Fast pyrolysis of biomass in a fluidized bed reactor: in-situ filtering of the vapors.

Elly Hoekstra*, Kees Hogendoorn, Xiaoquan Wang, Roel J.M. Westerhof, Sascha R.A. Kersten, Wim P.M. van Swaaij, Michiel Groeneveld
University of Twente, Faculty of Science and Technology,
P.O. Box 217, 7500 AE Enschede, The Netherlands
*Corresponding author: E.Hoekstra@tnw.utwente.nl, tel: +31 534894635, fax: +31 534894738

Abstract

A system to remove in-situ char/ash from hot pyrolysis vapors has been developed and tested at the University of Twente. The system consists of a continuous fluidized bed reactor (0.7 kg/h) with immersed filters (wire mesh, pore size 5 μm) for extracting pyrolysis vapors. Integration of the filter system in the fluidized bed should overcome operational problems related to the increase in pressure drop across the filter in time and a decrease in oil yield as typically observed in downstream pyrolysis vapor filtration and leads to process intensification. In this study the effect of in-situ hot pyrolysis vapor filtration has been studied with respect to process stability, products yields and product quality. Oil obtained via a more conventional cyclone system placed in parallel to the filter system served as reference for the quality and yields of the filtered oil. Good process stability concerning temperature and pressure drop across the hot gas vapor filter was achieved during a two hour run, even when using a re-used filter. Particles (char/sand) were retained inside the filter pores located at the outside surface of the filter, while the inside of the filters remained clean apart from some deposits formed on the metal wire and small 1 μm particles which slipped through the filter. Mass balance closures higher than 94 wt% were obtained. Comparable yields (cyclone + filtered oil) were obtained as in the experiments carried out with only the cyclones. The filtered oil contained significantly less solids, alkali metals and ash as compared to cyclone oil. For the alkali metals, only a considerable amount of potassium (K) was still present in filtered pyrolysis oil, which most likely entered the filtered oil via the vapor phase. There were no significant differences in the elemental composition of the oil produced via the filter line and cyclone line. The molecular weight of the filtered oil obtained with non-dried feed was always lower as compared to the cyclone oil (ΔM_w ~ 20 g/mol). Results of the aging tests show that the reactivity of pyrolysis oil can already originate from the highly reactive components in pyrolysis oil itself and does not need the presence of char/ash. To show the intrinsically high reactivity of solids free pyrolysis oil vapors, an external filter section (1 μm pore size) was placed additionally and in series with the filter inside the fluidized bed. The results show that char is formed from the reactive pyrolysis vapors.