SLOW PYROLYSIS OF LIGNIN RICH RESIDUE FROM LIGNOCELLULOSIC BIOREFINING OPERATIONS

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Europe is committed to have a bio-based economy in 2030. It follows that a huge contribution of biorefinery products on the European demand for chemicals, energy, materials and fibers is expected in the near future. To be environmentally and economically sustainable, biorefinery will need to be flexible, versatile, energy and cost efficient [1]. In a lignocellulose based biorefinery, the sugar platform that leads to bioethanol and added-value products through biochemical processes represents a challenging option. After ethanol distillation a lignin reach residue (LRR) is produced and used as energy source. However, it is currently underutilized with about 60% more lignin generated than is needed to meet the internal energy use [2, 3]. The exploitation of this residue for the combined production of biofuels and added value chemicals and materials represents a key factor for the increase of the efficiency of the overall ethanol production chain and its valorization is mandatory for the viability of future biorefinery operations.

Biomass pyrolysis is a very flexible thermochemical treatment that in the absence of molecular oxygen is capable of producing a solid residue (char) suitable for application in several fields and liquid (bio-oil) and gaseous products that can be exploited for energy production or as chemicals’ source. By properly tuning the main process variables (temperature, heating rate, carrier gas flow rate) the pyrolysis process can be guided towards the maximization of the yields and/or the optimization of the quality of the desired products. To this aim a comprehensive knowledge of the thermal behavior of the biomass is needed. A lot is known about pyrolysis of many types of lignocellulosic biomasses and of cellulose, one of the main biomass organic components. However, lignin was less explored and even less the LRR from ethanol production that is contaminated by micro-organisms and not-hydrolyzed sugars [4].

In this work a preliminary study on the thermal behavior of the LRR under nitrogen atmosphere was conducted. Thermogravimetric analysis (cf. Fig. 1) and pyrolysis tests were performed at 10 °C/min exploring a wide range of final temperatures from 300 to 700 °C. The pyrolysis products yields (gas, liquid and char) and the composition of the gas mixture were quantified and the evolution of the gaseous products during the process was monitored. Chemical and physical analyses were carried out on the chars in order to investigate changes in the elemental composition, volatile matter content and porosity characteristics as a function of the temperature. The char yields, the elemental composition and the porosity characteristics allowed to deduce that LLR had a thermal behavior very different from the alkali lignin typically used as reference compound for biomass lignin. Both products yields and char composition were more similar to the typical values of woody and herbaceous biomasses. The chemical characterization of the chars’ organic matrix as well as the content of the main inorganic species suggest the possibility to perform pyrolysis at low temperature for producing high yields of chars suitable to be used as carbon sink or soil fertilizers. The BET values of chars obtained at final temperature in the range 500 - 700 °C seem to be promising for char application in processes involving surface phenomena (e.g. adsorption, catalyst support), thus encouraging further analyses on porosity characteristics and surface chemistry.