Fast pyrolysis processing of rape straw from Spain

Daniel Nowakowski of Aston University, UK and Natalia Gómez Marín of IRENA, University of León, Spain report back on Natalia's visit to Aston University and the conclusions of the experiments conducted during her BRISK experience.

Figure 1: Rape straw harvest.

Large amounts of residual straw are generated every year and this waste can be a potential resource for chemical production and energy generation. Thermal conversion of the straw can provide useful products and helps to reduce waste accumulation. Agricultural residues can be processed by thermochemical conversion including pyrolysis, gasification and combustion.

Aston University bioenergy researchers with the collaboration of engineers from the University of León, Spain investigated the impact of pyrolysis temperature on the quality of rape straw fast pyrolysis derived bio-oil. The rape straw was delivered from Villaturiel in the Province of León. Biomass was characterised using a wide range of analytical techniques including thermogravimetric analysis (TGA) and analytical pyrolysis (Py-GC-MS). Bio-oil was produced using a 1 kg/h fast pyrolysis reactor.

The experiments were carried out at four different reaction temperatures (450, 480, 510 and 550°C). Bio-oil quality was defined by its stability measured by a viscosity index, a water content index and analysis of phase separation. The normalised fast pyrolysis mass balances are shown in Figure 2. This clearly shows the differences in pyrolysis yields between different pyrolysis temperatures. The organic liquid yield was highest for rape straw processes at 450°C.

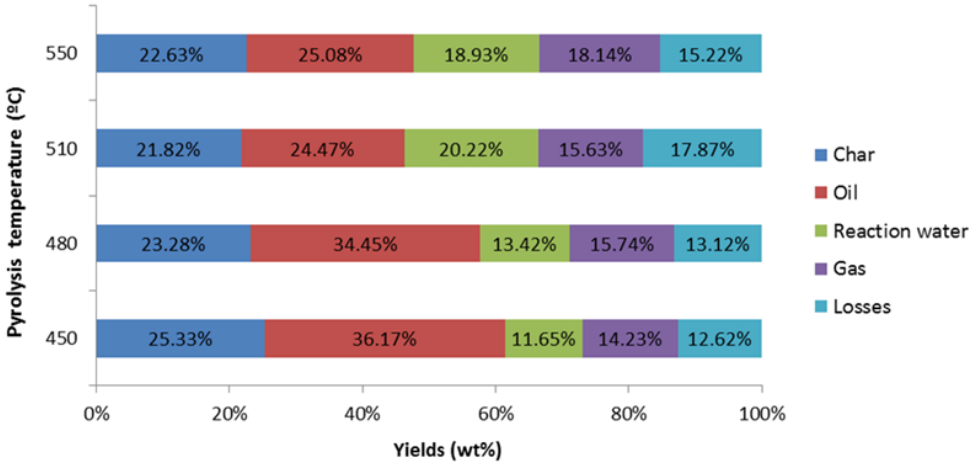

Figure 2: Mass balances (on dry basis) for rape straw pyrolised at different temperatures.

The properties of the bio-oil are affected by feedstock variation, production processes, reaction conditions, and collecting. In this study, all experiments were carried out under similar conditions, and the only

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Fast pyrolysis processing of rape straw from Spain...*continued*

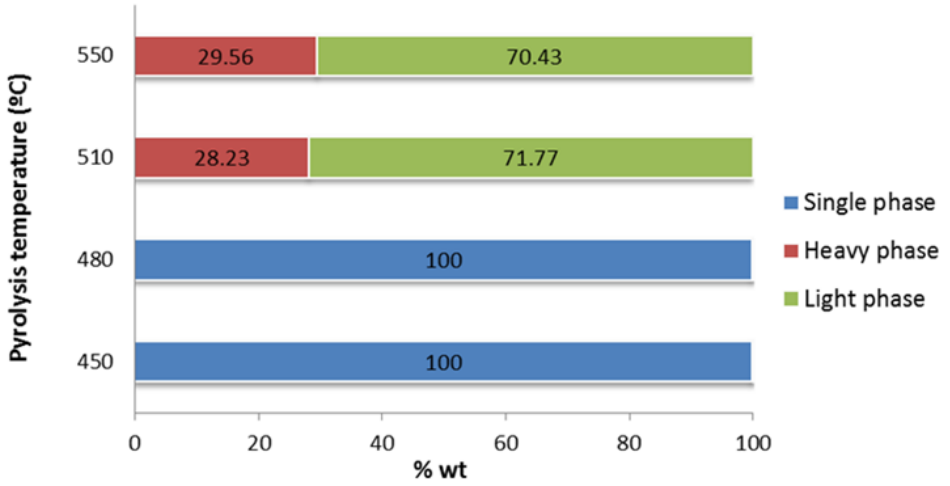

Figure 3: Bio-oil quality after the fast pyrolysis experiments.

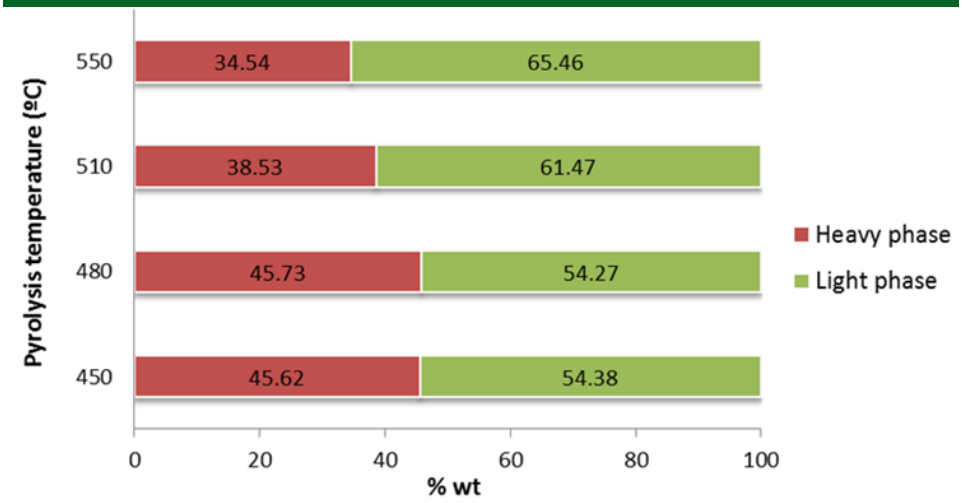

Figure 4: Percentage share (wt.%) for phase separated light and heavy bio-oil fractions after the accelerated storage experiment.

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exception was the pyrolysis temperature. It was found that the bio-oil produced at 450 and 480ºC was a single-phase product. Phase separation occurred when rape straw was pyrolysed at 510 and 550°C.
Figure 3 shows the percentage of each phase depending on the pyrolysis temperature.

For the purpose of measuring bio-oil stability, accelerated storage tests were performed at 80°C for 24 hours, which is claimed to simulate degradation at ambient temperatures for one year. The whole bio-oil from the 450 and 480°C runs and the heavy fraction from the 510 and 550°C runs were assessed for stability. Figure 4 shows the results for phase separation after the accelerated storage experiment.

Conclusions

- Pyrolysis temperature impacts the bio-oil quality and stability. Fast pyrolysis processing of rape straw up to 480°C gives the highest organic yield with a single-phase bio-oil with a low water content.
- Accelerated storage experiment revealed that rape straw bio-oil undergoes phase separation during long storage, thus this type of bio-liquid should be used or upgraded immediately after its production.