ABSTRACT

The increasing energy demand of the transport sector has encouraged the search for non-fossil sources, economically viable and environmentally sustainable that can meet the production requirements and provide energy security. Lignocellulosic biomass (forest, agricultural residues and so on.) is a renewable energy source available in a large quantity throughout the world. It presents many advantages over fossil fuels and first-generation biofuels (produced from starch, sugar, animal fats and vegetable oil), among which are the possibility to decrease CO_2 emissions and atmospheric pollution and eliminate the impact on food supply since they do not compete with food production. Moreover, from the conversion of these sources, products equivalent to petroleum products in terms of their properties are produced and if necessary, the properties can be adapted to meet the requirements of current internal combustion engines, filling stations and storage units. For these reasons, these products are considered as promising alternatives to gradually replace fossil fuels for transportation, power generation and production of chemicals. However, their major disadvantages are the high production costs and the lack of infrastructure. Therefore, in this project, the focus has been in the development and evaluation of technologies for the conversion of biomass into liquid transportation fuels, also known as biomass-to-liquid (BtL) and find the technology that produces biofuels in a sustainable and economically feasible manner.

A methodology was proposed for the synthesis, simulation and optimization of lignocellulosic BtL processes to produce green gasoline and diesel. The approach was divided in five levels. In the first level, the synthesis of five technological routes based on literature data was performed by considering different thermochemical conversion, upgrading, and separation technologies. In the second level, the rigorous simulation of the process routes was carried out on the software Aspen Plus to predict flowrates, reactor and separation units' performances, fuels properties, and production costs. In the third level, a BtL processing superstructure (network) was defined considering the interconnection between the technological routes, as well as mass (liquid, gas and solid recycles) and energy (production of heat and power) integrations. In the fourth level, the superstructure was defined as an optimization problem, which sets the objective to minimize the total cost of manufacturing of BtL fuels under different product profile scenarios. From the different scenarios, optimal process configurations were generated. Finally, in the fifth level, the optimal process configurations were further optimized in terms of unit operations' design parameters and considering as objective function the combination of safety and environmental indexes, as well as green chemistry metrics. By applying the methodology, it was confirmed that the implementation of process synthesis, simulation and optimization techniques can propose optimal BtL process configurations and operation conditions.