Hydrothermal liquefaction as a promising thermochemical route to produce energy vectors from highly chromium-rich biomasses: The case study of a tannery sludge

Biomass, and in particular waste biomass, has begun to be used as a renewable source to produce high-value materials or chemicals. A large number of biomasses (i.e. solid waste, agricultural residue, sewage sludge) are still regarded as a useless re-source, and disposed of using expensive, unsustainable methods such as incineration and landfilling. Nowadays, one of the primary goals of waste biomass treatment plants is to develop more environmentally friendly processes to reduce the volume of waste for disposal and to convert biomass into bio-energy. However, the thermochemical valorisation of biomass is often hindered by the high content of metals present in it. In fact, heavy metals in waste biomass can be released with changes in soil chemical properties such as pH reduction and metal sulfide oxidation causing secondary pollution to crops and soil. An example of this issue lies from biomass with a high chromium content, as in the case of tannery sludge, where the mismanagement of this waste residue may result in the oxidation of chromium from its trivalent to its highly toxic hexavalent form. The aim of this work was the energetic valorisation of tannery sludge through hydrothermal liquefaction process (HTL) that represent an emerging technique for the conversion of wet biomass into liquid fuels by processing it in a hot pressurised water environment (250–350 °C and 40–200 bar), for sufficient time to break down the solid bio-polymeric structure and produce a liquid bio-oil as energy vector. This process aim at the production of energy carriers while allowing to reduce the volume of sludge to be disposed of, saving natural resources (e.g., land in which to dispose of sludge) and generate co-products of potential value (e.g., ash for use in the field of building materials, or as adsorbents in wastewater decontamination processes). Moreover, in this process not aiming at the complete oxidation of the organic component, it is possible to neglect the oxidation of Cr in its hexavalent form. Results show that, it possible obtain a bio-crude yield on dry and free-ash basis of 29.5% with an energy recovery of about 44%. Moreover, the bio-crude is characterised by a higher content of aliphatic compounds than aromatic and amines compounds. Finally, metals after the HTL process, are concentrated mainly in the solid residue and the Cr(VI) content in the solid residue, biocrude and aqueous phase produced during HTL test would not exceed 0.5 ppm. This result confirms the potential use of high chromium content waste (i.e tannery sludge) as energy carriers in the hydrothermal liquefaction process, avoiding the problem of chromium oxidation found in other waste-to-energy process (i.e combustion, gasification).