PYROLYSIS OF LIGNIN-RICH BIOMASS FOR RENEWABLE AROMATICS

Paul de Wild, ECN part of TNO
paul.dewild@tno.nl

Key Words: Biorizon, Biomass residues, Pyrolysis, Product separation, Applications.

Currently, several national projects are conducted as an activity along the thermochemical horizon towards functionalized aromatics from lignin and lignin-rich biomass sources in the framework of the BIORizon shared research center in the south of the Netherlands [1]. Regarding the pyrolytic valorization of lignin-rich biomass towards aromatic chemicals for various applications, it is thought that the collection of pyrolysis vapors in separate fractions [2] offers interesting opportunities for valorization, e.g. towards (additives for) bitumen, resins, rubber and specific marine biofuels. For these high market volume – medium market value products, earlier work has revealed that the application of lignin as such (so without derivatization / modification) was not successful because of various incompatibilities. Consequently, it was deduced that specific depolymerized fractions from lignin-rich residues would possibly be usable because of lower molecular weight and/or higher reactivity and/or better miscibility with their petrochemical counterparts.

PYRENA (PYrolysis for RENable Aromatics) features integrated char combustion in a bubbling fluidized bed to generate process heat for pyrolysis in an internal riser reactor [3]. The gaseous pyrolysis products and aerosols are in-situ separated and collected via innovative methods such as high-temperature electrostatic precipitation and low-temperature continuous distillation. The major goal is to achieve a progressive separation between higher molecular weight material such as monomeric and oligomeric phenolics and anhydrosugars, lower molecular weight material such as specific polysaccharide degradation products and water.

DDB (dried distilled biomass, a straw-derived biorefinery residue with ~50 wt% lignin), agro-food walnut shell granulate (~50 wt% lignin) and crushed cocoa shells (~20 wt% lignin and polyphenolics) were pyrolyzed at 500°C to collect specific organic fractions, that might be applicable for bitumen, rubber, resins and marine fuel, products that constitute relatively large markets with medium value.

Pyrolysis of the three feedstocks gave comparable results with an overall mass balance of 85 – 97% (liquid yield ~40-60%), based on the intake of feedstock. The pyrolysis liquids contained approximately 40 – 60% organics (light, medium and heavy molecular weight species). The largest amount of pyrolysis liquid (mainly water and medium to light organics) was collected in the ice-water cooled condenser while most of the heavy and medium molecular weight material (mostly lignin-derived oligomeric products) ended up in the high temperature gas cooler and ESP. Regarding the monomer composition of the different fractions, the major feature is the fact that the ESP mainly traps phenolics, while the ice-water cooled condenser collects the lighter, lower boiling components. See figure below.

The heavy molecular weight material from the 100C cooler and the ESP blends well with commercial shipping fuel and bitumen. The work conducted, indicates that pyrolysis products can be recovered in usable fractions such as monomeric phenols, oligomeric phenols, char and combustible gas. The progress in industrial application trials for bitumen, rubber, resins and marine biofuels with residue-derived pyrolysis oils will be highlighted and an outlook will be provided of potential end-uses for the fractionated pyrolysis products. For this work the financial support of the Dutch Ministry of Economic Affairs is gratefully acknowledged.