally non-modified
alkanes
acetic acid
furfural and derivates
acetate


Area percent
70
60
50
40
30
20
10
0
control, thermally modified
urea, 0.25 M, thermally modified
urea, 0.5 M, thermally modified
urea, 1 M, thermally modified
acetic acid
furfural and derivates
alkanes
urethane
acetamide

FLEXURAL MODULUS OF ELASTICITY

Characterization of changes in strength properties due to chemical impregnation and thermal modification

- three- point bending test according to DIN 52186
- samples are conditioned under standard atmosphere
- annual rings are arranged vertically towards application of force

→ *flexural modulus of elasticity* f_m [N/mm²]

FLEXURAL MODULUS OF ELASTICITY

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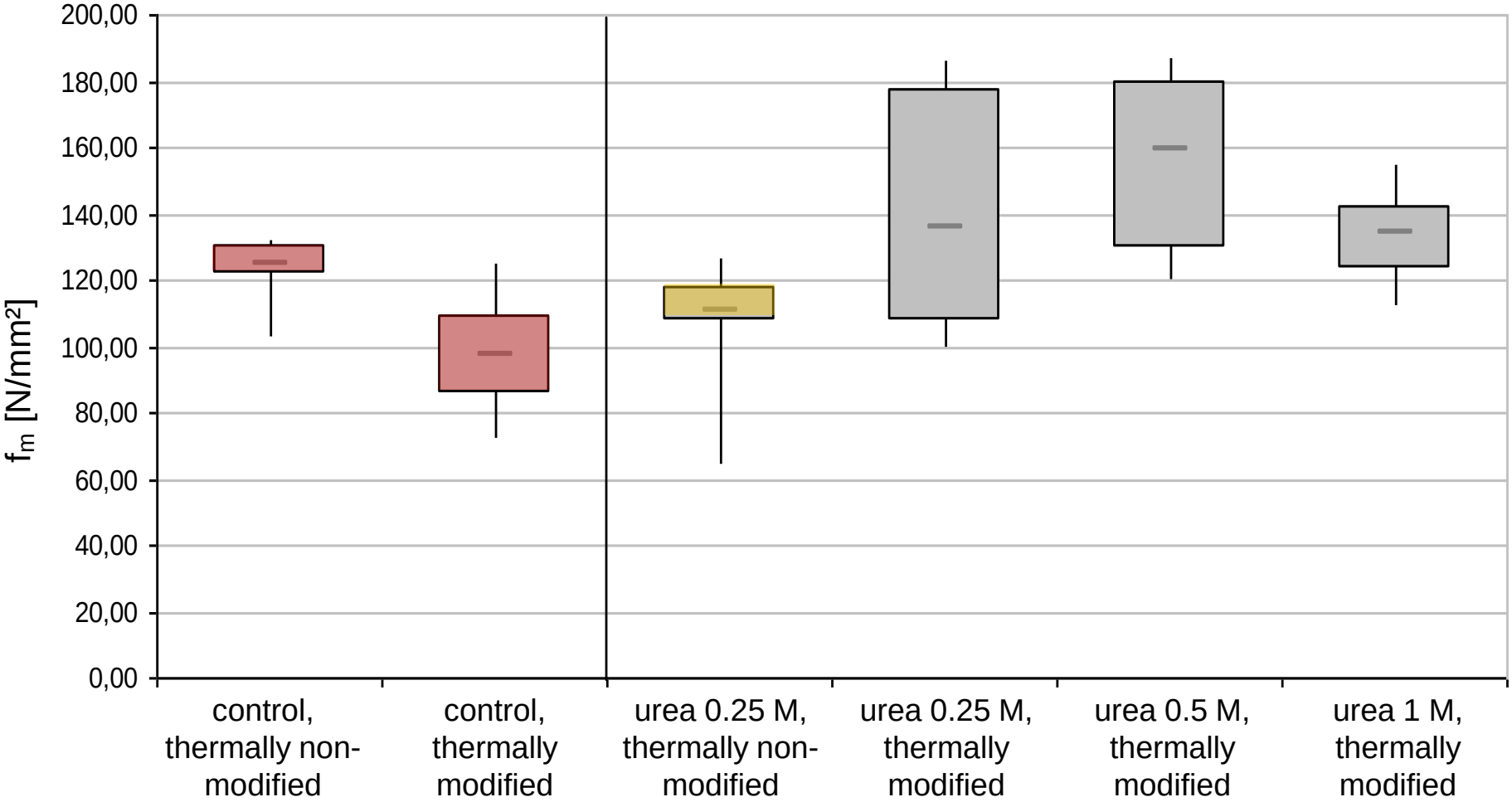


DIMENSIONAL STABILITY

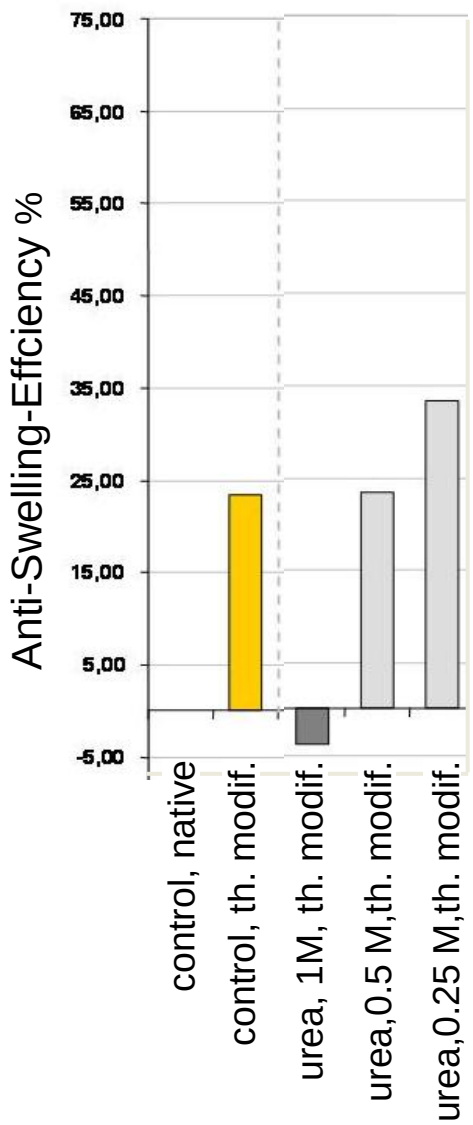
Determination of changes in dimensional stability due to chemical and thermal modification

$$ASE\% = [(S_u - S) / S_u] * 100 (\%)$$

S – change of volume; chemically and thermally modified

S_u – change of volume; reference, thermally non- modified

DIMENSIONAL STABILITY



CONCLUSION

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- Best sensoric effects have been obtained by impregnating samples with a **0.25 M urea** solution.
- Changes in chemical structure due to the impregnation with urea could be verified by SPME-GC/MS, FT-IR-, and Raman- spectroscopy.
- Raman- spectroscopy has not been successfully conducted on thermally modified samples; absorbence has been too strong.
- The application of a **0.25 M urea** solution prior to thermal modification results in an increased flexural modulus of elasticity and an improved dimensional stability.

Thank you for your attention!

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