**Bio-Cascading of Heat-Treated Wood after Service Life to Obtain Lignocellulosic Derivatives**

Eduardo Robles\*, Pedro L. De Hoyos Martínez, Javier Fernández, René Herrera, Oihana Gordobil, Jalel Labidi

*Biorefinery Processes Group, Chemical and Environmental Engineering Department, Faculty of Engineering Gipuzkoa, University of the Basque Country UPV/EHU, Plaza Europa 1, 20018 Donostia, Spain*

[*\*joseeduardo.robles@ehu.eus*](mailto:*joseeduardo.robles@ehu.eus)

**Highlights**

* Include 3 to 4 highlights in bullets format. [Calibri 10].
* Max. 90 characters per highlight including spaces.
* Only the core results should be covered.
* Please do not change the selected fonts.

**1. Introduction**

The use of wood-based products in Europe is projected to increase threefold worldwide between 2010 and 2050. The need for innovative products from fewer resources to help reducing pressure on forests is attracting the attention of scientific community to provide a value-added use of wood-based products after their traditional service life. In this sense, cascading of wood is an efficient use of these resources from the point of view of natural resource higher value uses that allow the reuse and recycling of products and raw materials. In this work, heat-treated wood (*Pinus radiata* L., 212 ºC) after one year of weathering exposure was subjected to a multi-stage lignocellulosic fractioning following the cascading and the biorefinery principles. This fractioning allowed the obtaining of hemicelluloses and lignin as chemical precursors, which were analyzed in their yield and quality. To determine the quality of the obtained products, the same fractioning was done to natural wood and heat-treated wood with no weathering exposure, as well as the natural wood after being exposed to the same conditions.

**2. Methods**

Monterey pine (Pinus radiata D. Don) was harvested from the forest areas of the Basque Country (Spain) was debarked, sawed, stored and conditioned before the heat-treatment. Pine boards were thermally modified according to industrial production standards a heat-treatment chamber with steam presence and under inert N2 atmosphere [1]. Monterrey pine samples (natural and thermally modified) were exposed to natural weather [2].

Organosolv process was conducted using a mixture of ethanol/water (65:35 v/v) as white liquor, at 200 ºC during 90 min and a fiber to liquid ratio of 1:10 (w/v) 0.05M MgSO4 was used as catalyst. Liquid fraction was separated via filtration and the solid fraction was washed several times until driving the remaining fibers to a neutral pH level. Lignin (L1) was precipitated by adding 2 volumes of acidified water (pH 2), after which solid fraction was filtered with a 0.22 µm membrane. Filtrate was concentrated and then added to 4 volumes of ethanol and kept at 3 ºC during 24 h, precipitated solid (H2) was separated by centrifugation.

A Totally Chlorine Free Bleaching (TCF) sequence was selected, which was based on two alkaline oxygen stages, (EO), one peroxide stage (P) with secondary chelating reaction (POQ) and an alkaline peroxide stage under oxygen atmosphere (PO). Lignin was precipitated from the first liquor (L2) by acidifying them dropwise until pH ~2.

**3. Results and discussion**

Lignin yields showed a higher recovery of lignin during Organosolv process (Table 1) especially in the case of pine, either weathered or not. I In case of lignin from P extracted during organosolv, it can be seen that Pw has a lower recovery (~16% less) regarding the original mass. Organosolv lignin from thermotreated wood showed lower yields than that of normal pinewood in absolute values. Table 1 also presents the content of acid insoluble lignin (AIL), acid soluble lignin (ASL), carbohydrates, ashes, molecular weight (Mw) and polydispersity index (Mw Mn-1).

**Table 1.** main purity indicators of the recovered lignins.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | Yield  [%] | AIL  [%] | ASL  [%] | Carbohydrates  [%] | Ashes  [%] | Mw  [g mol -1] | Mw Mn-1 |
| Po | L1 | 17.92 | 93.37 | 0.88 | 1.84 | 1.13 | 5534 | 4.43 |
| L2 | 8.67 | 83.34 | 1.46 | 3.01 | 1.15 | 2772 | 2.94 |
| Pw | L1 | 15.03 | 93.89 | 0.53 | 1.83 | 0.29 | 7401 | 5.32 |
| L2 | 5.29 | 93.05 | 1.20 | 4.44 | 0.65 | 10049 | 8.68 |
| To | L1 | 8.54 | 93.36 | 0.74 | 1.73 | 0.51 | 1453 | 2.36 |
| L2 | 9.06 | 92.82 | 1.08 | 5.27 | 1.06 | 3477 | 4.16 |
| Tw | L1 | 9.80 | 94.62 | 0.95 | 2.58 | 0.25 | 4307 | 3.71 |
| L2 | 7.14 | 89.92 | 1.29 | 6.11 | 0.49 | 3465 | 3.88 |

**4. Conclusions**

The recovery of lignin from Organosolv treatment and mild-alkaline bleaching sequence resulted in very different technical lignins, with different possible applications.

**References**

1. Herrera, R.; Erdocia, X.; Llano-Ponte, R.; Labidi, J. J. Anal. Appl. Pyrolysis 107, 256–266, 2014. https://doi.org/10.1016/J.JAAP.2014.03.010.
2. Herrera, R.; Arrese, A.; de Hoyos-Martinez, P. L.; Labidi, J.; Llano-Ponte, R. Constr. Build. Mater., 172, 233–242, 2018.