Effect of feedstock moisture content on the quality of liquids from fast pyrolysis of spruce wood

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The presence of water in biomass influences its behaviour during pyrolysis and affects the physical properties and quality of the pyrolysis liquid. The effects of varying feed moisture content were investigated in a 150g/h rig. The feedstock was spruce; the range of temperatures covered 450-550°C and the range of feed moisture contents from bone dry to 13.4% wet basis. The average vapour residence time varied between 0.48 and 0.56 seconds. The results obtained show that for higher feed moisture contents the maximum liquid yield on a dry feed basis occurs at lower reactor temperatures. For higher pyrolysis temperatures and at higher feed moisture contents investigated it was found that the pyrolysis oil was unstable and phase separated. Bone dry feed material on the other hand led to the production of very viscous oil, particularly at higher reaction temperatures. Finally, the highest liquid yields, around 76%, were found for feed moisture contents between 7-11% and reactor temperatures around 475°C, conditions that also gave the most stable oil and lowest viscosity.

Results and discussion

The results of the pyrolysis experiments with different moisture content spruce and at reactor temperatures from 450?C to 550?C are summarised below, all data are presented on a dry feed basis:

1. As the reactor temperature increased from 450?C to 550?C, the yield of char decreased and the yield of gases increased. The trend was not affected by feed moisture content, but higher moisture content feed leads to lower char yields.
2. Figure 1shows reaction water yield versus reactor temperature and feed moisture content. This shows that water yield decreases with increasing reactor temperature and that higher feed moisture content slightly increases reaction water. This may be due to water evaporation slowing the rate of reaction.
3. Both total liquid and organics give maximum yield on a dry feed basis at a reactor temperature of about 500?C for both bone dry and 7% moisture content spruce (Figure 2). For high moisture content spruce the maximum liquid yield is at 475?C.

Oil water content

The total water content of pyrolysis oil is typically between 15 and 30wt% and originates from the water present in the biomass feedstock and reaction water that is dependent on the process condition [1, 2]. This water content changes with time and is a function of both storage temperature and duration of storage. All oil water contents were therefore tested at the same time after oil production. Oil water content decreases at higher reactor temperatures and increased feed moisture content leads to higher oil water content.

Oil viscosity and stability

Figure 3 shows the viscosity of fresh bio-oil, 24 hours after production. This is the bio-oil sample derived from the collections pot at the base of the electrostatic precipitator and represents about 85-90% of the total liquid produced. The viscosity of the bio-oil is known to increase under storage and this is known as instability. Viscosity and stability measurements were therefore always taken at the same time after production (24 hours) and under identical conditions of temperature and storage. Both high reactor temperatures and low feed moisture leads to increased oil viscosity.

The stability of bio-oil is measured by the established Viscosity Index (VI) [3]. Figure 4 shows the VI value of bio-oil from different feed moisture contents. The highest (11.3%) moisture content feed

produced at the highest temperatures phase separated, making the determination of a viscosity index impossible. For the lowest moisture content spruce (bone dry spruce) the VI is also relatively high, particularly at higher reactor temperatures. Moderate moisture contents (5%-10%) show better stability, though again less so at higher reactor temperatures. The stability of the oil therefore appears to decrease with increasing reactor temperature. In addition, it was found that there was an optimum feed moisture content with regards to stability of 7-11%, and an optimum temperature of 500°C for maximising liquid and organic yield.

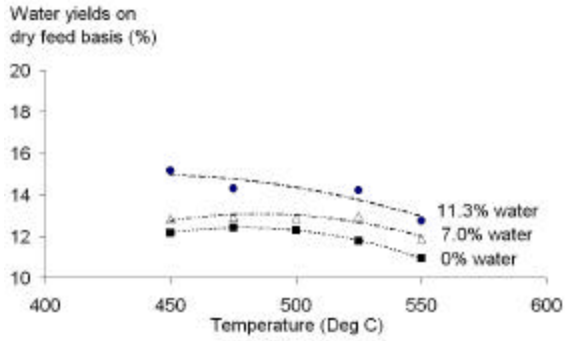

Figure 1 Water yields (water from reaction only) versus reactor temperature for spruce with different moisture content

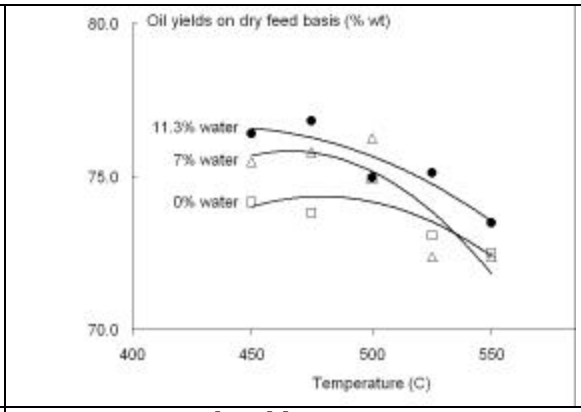

Figure 2 Bio-oil yields versus reactor temperature for spruce for different feed moisture contents

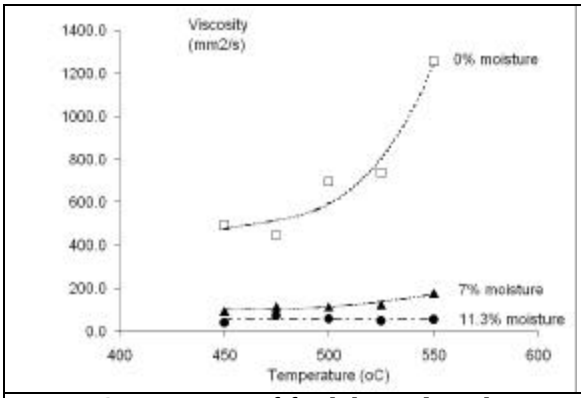

Figure 3 Viscosity of fresh bio-oil, 24 hours after collection, versus reactor temperature

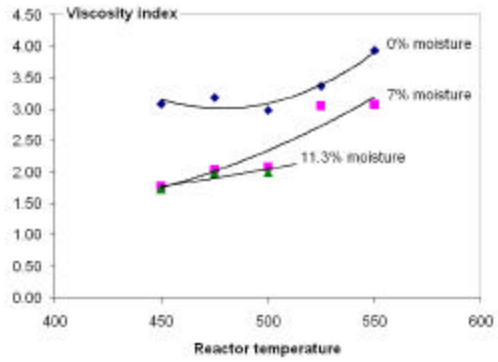

Figure 4 VI value versus reactor temperature for different moisture content spruce

Acknowledgement

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