Biological and electrochemical valorisation of lignocellulosic wastes from pulp & paper industry to give new generation biodiesel and aromatic compounds

N. DI FIDIO[1], C. ANTONETTI[1], A. M. RASPOLLI GALLETTI

[1] Department of Chemistry and Industrial Chemistry, University of Pisa, Via G. Moruzzi 13, 56124 Pisa, Italy;
e-mail: n.difidio@studenti.unipi.it

Technical lignin and cellulosic wastepaper represent the main side-streams of the existing industrial-scale biorefineries and paper industry. The valorisation of these renewable and low- or negative-value feedstocks is a strategic approach to enhance the biorefinery and paper industry sustainability. Lignin represents a promising source of aromatic compounds, while cellulosic wastepaper is a high-quality source of sugars which can be converted into several added-value bioproducts, such as biofuels, biochemicals and biomaterials. In this perspective, in the present work, the electrochemical valorisation of lignin to give aromatics was performed [1], whereas in the case of wastepaper, a direct enzymatic hydrolysis was optimised to simultaneously produce glucose and xylose which were then fermented by oleaginous yeasts to produce new generation biodiesel [2]. In particular, the soda technical lignin Protobind™ 1000 (P1000) was adopted as starting material. It is produced on an industrial scale by the company GreenValue (Switzerland), starting from a mix of wheat straw and sarkanda grass, after an alkaline extraction with sodium hydroxide.

In order to improve the lignin exploitation to added-value aromatic compounds, a mild chemical conversion route based on electrochemistry was investigated [1]. Under the optimal reaction conditions (NiOOH electrode, pH 14, lignin 20 g/L, 0.4 V), the electro-oxidative depolymerisation of lignin by electrolysis was performed in a divided cell. The main products were sinapic acid, vanillin, vanillic acid, and acetovanillone. The obtained preliminary results demonstrated the potential feasibility of this innovative electrochemical route for lignin valorisation for the production of bio-aromatic chemicals.

The wastepaper derived from the converting process for the production of tissue paper products by different local companies in Lucca (Italy). The waste cellulosic powder is produced in the converting section, where the paper coil is unrolled and the sheet is subjected to mechanical operations to give the final commercial product. This cellulosic waste is not suitable to be recycled within the same papermaking process. For this reason, it is typically recovered by aspiration and sent to the landfill. Regarding the exploitation of wastepaper, an innovative two-step process for the conversion of waste tissue paper to single cell oil (SCO) was optimised. SCO represents an outstanding alternative to both fossil sources and vegetable oils for the production of biodiesel. Hydrolysates containing glucose and xylose were produced by enzymatic hydrolysis of the untreated waste. Under the optimised reaction conditions (Cellic® CTec2 25 FPU/g glucan, 48 h, biomass loading 20 g/L), the yield of 95 mol% was reached for both glucose and xylose. The undetoxified hydrolysate was adopted as substrate for a batch-mode fermentation by the oleaginous yeast *Lipomyces starkeyi*. Lipid yield, lipid content for single cell, oil production and maximum oil productivity were 20.2 wt%, 37 wt%, 3.7 g/L and 2.0 g/L/d, respectively. This new generation oil, obtained from a negative value industrial waste, represents a promising platform chemical for the production of biodiesel, biosurfactants, animal feed and biobased plastics.

References:

[1] N. Di Fidio, J. Timmermans, C. Antonetti, A.M. Raspolli Galletti, R.J.A. Gosselink, R. Bisselink, T. Slaghek, *New J. Chem*., in press, (2021), https://doi.org/10.1039/D1NJ01037A.

[2] N. Di Fidio, F. Dragoni, C. Antonetti, I. De Bari, A.M. Raspolli Galletti, G. Ragaglini, *Bioresour. Technol.,* 315, 123790-123798 (2020).