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Biomass based energy intermediates boosting biofuel production

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D5.12

Report on pilot scale panel production with renewable resins

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Responsible:	CHIMAR Hellas S.A.
Authors:	Electra Papadopoulou
Contact:	papadopoulou@ari.gr; office@ari.gr
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Publishable Summary

CHIMAR HELLAS S.A. has scaled up the production of plywood panels with a resol phenol formaldehyde resin modified with phenolic fractions from the catalytic pyrolysis of biomass. The resin with a phenol replacement up to 50%wt. was successfully synthesised and applied to the production of plywood panels of 9 plies. The panels were tested and evaluated according to the European standards EN 314-1:2004 and EN 314-2:1993. It was found out that the 9-ply panels can meet the standard requirements for exterior applications. Market penetration of these products depends primarily on the availability of the phenolic fraction at commercial quantities and its competitive price compared with the price of phenol.

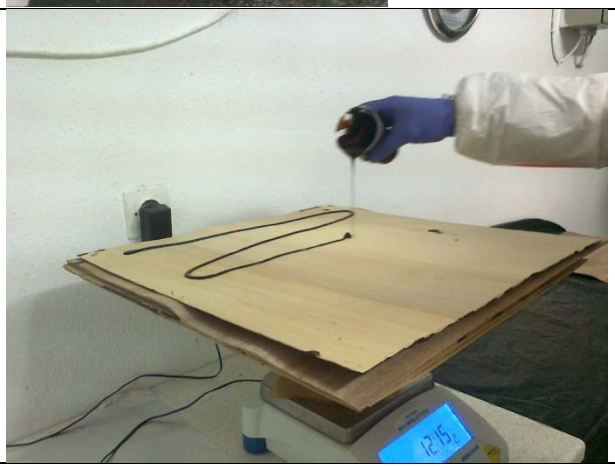
Table of Content

Introduction

Based on the results of the work carried out in WP3, CHIMAR evaluated the best performing resin in the production of panels at pilot scale. This step is considered as prerequisite for any new product before its commercial introduction to the industry.

Experimental part

According to the results of the work that was carried out in WP3, the experimental phenol formaldehyde (PF) resin with 50%wt. phenol replacement by the last phenolic fraction provided from the catalytic pyrolysis of biomass (CPERI name of sample: “Chimar 5”) that was the best performing overall, was used for the production of 2 plywood panels of 9 plies and dimensions of 60x60 cm. The synthesis process of the resin, the methodology followed for the manufacturing of panels as well as their testing was carried out according to the methods described in the deliverable 3.10. Particularly:

	Initially a glue mixture was prepared from resin, flour and water.
	A certain quantity of the glue mixture was weighed before its spreading on the veneers.

	The glue mixture was then spread on each veneer with the use of a spatula.
	The plywood panels were constructed by putting one veneer on top of the other at right angles. 7 veneers from Poplar were used for the inner part of each panel while 2 veneers from Okoumé were used for the face of each panel. So each panel was consisted of 9 veneers in total.
	The panels were cold pressed and then hot pressed at 135°C for 15 minutes.
  Pieces of the 9-ply panels	

Next, the panels were tested for their shear strength and wood failure performance according to the European standards EN314-1:2004 and EN314-2:1993 as described in details in the deliverable 3.10.

The results of their testing (average values) are presented in the following Table 1.

Table 1: *Testing results of 9-ply plywood panels*

Resin:	**PF-50**
CPERI name:	Chimar 5
Phenol substitution level:	50%
Testing according to:	EN314-1:2004
Pre-treatment 5.1.1	*Immersion in water of 20°C for 24h*
Shear strength, N/mm^2	**1.20**
Wood failure, %	**47**
Pre-treatment 5.1.3:	*4h in boiling water -16h drying at 60°C- 4h in boiling water- 1h in cool water*
Shear strength, N/mm^2	**1.01**
Wood failure, %	**29**

Pieces of 9-ply panels after testing

Evaluation of results/Discussion

The panels were evaluated with criterion their compliance with the performance threshold values that have been set by the standard EN314-2:1993 (table 2).

Table 2: *EN314-2:1993 standard bonding performance requirements*

Mean shear strength fv, N/mm^2	Mean apparent cohesive wood failure w, %
$0.2 \leq fv < 0.4$	≥ 80
$0.4 \leq fv < 0.6$	≥ 60
$0.6 \leq fv < 1.0$	≥ 40
$1.0 \leq fv$	No requirement

According to the specifications set by this standard, when a panel performs mean shear strength value above 1.0 N/mm^2, then there are no requirements relatively with the wood failure performance of the panel. In our case, the panels prepared with the experimental resin comply with this regulation after they have been subjected to the pre-treatments set out by the standard EN314-1:2004 (pre-treatment No 5.1.1: Immersion in water of 20°C for 24h and pre-treatment No 5.1.3: 4h in boiling water-16h drying at 60°C-4h in boiling water-1h in cool water). At this point, it has to be noted that the latter pre-treatment is the severest one described in the relative standard. Hence, it can be said that such panels may be considered as of class 3 (suitable for exterior applications without covering). Although this standard applies to industrial productions, it is a good indication for the evaluation of the quality of pilot panels as well.

Market prospect of PF resins modified with phenolic fractions from the pyrolysis of biomass

As the resins developed in BioBoost project are not available on the market yet, any assessment for their marketability has to be based on the market of PF resins.

In most regions of the world, the largest markets for phenolic resins are in plywood and in fibrous and granulated wood products, while the demand for wood products is influenced by the health of the construction industry and overall state of the economy **[1].**

The global market of wood-based panels was valued more than 80 billion USD in 2011 **[2],** while according to information provided by FAOSTAT the production volumes in m^3/year of wood-based panels in 2012 were:

Wood based panels production, m^3/year, 2012 (FAOSTAT data [3])

Asia	America	Europe	World
159,107,427.00	61,524,671.00	74,320,286.00	301,122,837.00

Especially the production volumes of plywood for 2012 were:

Plywood production, m^3/year, 2012 (FAOSTAT data [3])

Asia	America	Europe	World
60,713,412.00	11,317,185.00	7,586,644.00	85,575,819.00

Wood-adhesive production was the largest application segment for phenolic resins in 2012 and accounted for over 34% of the global demand for phenolic resins **[4].**

The global demand for the phenolic resins was valued at USD 9.19 billion in 2012 while their global market is expected to grow at a CAGR of 5.7% from 2014 to 2019 to reach a value of $19.31 billion.

Asia-Pacific, North America, and Europe dominated the phenolic resin market in 2013 and accounted for over 90% of the market. The market for phenolic resins in most countries closely tracks GDP growth and housing market growth.

Resol resins, that are the type of PF resins used for the production of wood-based panels, were accounted for more than 75% of the global market in 2013. Resol phenolic resin market is expected to increase at a growth rate of 4.1% till 2019 **[5].**

The following pie chart shows world consumption of phenolic resins per country, in 2014 **[6]**

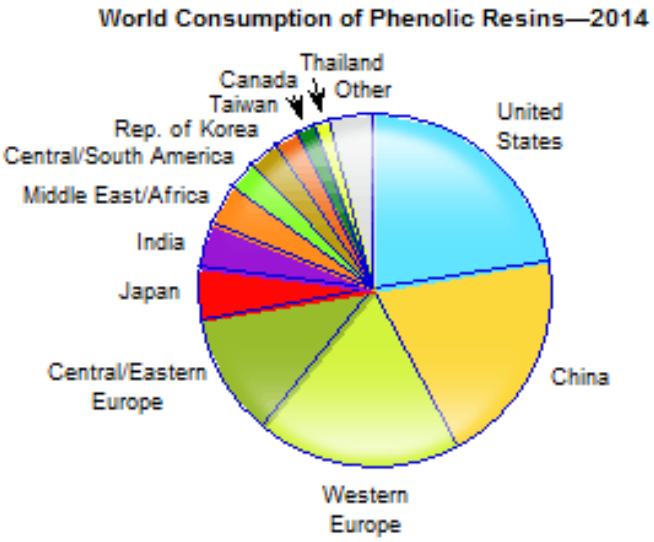


Figure 2: World consumption of PF resins by region **[6]**

Wood adhesives will continue to have the largest market share and will drive phenolic resin consumption on a global scale. The developing regions of Central and South America and Central and Eastern Europe is expected to experience the largest growth in this application **[6]**.

The PF type resins developed in the BioBoost project are addressed to enter this market. Of course, a prerequisite for their market penetration and their ability to claim share of sales of conventional PF resins is that they can be competitive with the existing PF resins with regard to properties and price. However, as their performance is somewhat inferior to the conventional PF, they must have other qualities that will give them an advantage over the classical petrochemical resins. Hence, the phenolic fraction produced from biomass processing should be:

- available at large quantities in order to be able to meet a demand for industrial production scale and capacities. For example, for the production of one industrial batch of resin (average size 30t), a quantity of about 3 t of phenolic fraction is required. Taking into account that normally, a plant operates 24 h, then 9-10 t of phenolic fraction is projected to be needed for one day's production of resin.
- available throughout the year at constant quality.
- offered to the market at a price competitive to fossil based phenol (the current price of phenol is about 1100 to 1200 Euro/t).

Conclusions

The phenolic fractions from the catalytic pyrolysis of biomass may be successfully used as phenol substitute up to 50% in the synthesis of resins of phenol-formaldehyde type. Such resins are suitable for the production of plywood panels of interior or exterior grade and from technological point of view they are ready to be introduced to the industry. However, their penetration to the market depends on the availability and price of the phenolic fraction compared to the price of phenol.

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