NewWave

D6.8 - Pilot plant production of modified wood

Funded by
the European Union

Document control sheet

Project	New Wave – Building a sustainable & circular economy through innovative, biobased manufacturing lines
Call identifier	Horizon-CL4-2021-TWINTRANSITION-01-05: Manufacturing technologies for bio-based materials
Grant Agreement N°	101058369
Coordinator	BTG Biomass Technology Group BV
Work package N°	6
Work package title	ML4 Manufacturing line for wood modification
Work package leader	InnoRenew
Document title	D6.8 Pilot plant production of modified wood
Lead Beneficiary	Foreco
Dissemination level	PU (Demo)
Authors	Lex Kiezebrink & Klaas Jan Swager (Foreco)
Contributors	Anna Sandak (Innorenew)
Reviewer(s)	BTG Biomass Technology Group BV
Issue date	31/03/2025

Index

List of figures

List of tables

Executive Summary

This deliverable deals with the modification of wood with a formulation based on fast pyrolysis oil on pilot scale. Foreco modified three wood species with formulation “IS15” which was prepared by BTG. Indicative results show a high variability in uptake for beech and low uptake for pine. The uptake in radiata sapwood is very good. Samples have been provided to InnoRenew, and they will execute different types of testing such as durability, dimensional stability and more. These results will provide more insight into the effectiveness of the treatment.

Content of Deliverable

D6.8 is a deliverable of sub-task 6.6: Pilot-plant production of modified wood with selected resins (Duration: 23 months; Leader: Foreco, Participants: BTG & InnoRenew).

Introduction

NewWave will contribute to building a circular economy by introducing sustainable raw materials in different manufacturing lines (ML's), replacing toxic chemicals, and lowering the environmental footprint of the products. The four manufacturing lines (see Figure 1) will produce engineered wood panels, furan base-chemicals, polyols and polyurethanes, and modified/engineered wood. The subject of ML4 is the production of modified wood using formulations based on fast pyrolysis bio-oil.

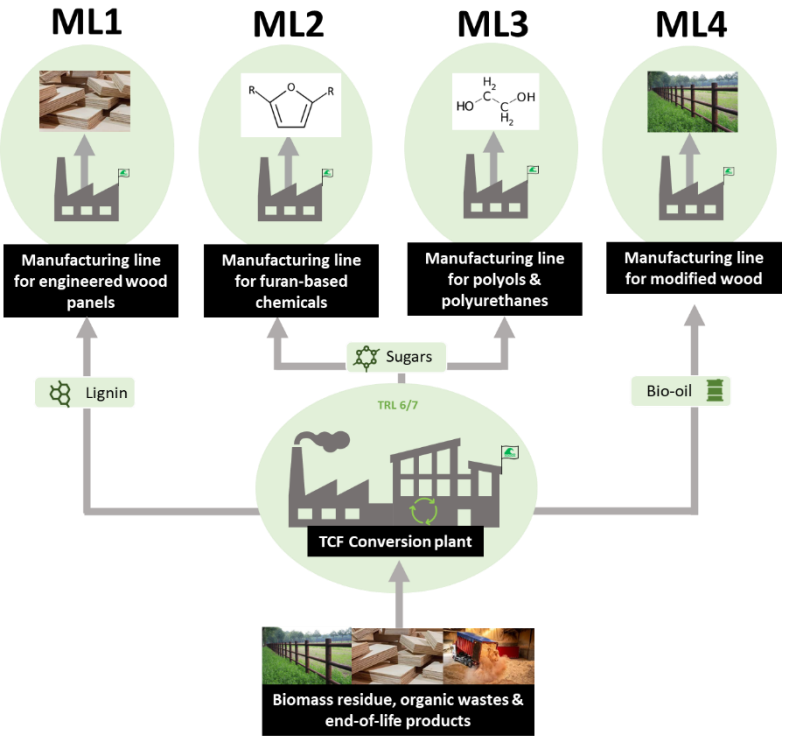

Figure 1: Schematic overview of the NewWave ML's

The task of Foreco is the production of modified wood samples and this deliverable provides a brief overview. The impregnation formulations is prepared and supplied to Foreco. Samples of the modified wood will be delivered to InnoRenew for analysis (e.g. durability testing).

Bench-scale testing

In the frist part of the project a large number of different formulations have been tested and eventually three promising formulations were selected for further evaluation (IS1, IS9 and IS15), see Table 1.

Table 1. Selected formulations

Formulation number	Amount provided by BTG (l)
IS1	30
IS9	30
IS15	850

The most promising appeared to be IS15 and this formulation was selected by the WP partners for the pilot plant work. Besides the formulations also different types of wood are considered and these wood species have been selected on availability and impregnability.

Foreco modified the following wood species:

- Beech
- Radiata pine
- Scots pine

The pilot plant impregnation unit is shown in Figure 2.

Figure 2. Pilot impregnation unit at Foreco

Wood modification process

Impregnation

For impregnation on pilot scale it was decided to avoid heating the impregnation solution. However, preheating might be of interest since it lowers the viscosity resulting in a high uptake. But if not necessarily it is obviously better to prevent heating of the impregnation solution, because it leads to energy consumption. Moreover, in industrial applications impregnation uptake is often limited to prevent unnecessary uptake.
For the pilot runs described in this document the aim was to maximize the impregnation uptake to prove effectiveness of the modified wood. This approach is known in the industry as a "to-refusal process". However, the impregnation solution was not preheated. The typical process conditions are summarized in the Table below.

Table 2. Typical process conditions

Process step	Pressure in kPa	Duration in minutes
Pre-vacuum	20	30
Pressure	900	180
After-vacuum	20	30

Although higher pressures and longer impregnation times are sometimes applied, there is consensus in the wood impregnation industry that longer treatment generally does not make sense.

Drying

It was decided to air- dry the material before starting the drying and curing process. The objective is to reach a moisture content that is well below fibre saturation point. To be more precise, a wood moisture content of approximately 16%-25% was targeted before starting the additional drying and curing process. A slow drying has the advantage that is a minimum risk of drying effects. The general consensus in wood modification literature is that dry curing has many advantages above wet curing. The effect of impregnation agents is the largest when they bulk cell wall of the wood and bond with wood polymers. Drying the wood allows the impregnation agent to diffuse to the cell wall. But a long drying cycle might also result in pre-polymerisations of the impregnation agent which prevents it from entering the cell wall simply because the size of the micropores prevents the impregnation agent from entering the cell wall.

Curing

The curing temperature is not given as specification, but generally the higher the curing temperature the better the polymerisation and durability effect. However, a higher temperature also has a negative effect on mechanical properties. Therefore we decided to run test in atmospheric steam drying kiln and not in a closed vessel. The maximum temperature on which these kilns operate is 140 °C. A typical curing process is given below. During initial stages the temperature is kept constant and gradually reduce the relative humidity in the kiln. Then temperature will be raised to approximately 100 °C while keeping humidity as high as possible. This results in steam drying. The water inside the wood reaches boiling point and the over-pressure forces the moisture outside the wood. The high humidity prevents overdrying of the shelter of the wood which prevents case-hardning and over-drying. A typical curing process has been visualised below in Figure 3.

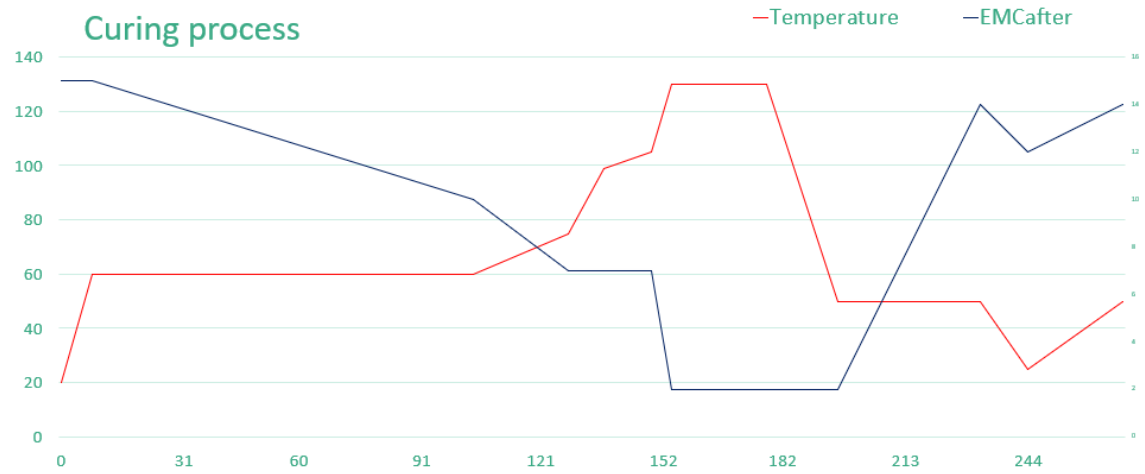

Figure 3. The curing process- temperature as function of time

Crack detection

Drying effects may occur during curing because moisture difference between the core and shell cause drying stress. Foreco owns an ultrasonic crack detection system (see Figure 4). This is a non-destructive testing method that helps with the development of different processes. Part of the produced wood has been analysed with this device, and data will need further evaluation.

Figure 4. Crack detection device at Foreco

Results

Different wood species have been modified on pilot scale using the formulation provided by BTG. At Foreco only the uptake and density are evaluated. Further analysis (e.g. durability) is being examined by project partner InnoRenew. Below a summary of the pilot impregnation runs is given.

Scots pine wood

Table 3. Scots pine dimensions

Dimensions (mm)	18x145x2100
Average (kg/m^3)	113
St.dev	47
N	20

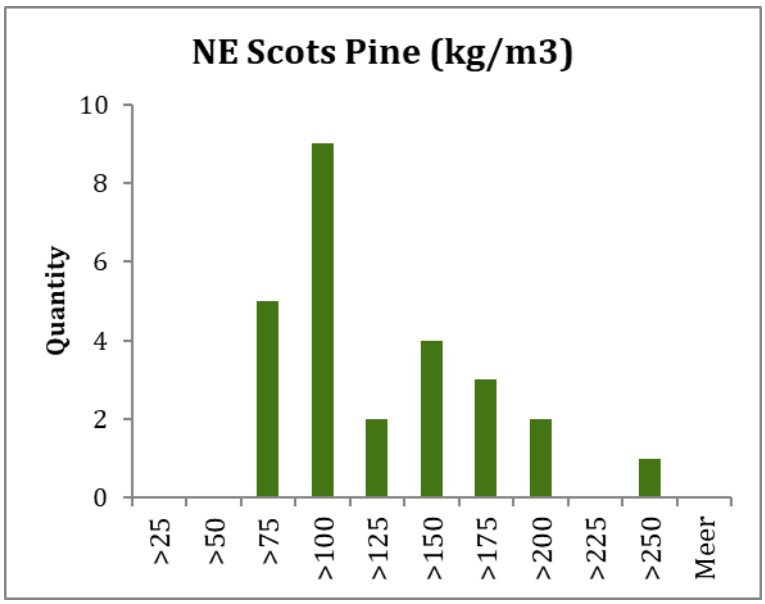

Figure 5. a: Density distribution Scots Pine, b: Scots pine after curing

Beech wood

Table 4. Beech wood dimensions

Dimensions (mm)	50x100x2200
Average (kg/m^3)	209
St.dev	211
N	20

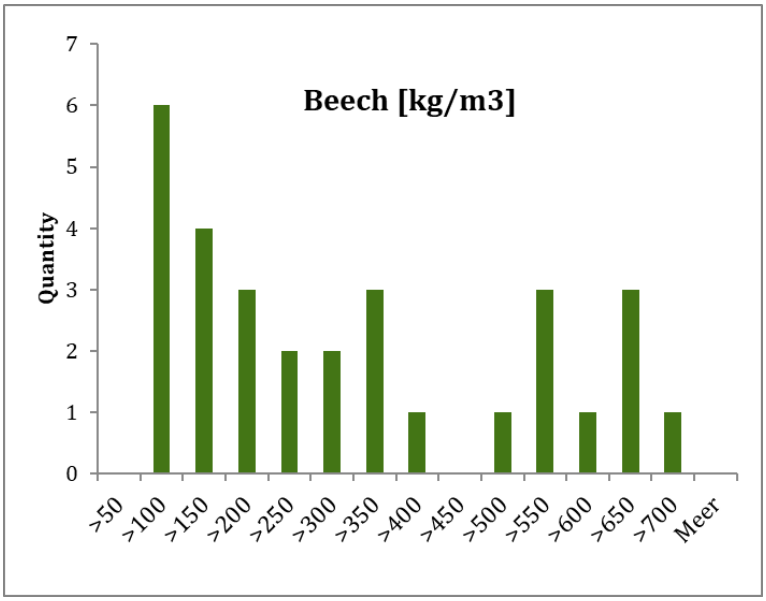

Figure 6. a: Density distribution B, b: Beech wood after curing

Radiata pine wood

Table 5. Radiata pine wood dimensions

Dimensions (mm)	25x150x1000
Average (kg/m^3)	209
St.dev	211
N	20

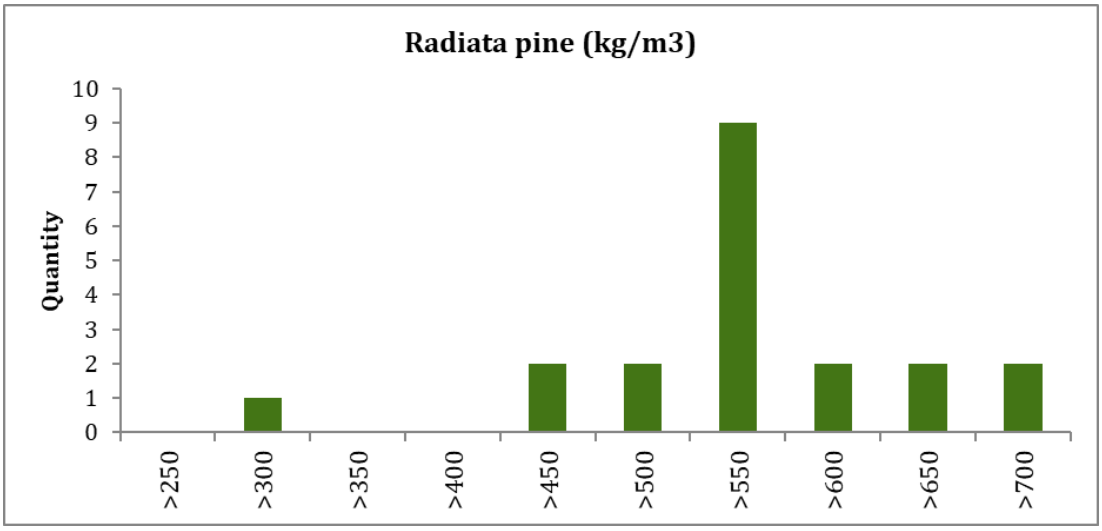

Figure 7. Density distribution

Figure 8. Beech and Scots pine impregnated with IS15

Conclusion and discussion

Different wood species have been impregnated with formulation IS15 on pilot scale, and in total around 0.75 m^3 of wood has been treated. Treatment with this formulation gave good uptake results on radiata pine; uptake results on beech and scots pine was less than expected. Probably, uptake can be improved by lowering the viscosity by either preheating the formulation or by modifying the formulation composition. Lowering viscosity would probably increase uptake performance. Determination of viscosity as a function of temperature would be helpful. From the current results “Pinus Radiata sapwood” is the preferred wood specie. Samples have been shipped to InnoRenew for durability testing.

References

No references.

NewWave

Funded by
the European Union

This project has received funding from the European Union's Horizon Europe Research and Innovation Programme under Grant Agreement No. 101058369