

CATALYTIC FAST PYROLYSIS OF BIOMASS: IS IT A WAY TO GO?

G. Yildiz^a, M. Pala^b, F. Ronsse^b, W. Prins^{*b}

* corresponding author: wolter.prins@ugent.be

^aDepartment of Energy Systems Engineering, Izmir Institute of Technology, Izmir, Turkey

^bDepartment of Green Chemistry and Technology, Ghent University, Ghent, Belgium

Pyrolysis is an essential step in dry-biomass conversion processes like combustion, gasification, fast pyrolysis, carbonization and torrefaction. Depending on the applied conditions, products are distributed in various proportions over a gas phase, a liquid phase and a solid phase. Fast pyrolysis (FP) is aiming at a maximum liquid (bio-oil) production, which is achieved by rapid heating of small biomass particles to temperatures of around 500 °C. Catalytic fast pyrolysis (CFP) is meant for a significant removal of oxygen and cracking of the high molecular weight compounds present in the primary pyrolysis vapors. This can be done either by adding catalyst particles to the pyrolysis reactor (in situ), or by ex situ treatment of the vapors in a secondary fixed bed reactor.

In CFP research, the intention of catalyst development is to suppress the formation of coke, water, and gases other than CO₂, and to increase the yield of a hydrocarbon fraction that can be used for co-feeding refinery units in the production of transportation fuels. An early report from NREL [1] already showed that fast pyrolysis oil can be upgraded by hydro-deoxygenation (HDO) at a very competitive price compared to other biomass-to-fuel technologies, despite its significant hydrogen consumption. Catalytic pyrolysis could perhaps reduce the need for HDO upgrading up to a considerable level. The concept has been introduced already into the IH2 process developed by GTI, Chicago [2] and licensed to CRI Catalyst Company (Shell Group). But here hydrogen pressure is applied to a CFP fluid bed reactor which is then connected to a fixed bed reactor for further HDO upgrading of the vapors. While catalytic hydro-pyrolysis (hydrogen pressures of up to 50 bar) is currently drawing the attention of academic institutions [3], atmospheric CFP has been under investigation already over a decade. However, the attempts by KIOR [4] to demonstrate / commercialize CFP technology in a multi-million project, were much too hasty and failed miserably in 2015.

Screening in Py-GC/MS (µg to mg scale) indicated the potential of various catalyst types for promoting the conversion of fast pyrolysis vapors to aromatic compounds. However, continuous bench-scale and (occasional) pilot scale testing (kg scale) with zeolite based catalysts have shown poor results: de-oxygenation of the pyrolysis vapors appears to go along with a progressive reduction in organic liquid yield. Apart from any control over the catalyst activity, selectivity and lifetime, the other critical issue is in the process design which is complicated by the rapid catalyst deactivation through coke-on-catalyst formation and catalyst poisoning by the biomass minerals.

This presentation will first briefly discuss the status of the fast pyrolysis technology and the possible bio-oil applications, but then focus further on biofuels production opportunities. Here, the emphasis will be on how to apply heterogeneous catalysis in fast pyrolysis for promoting the production of hydrocarbon compounds. Results from the literature and own experimental work will be reviewed, and possible CFP process configurations discussed. The intention is to arrive at a conclusion with respect to the overall question of how realistic it is to add catalysts to an atmospheric fast pyrolysis process. Considering prior backsets, is there a way forward?

References

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