HEAT OF REACTION OF HYDROTHERMAL LIQUEFACTION REACTIONS

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Wet waste streams include a wide variety of products such as food processing residues, sewage sludge but also the organic fraction of municipal solid waste. Humidity typically varies from 50 to above 90 %. Dewatering and drying is possible for most feedstocks but at a significant cost. Hydrothermal liquefaction produces a biocrude that can be further upgraded into biofuels. The conversion takes place at temperatures between 250 and 400 °C and at pressures above the saturation pressure to ensure that water remains in the liquid phase, typically above 100 bar [1]. Even though the basic principles of hydrothermal liquefaction are well known, there are still some significant scientific questions and technical issues. One of the important questions that remain is the heat of reaction and the heat balance of the reaction.
Hydrothermal liquefaction is performed in the laboratory in batch reactors and in continuous reactors. Industrial applications are only envisaged in continuous reactors. Most scientific work is performed in batch reactors making it difficult to anticipate the results for industrial applications. Typical reactions that occur are de-polymerisation by hydrolysis (100 to 200°C), carbonisation (200 to 250°C), liquefaction (250 to 400 °C) and gasification (350 °C and upwards).

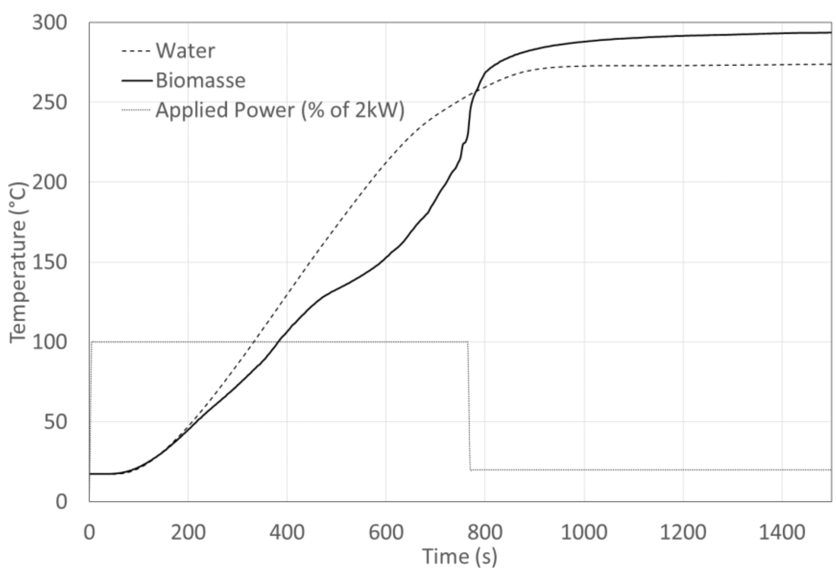

Figure 1 – Temperature response reactor

Figure 1 shows the temperature response of the reactor content with an imposed power. We compare the response of the water biomass mixture with an equal quantity of pure water. The biomass-water mixture is 10% ground blackcurrant pomace in water. The power profile was selected to obtain approximately 300°C with biomass. Precise temperature control is not possible in this case. The difference between the two curved is caused by the reactions taking place in the reactor.

From Figure 1 we can see that the biomass-water mixture heats slower than the pure water content. This is probably due to endothermal de-polymerisation reactions caused by the hydrolysis of the biomass. At about 200°C the biomass water mixture accelerates its heating, compared to the pure water case. During this phase exothermal carbonisation reactions dominate. Above 250°C the hydrothermal carbonisation reactions calm down and liquefaction reactions dominate. In practice the distinction between carbonisation and liquefaction reactions are difficult to make and in reality the frontier is probably not clear cut and difficult to establish.

It is possible to calculate the heat of reaction in the different phases of the experiment. With identical power applied (and assumes identical losses) the biomass case ends up with a higher temperature. This in its own shows that the global reaction is exothermal. The overall heat of reaction is about 0.5 MJ/kg biomass.
This paper presents the results of a study on heat of reaction of the hydrothermal transformation of blackcurrant pomace. The presented results include yield data combined with an energy balance calculated with different techniques.