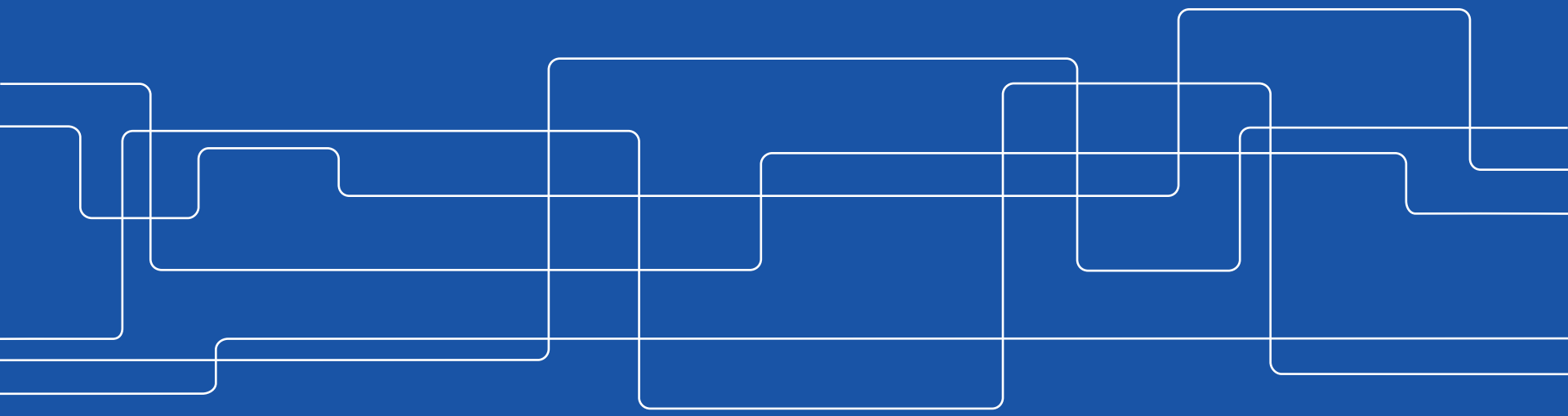
STSM
Water vapour sorption characteristics of thermally modified Norway spruce particles

Susanna Källbom, Michael Altgen, Kristoffer Segerholm, Dennis Jones, Holger Militz and Magnus Wålinder



COST FP1303 workshop in Sofia, Bulgaria, Feb 28 – March 1, 2017

INTRODUCTION

INTRODUCTION

Wood residuals

Modified wood

Thermal modification

Improved properties

New bio-based building materials

INTRODUCTION

Thermal modification process →

- Changed properties: *e.g.* hygroscopicity, dimensional stability
- Changes → loss of dry weight (degradation of amorphous carbohydrates)
- Depending on process technology and process conditions …

INTRODUCTION

Open reactor system

- Temperature and duration
- Low RH conditions, emissions of organic compounds
- Thermal modification at very low MC

Closed reactor system

- Process conditions at higher RH using water vapour pressure
- Parameters: temperature, water vapour pressure and RH

INTRODUCTION

Research on thermal modification of wood particles:

- Weigl et al. (2013) performed thermal modification on wood particles to study water retention of wood particles
- Andrade et al. (2014) studied particleboards made from heat treated particles from waste material
- Medved et al. (2014) performed thermal modification on particles and tested the bending strength and MOE for particleboards from these particles

- Weigl, M., Schmidberger, C., Muller, U. (2013) Water retention of wood particles – characterization of polarity and particle size. Eur. J. Wood Prod. 71: 147-151.
- Andrade, P., Arújo, S., Vital, B. (2014) Particleboard produces with heat-treated particles from pine wood waste used for packaging. European Conference on Wood Modification 2014
- Medved, S., Humar, M., Pohleve, F. (2014) Bending strength and modulus of elasticity of particleboards made form thermally modified particles. European Conference on Wood Modification 2014

OBJECTIVES

- Modify spruce particles with thermal modification at two different conditions
- Study the water vapour sorption characteristics

METHODS

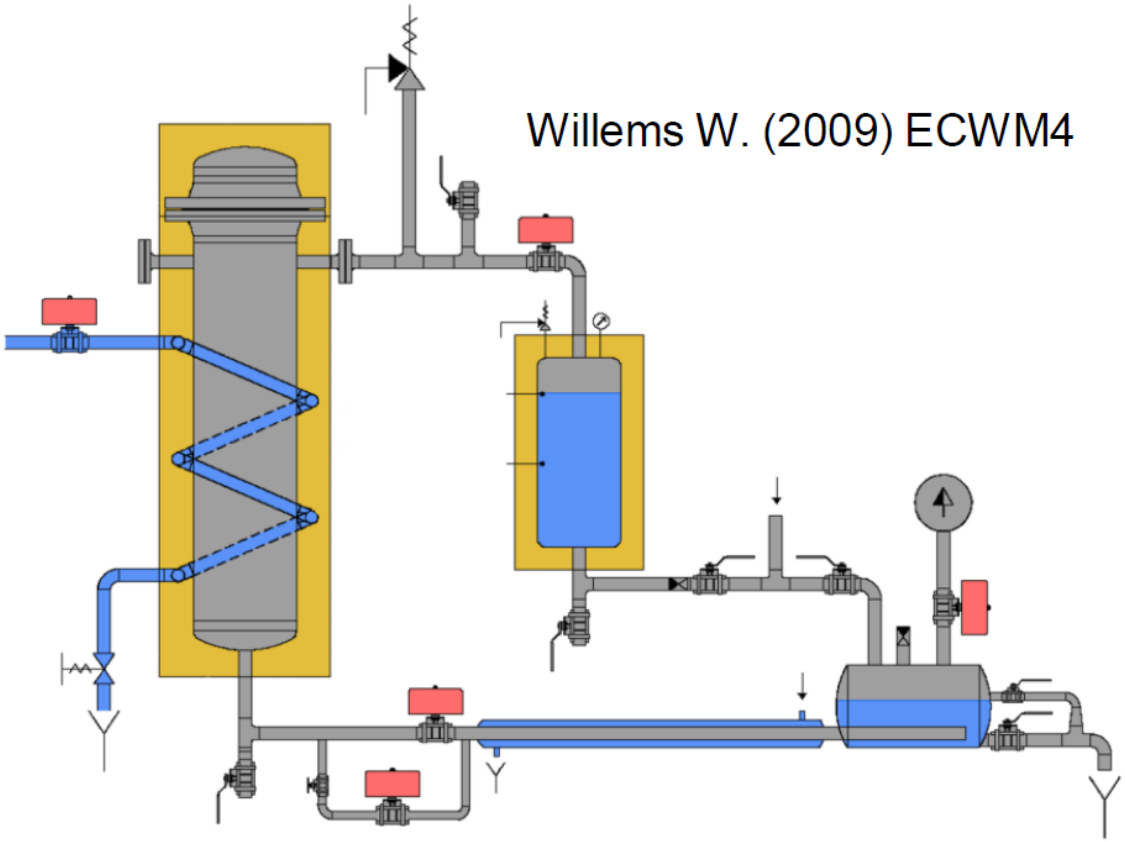
- Thermal modification using a steam-pressurised laboratory-scale treatment reactor (Willems, 2009)

- Dynamic vapour sorption (DVS)

Willems W (2009) Novel economic large-scale production technology for high-quality thermally modified wood. Proceedings of the 5th European Conference on Wood Modification, Stockholm, Sweden, pp 31–35.

METHODS

THERMAL MODFICATION



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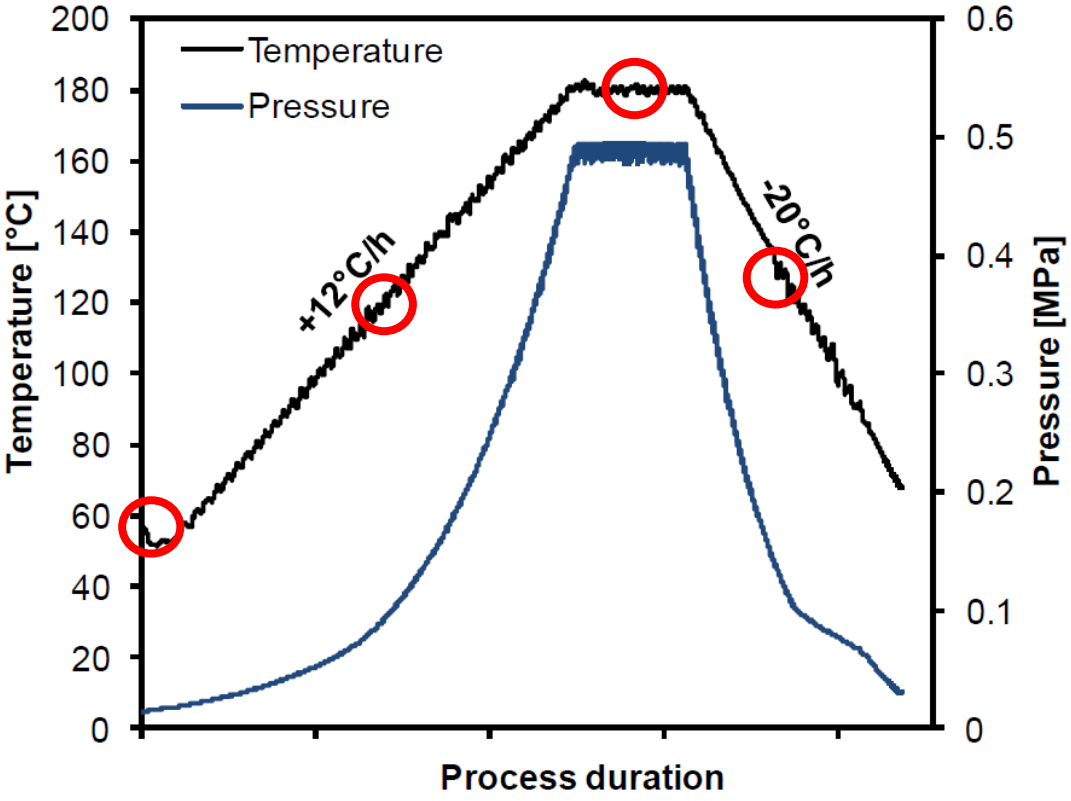
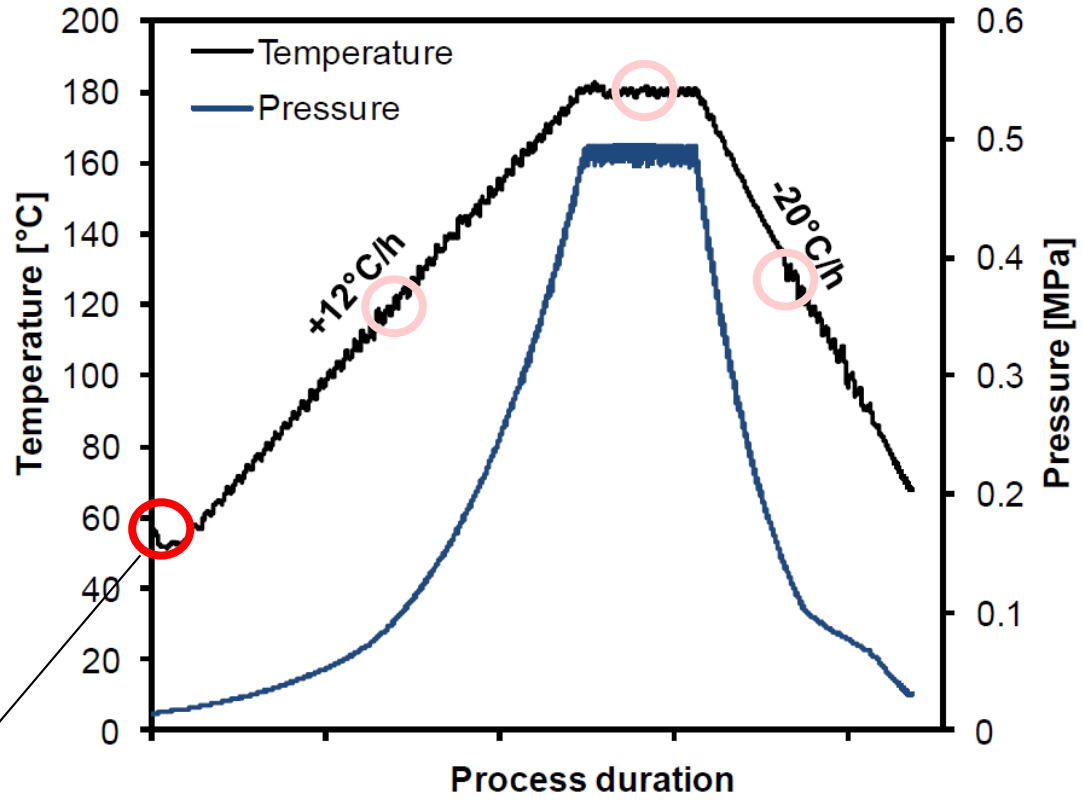
METHODS

THERMAL MODFICATION



METHODS

THERMAL MODFICATION

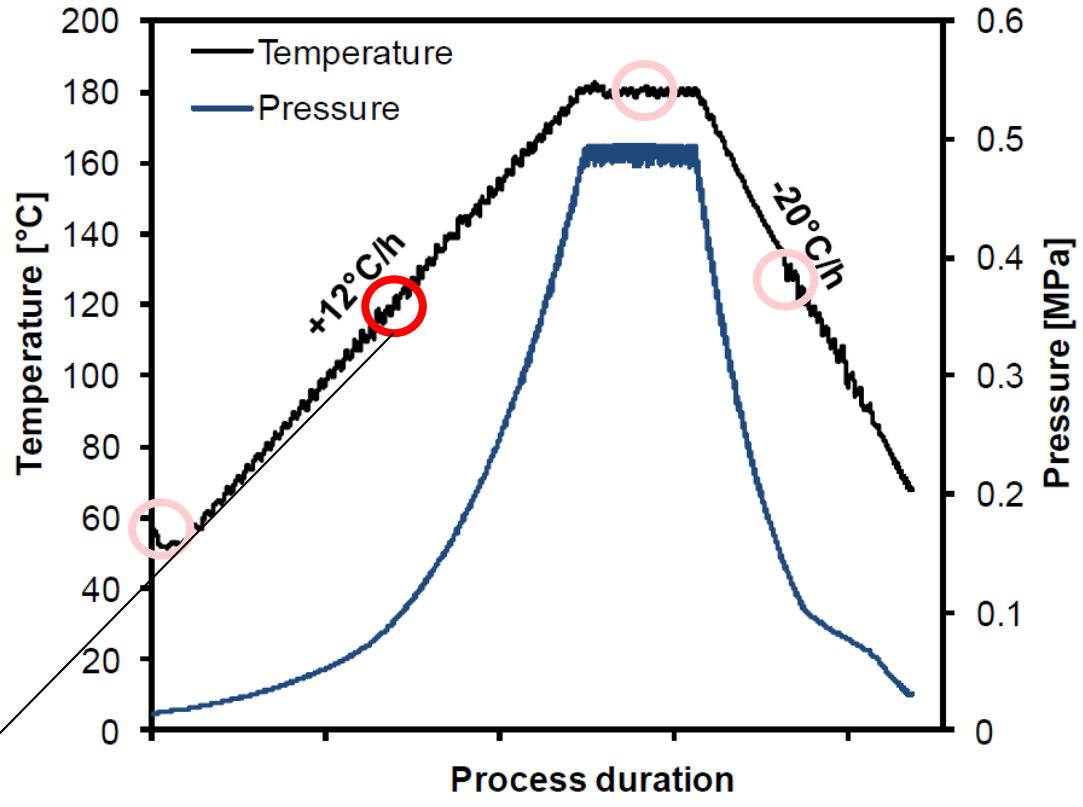


Step 1

Holding step (50 min, 50 °C)

METHODS

THERMAL MODFICATION

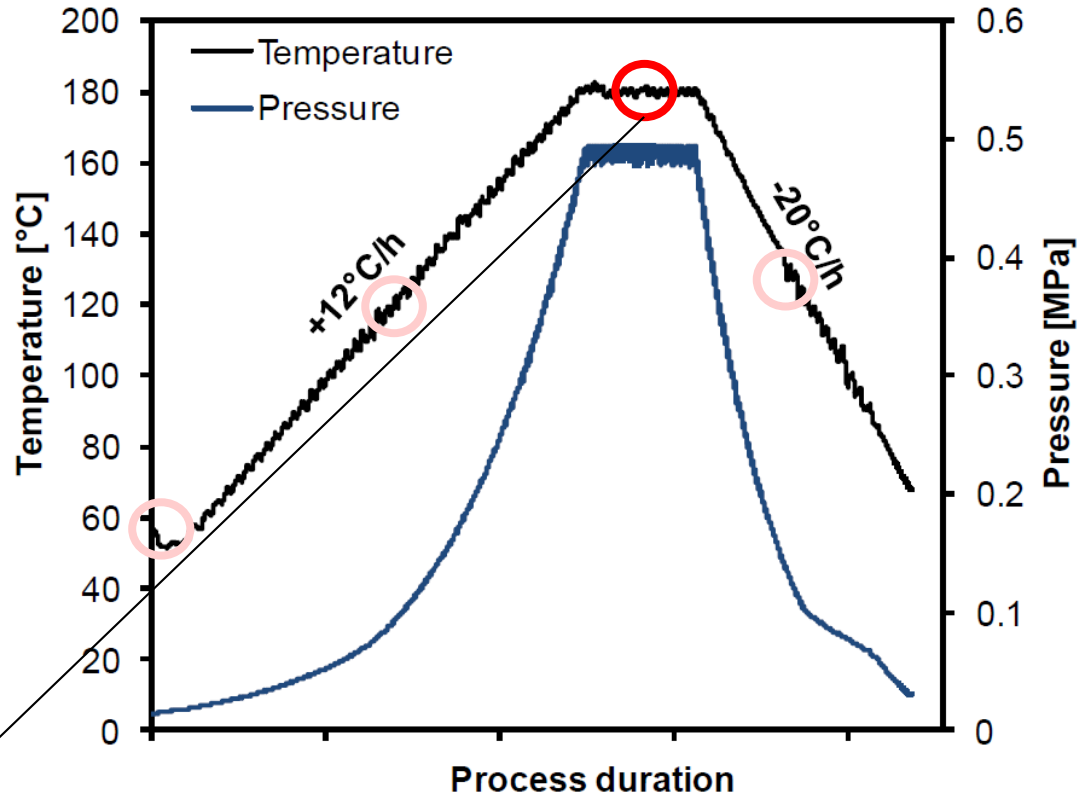


Step 2

Temperature increase 12˚C/h

METHODS

THERMAL MODFICATION

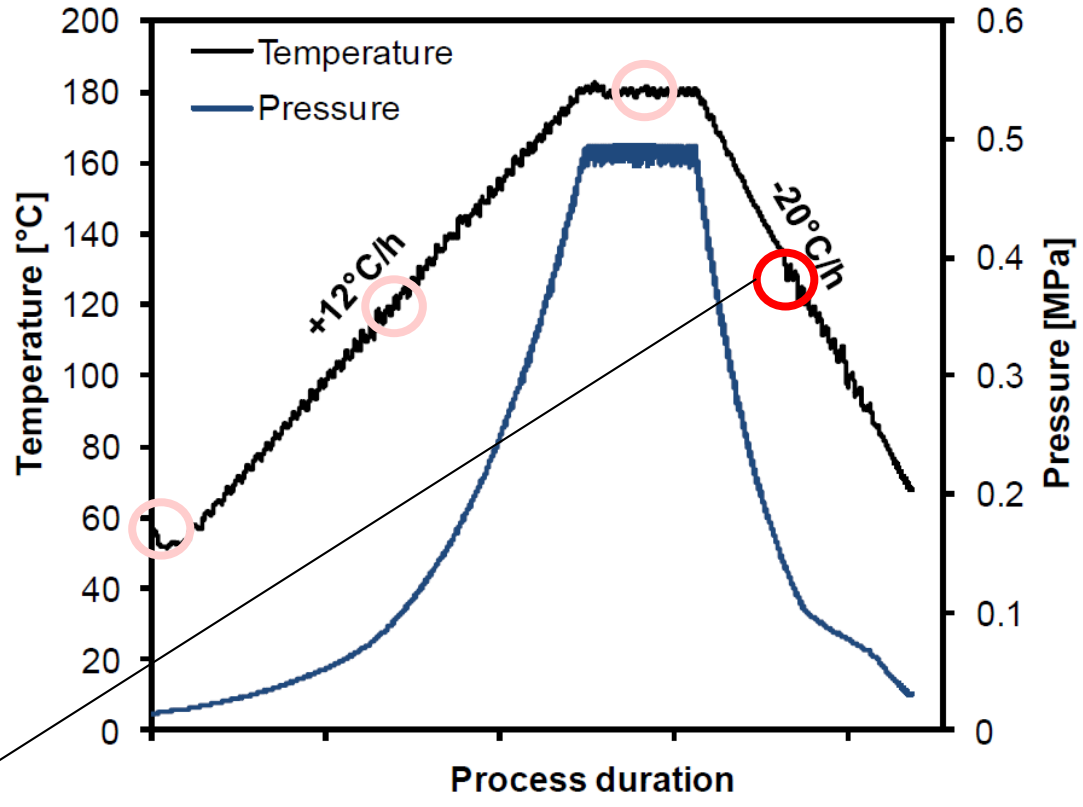


Step 3

Holding step at peak set point

METHODS

THERMAL MODFICATION



Step 4

Temperature decrease 20°C/h

METHODS

THERMAL MODFICATION

$$RH = \frac{P_{vap}}{P_{sat}(T)} \cdot 100\ \%$$

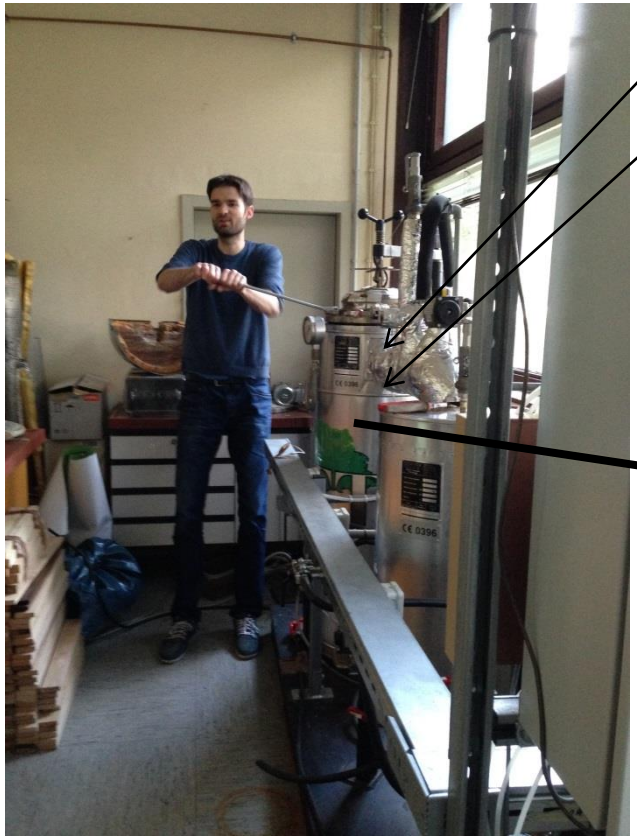
RH – Relative humidity (%)

P_{vap} - Water vapour pressure

$P_{sat}(T)$ – temperature dependent saturated water vapour pressure

METHODS

THERMAL MODFICATION



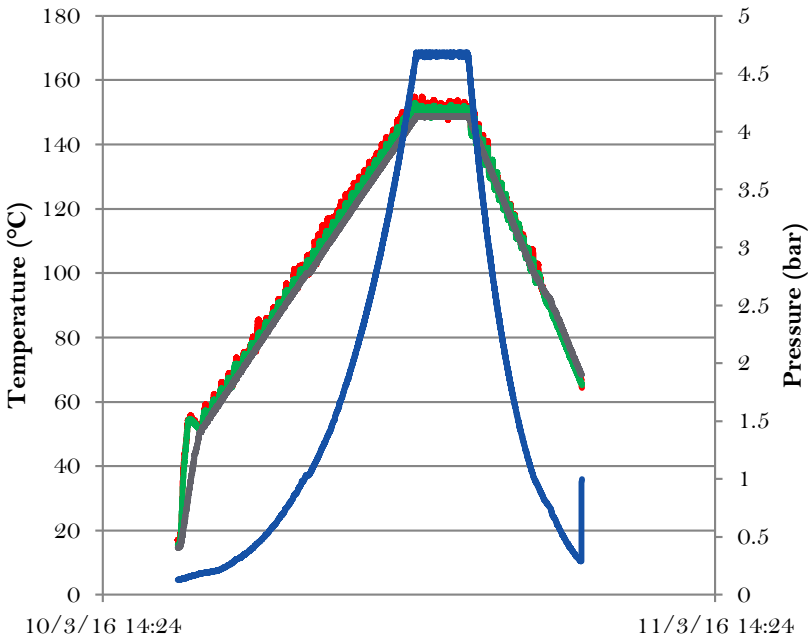
Spruce wood particles (sieve <2.0 mm)

- Willems W (2009) Novel economic large-scale production technology for high-quality thermally modified wood. Proceedings of the 5th European Conference on Wood Modification, Stockholm, Sweden, pp 31–35.
- Altgen, M., Willems, W., Militz, H. (2016.)Wood degradation affected by process conditions during thermal modification of European beech in a high-pressure reactor system. Eur. J. Wood Prod. 4(5): 653-662.

METHODS

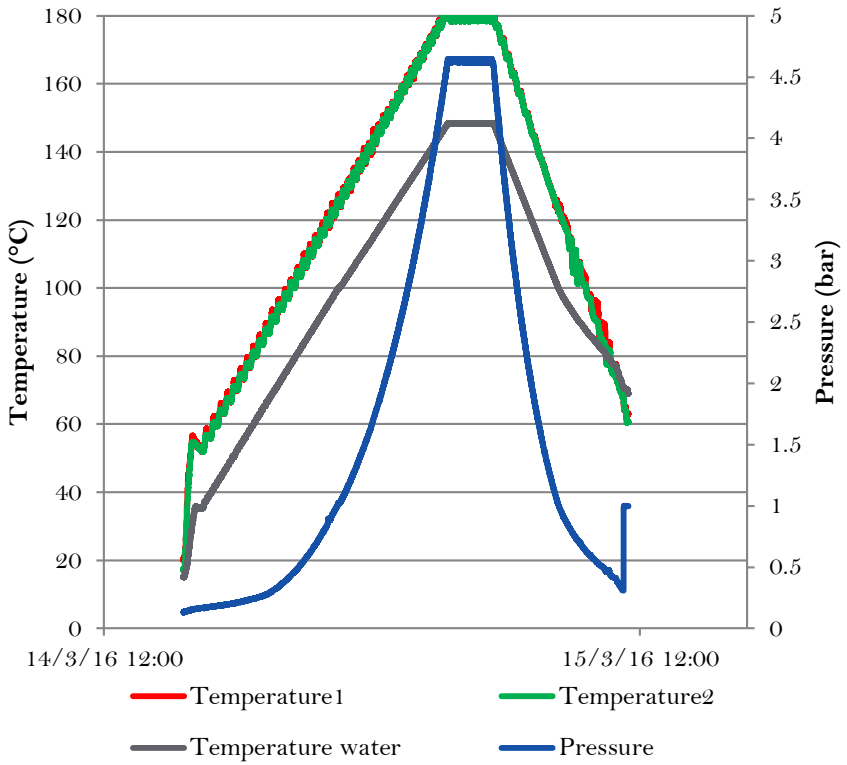
THERMAL MODFICATION

TM1



150°C, 100% RH

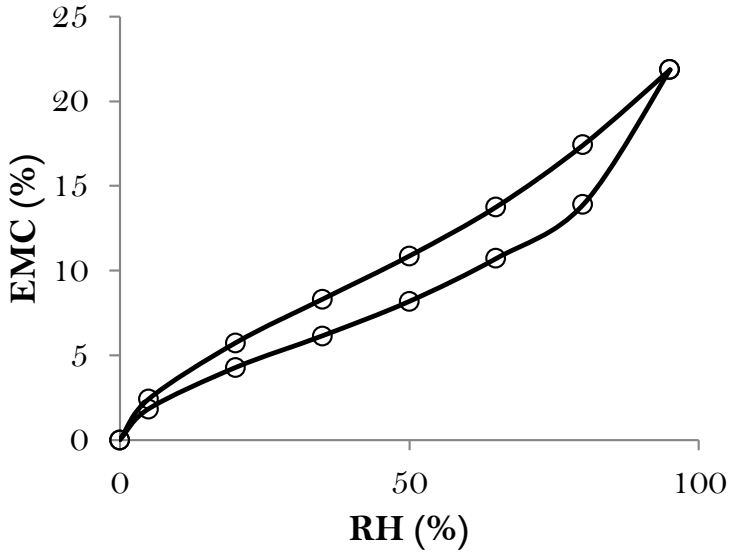
TM2



180°C, 40% RH

METHODS

DYNAMIC VAPOUR SORPTION



3 sorption cycles

RESULTS

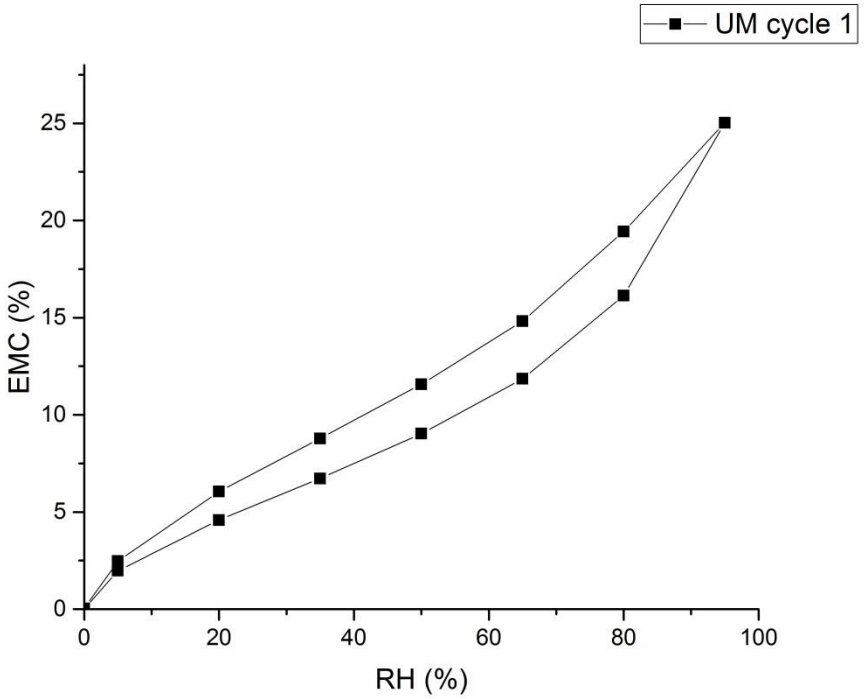
RESULTS

THERMAL MODFICATION

MC (%)			Weight loss (%)	
UM	TM1	TM2	TM1	TM2
4.9	4.3	1.6	2.6	4.0

RESULTS

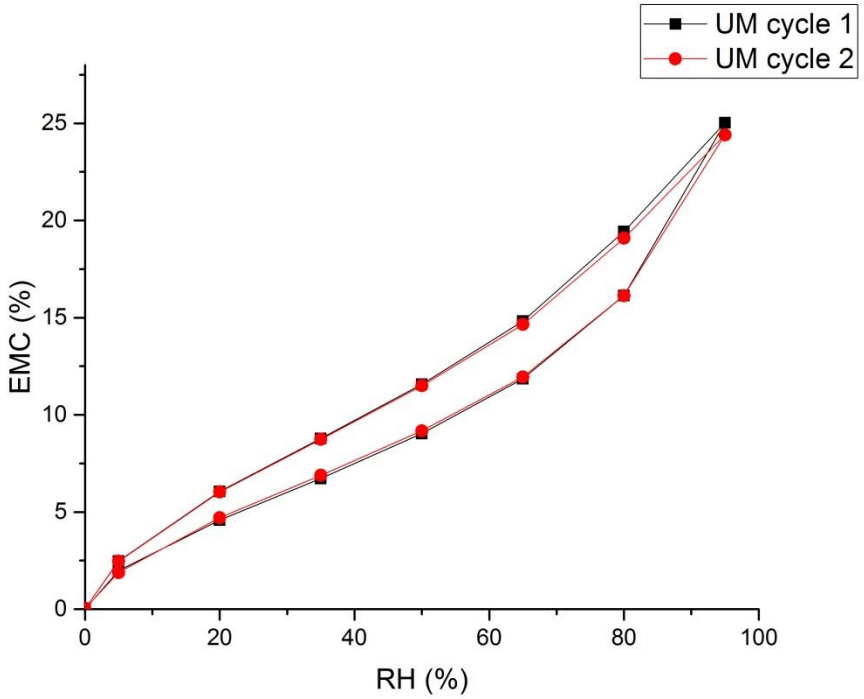
SORPTION PROPERTIES



Unmodified

RESULTS

SORPTION PROPERTIES



Unmodified

RESULTS

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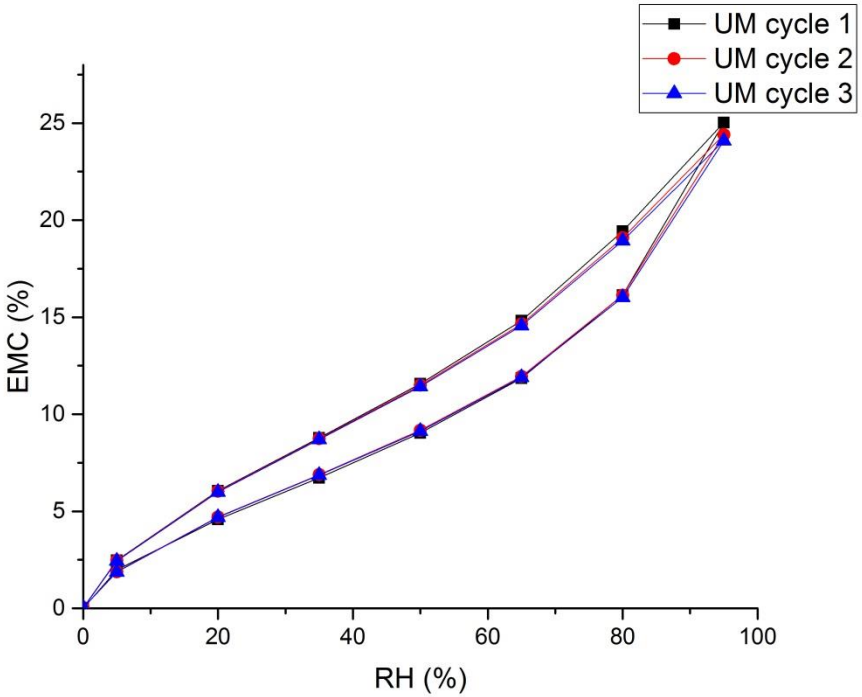
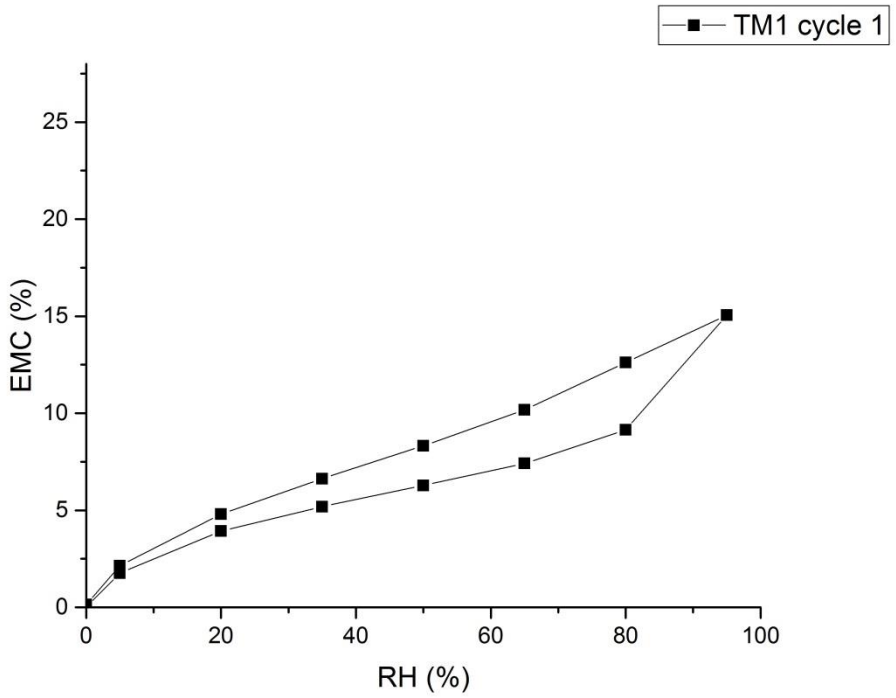


Unmodified

RESULTS

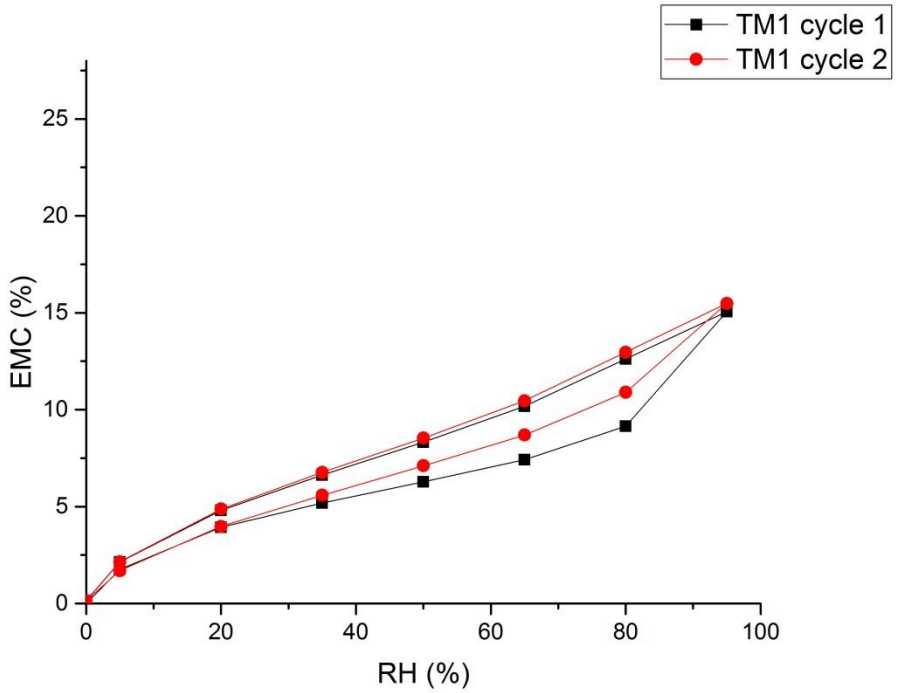
SORPTION PROPERTIES



Thermally modified 150˚C, 100% RH

RESULTS

SORPTION PROPERTIES



Thermally modified 150˚C, 100% RH

RESULTS

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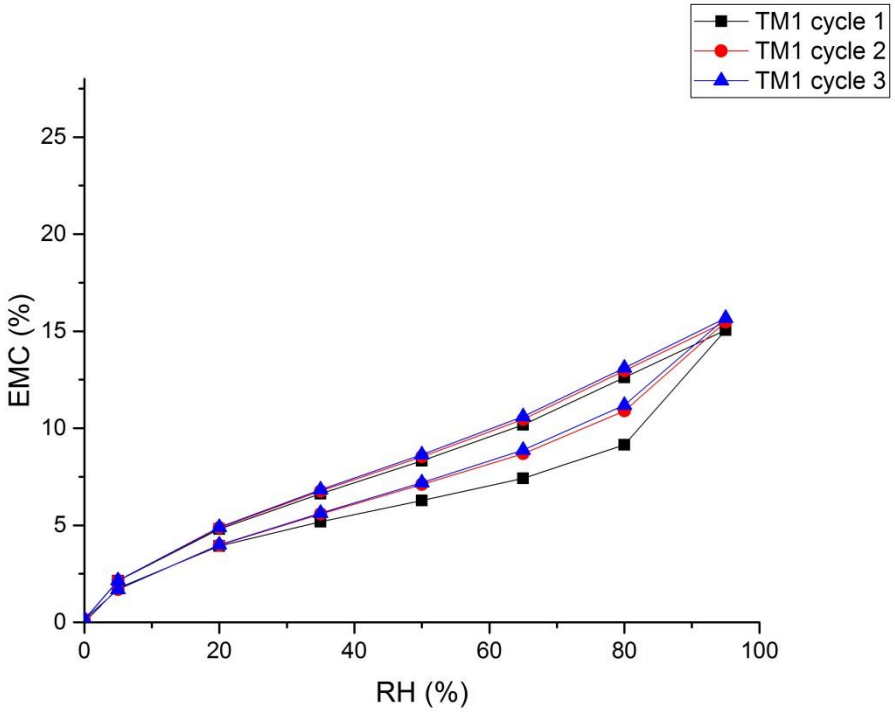

Thermally modified 150˚C, 100% RH

RESULTS

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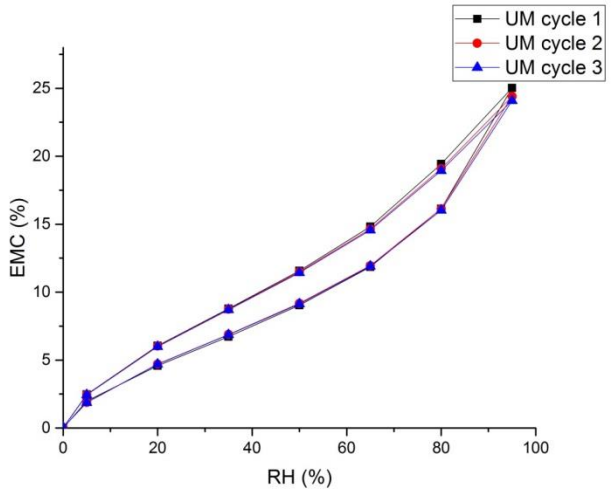

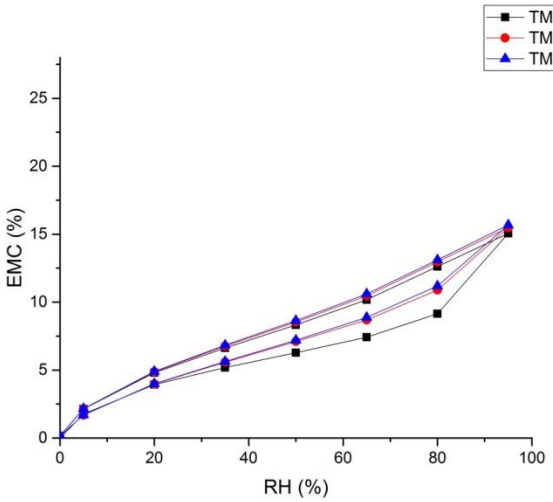

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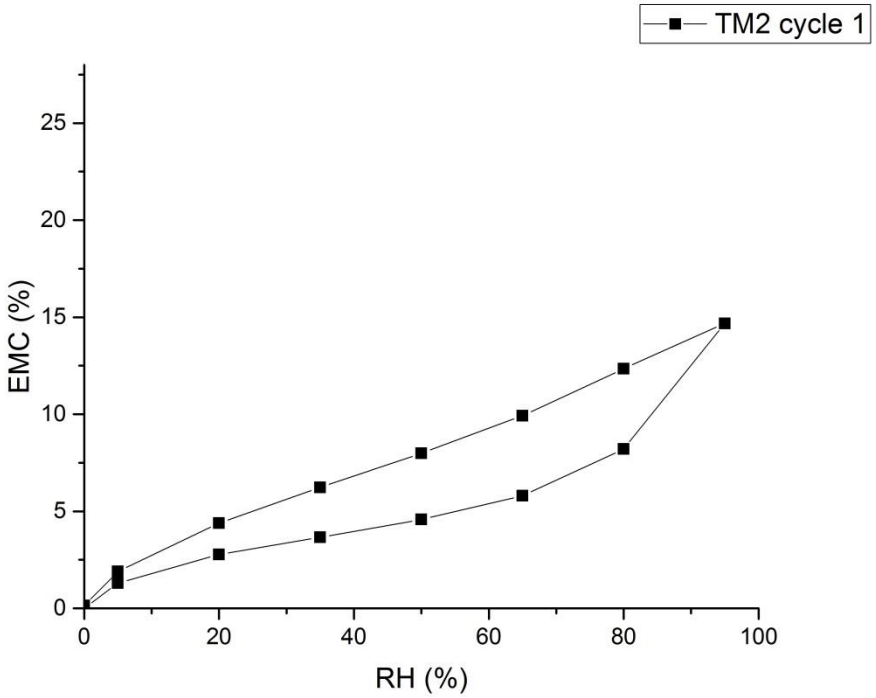
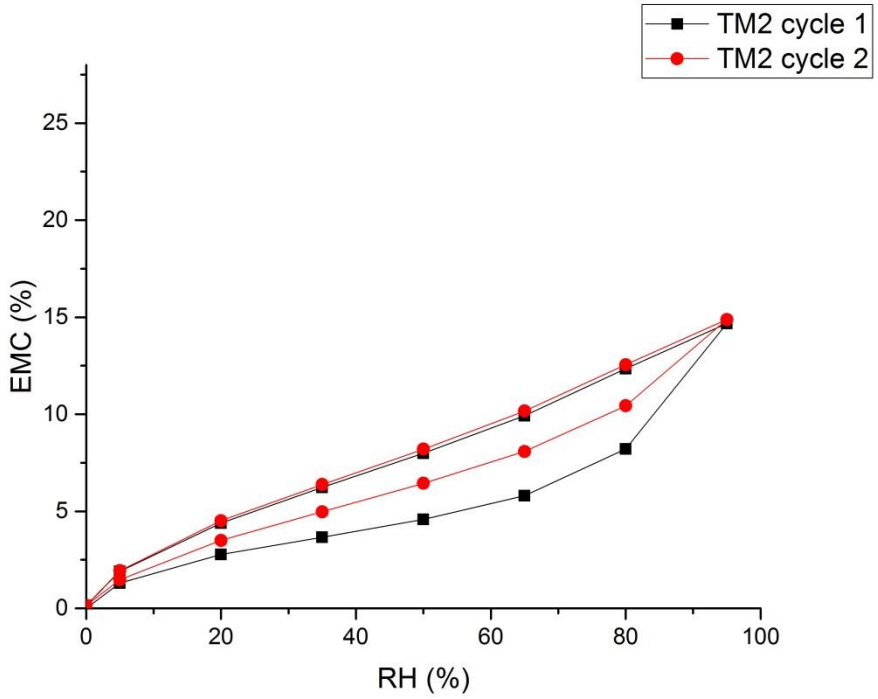


Thermally modified 180˚C, 40% RH

RESULTS

SORPTION PROPERTIES



Thermally modified 180˚C, 40% RH

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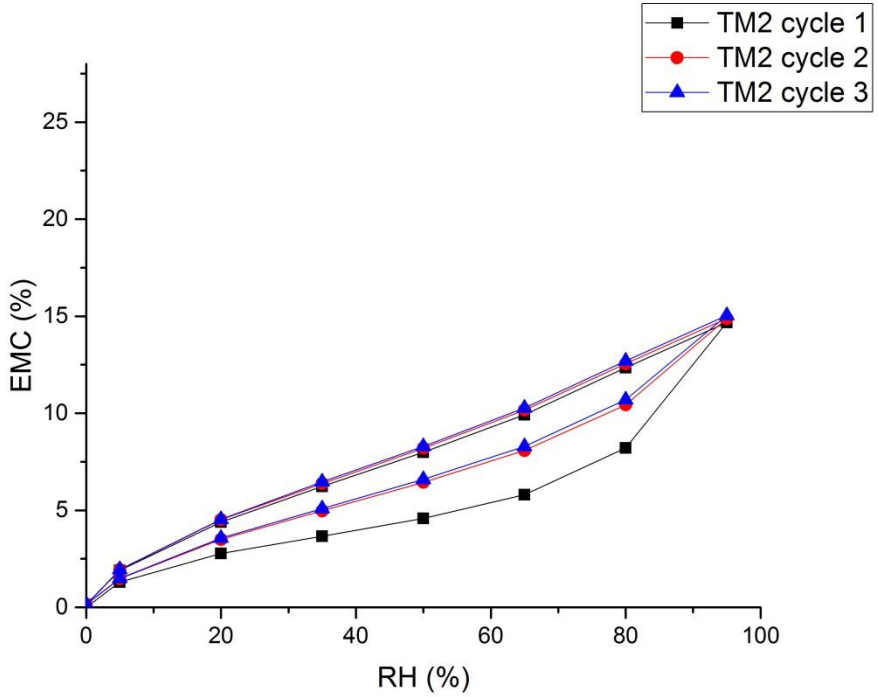

Thermally modified 180˚C, 40% RH

RESULTS

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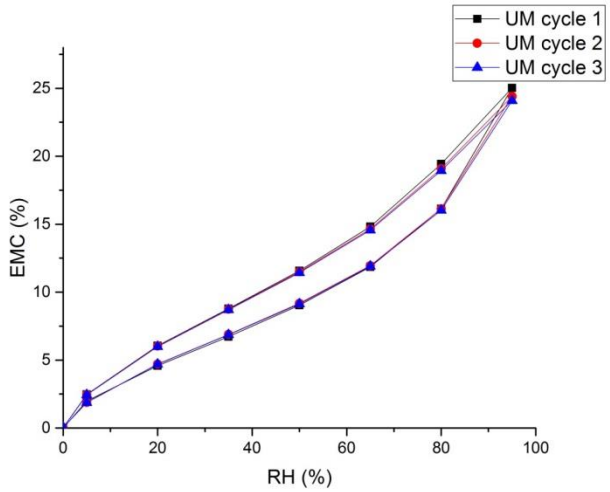

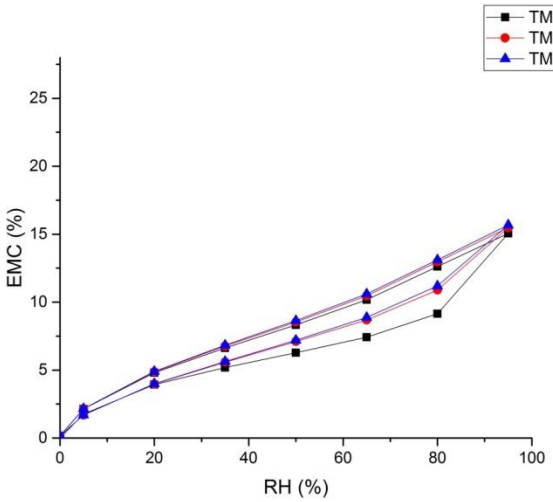

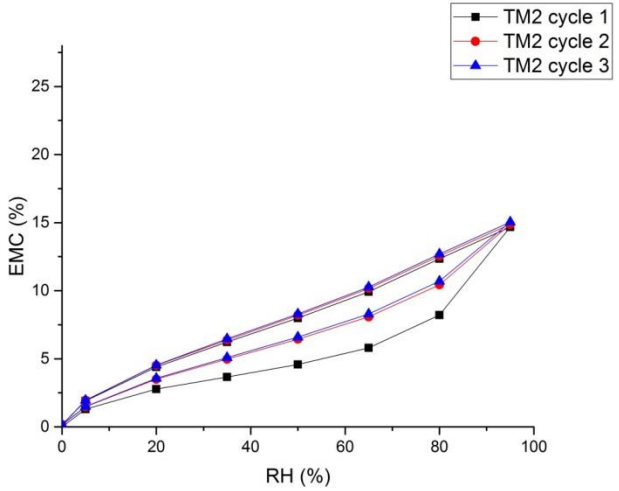

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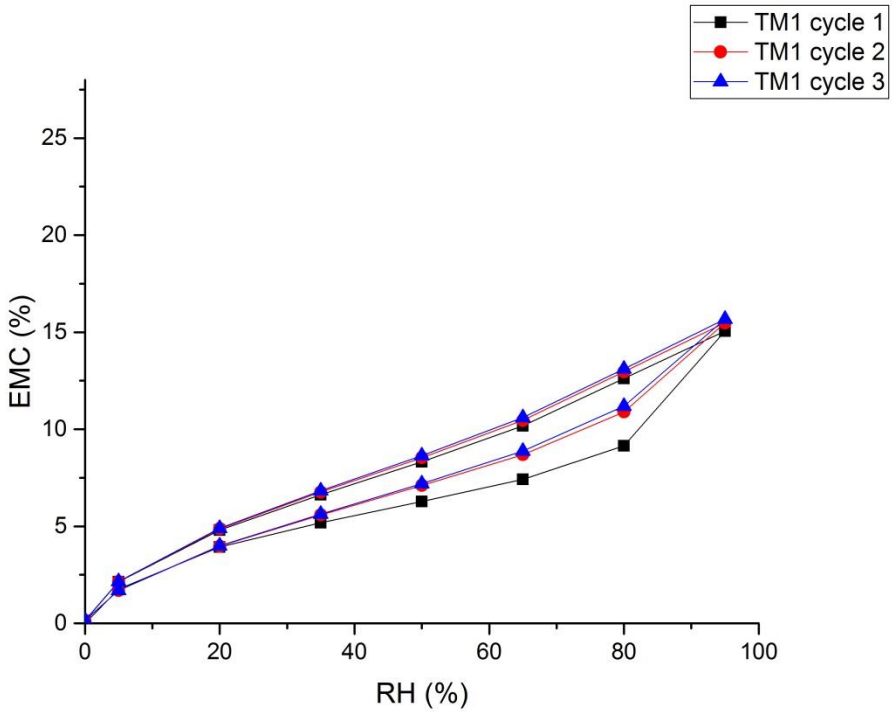
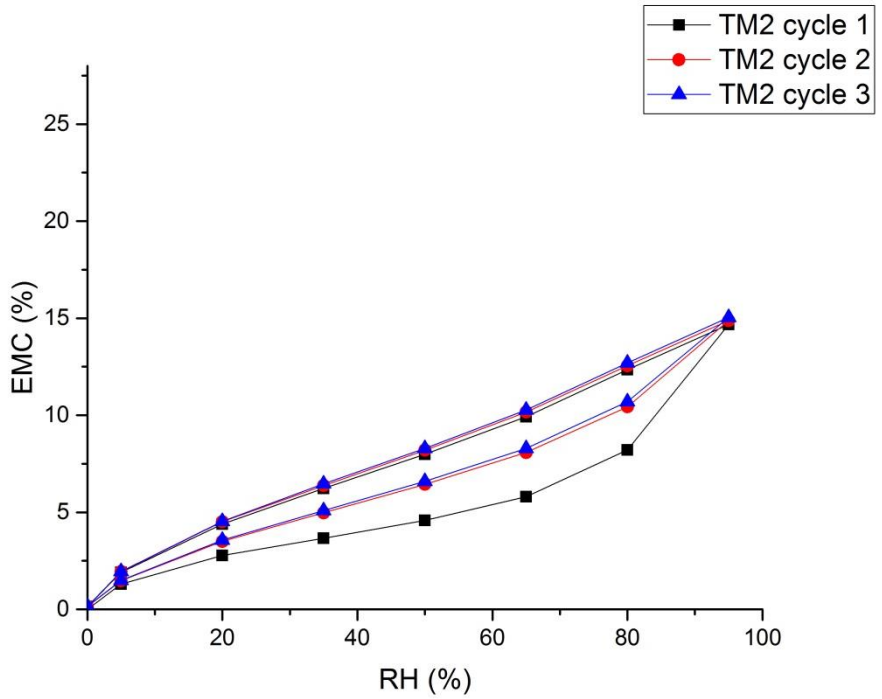


TM1: 150˚C, 100% RH



TM2: 180˚C, 40% RH

- Altgen, M., Hofmann, T., Militz, H. (2016). Wood moisture content during the thermal modification process affects the improvement in hygroscopicity of Scots pine sapwood. Wood Sci. Technol. 50: 1181-1195.
- Endo, K., Obataya, e., Zeniya, N. Matsuo, M. (2016). Effects of heating humidity on the physical properties of hydrothermally treated spruce wood. Wood Sci. Technol . 50(6): 161-1179.

CONCLUSIONS

- Thermal modification of wood particles in a closed reactor system using two different processes
- Comparing the two thermal modification processes; modification at higher temp and lower RH → lower final MC and more weight loss
- Reversible EMC reduction was observed after the 1st sorption cycle, for the both thermal modification processes
- The reversible EMC reduction was more pronounced for the thermal modification process using higher temp and lower RH

REFERENCES

- Altgen, M., Hofmann, T., Militz, H. (2016). Wood moisture content during the thermal modification process affects the improvement in hygroscopicity of Scots pine sapwood. Wood Sci. Technol. 50: 1181-1195.
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Thank you

Acknowledgements

COST FP1303
Performance of bio-based building materials

EnWoBio
Engineered Wood and Biobased Building Materials Laboratory