Hydrothermal Carbonization of Slaughterhouse Waste

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The growing demand for renewable energy sources, coupled with the challenge of managing organic waste safely, has driven recent research toward alternative technologies for converting waste biomass into energy and valuable materials, aligning with circular economy principles and waste-to-energy strategies in chemical engineering [1]. Among these technologies, thermochemical processes, including hydrothermal carbonization (HTC), transform wet biomass into carbon-rich materials. This technology has been gaining increasing attention in recent years due to its low investment and operating costs.

HTC takes place at moderate temperatures (170 – 250 ºC), under self-generated pressure and a subcritical water environment, with residence times varying from minutes to several hours. This process mimics natural coal formation, but at a significantly faster rate, enhancing carbon efficiency and energy densification. Additionally, the process yields a process water (PW) fraction with high organic carbon content, and a gas fraction mainly composed of CO_2 [2].

In this study, two slaughterhouse residues from a farm in Spain, one from raw cowhide (RCH) and another from cow offal (CO), were selected as feedstocks. These materials are characterized by a C content of 46.7% and 61.6%, and ash content of 1.2% and 3.0%, respectively. The lipid composition of the raw materials was evaluated by Soxhlet extraction, yielding 5.6% and 32.6%, respectively. HTC reactions were carried out in a 2.0 L reactor (4530, PARR Instrument Company, USA), at 180, 210 and 240°C, for 60 min, under autogenous pressure, using a feedstock with 14-15% solids. Additionally, acid catalysis was performed using 0.5M acetic acid.

The composition distribution including hydrochar (HC), PW, and the gas phase, is shown in Fig. 1. Moreover, a biocrude fraction was identified among the HTC products from the RCH at 210 ºC, and even at lower temperatures (180 ºC) from the CO. The yield of biofuel products (HC + biocrude) was within 16 – 29% in the HTC of RCH,

while it was in the range of 60 - 67% for the HTC of CO and between 65 – 74% in the acid HTC of CO. This fact was attributed to the higher lipid content of CO, which results in greater biocrude production compared to RCH [3].

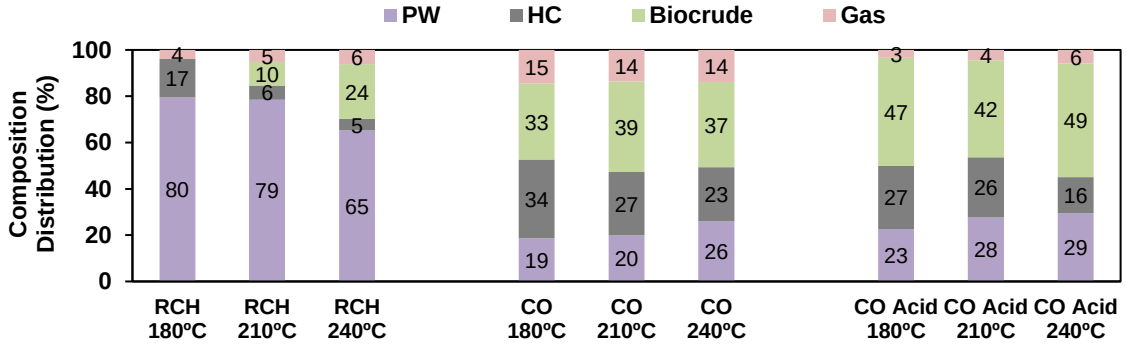

Figure 1. Product distribution of RCH and CO.

Higher heating values (HHV) of HC increased with treatment temperature, being in the range of 25 – 31, 28 – 31 and 30 – 35 MJ/kg for RCH, CO and Acid CO, respectively, while HHV of biocrude were between 35 – 38 MJ/kg in all cases. Energy recovery efficiency (ERE), calculated as the product of hydrochar and biocrude yield and the ratio of the HHV of the HC and biocrude relative to that of the raw material, increased for RCH products with temperature, from 19% at 180 ºC to 42% at 240 ºC. CO products exhibited a far superior ERE (65-70%), although this hardly differs with temperature. The highest ERE in this study was obtained in the acid HTC of CO, achieving 84% at 180 ºC. Both HC and biocrude demonstrated potential as a sustainable alternative for biofuel.

References:

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