CONTINUOUS COPROCESSING OF BIOMASS WITH WASTE PLASTIC BY FAST AND CATALYTIC PYROLYSIS

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Bio-oil produced from fast pyrolysis of lignocellulosic biomass has long been considered as a viable intermediate to producing drop-in hydrocarbon transportation fuels to contribute to the transition away from climate damaging fossil fuels. However, the stochiometric reality of converting the highly oxygenated and hydrogen deficient biomass to hydrocarbons means that yields would be limited without the addition of hydrogen at some point in the pyrolysis and/or upgrading steps. The most common source of this hydrogen is from reforming of fossil sourced methane (natural gas), which adds expense and decreases sustainability. An alternative that may help increase pyrolysis yields is to supplement the biomass feedstock with an inexpensive carbon and hydrogen rich material, and waste plastics are such a material. Although the plastic waste is also a fossil-derived resource, a preliminary life cycle analysis indicates that a pyrolysis feedstock blend of biomass and up to approximately 15% waste plastic (polyolefins) would qualify for proposed US incentives for production of sustainable aviation fuel.

In this presentation we will discuss results of continuous fast pyrolysis of biomass and waste polyolefins in a fluidized bed reactor with and without an additional pre-condensation *ex situ* catalyst step. Initial experiments were conducted with a blend of switchgrass and used polyethylene hay bail covers being disposed of by a local farm. A comparison of the yields and oxygen content of the bio-oils produced via fast pyrolysis at 650 °C is shown in Table 1. GC/MS analysis of the fast pyrolysis indicates in addition to a blend of oxygenated products derived from the switchgrass and straight chain alkanes and alkenes from the thermal depolymerization of PE, the bio-oil contained a higher concentration of alkyl phenols than observed from switchgrass alone including the presence of C3 and greater alkyl substituents on the phenolic rings. The liquid products also contained a small amount of waxes from partial depolymerization of the polyethylene. Diffusion NMR analysis (Figure 1) of the pyrolysis liquids indicated that the molecular weight distribution was narrower than found in biomass-only pyrolysis oils produced at this temperature. An initial test with HZSM-5 loaded in the *ex-situ* reactor produced an organic liquid composed almost exclusively of aromatic hydrocarbons. At a WHSV of approximately 2h^{-1} little signs of catalyst deactivation were found at cumulative biomass to catalyst mass ratios of up to 4/1, although coke was deposited on the catalysts accounting for about 5 wt% of the input feed.

Table 1. Carbon yields (%) from co-pyrolysis and oxygen content (wt%) of py-oil at 650 °C

Feed	Switchgrass	Switchgrass/PE (85/15)	Switchgrass/PE (85/15)
Catalyst/Temp	--	--	HZSM-5/500 °C
Py-oil	23.2	21.3	11.7
Wax	--	0.9	0.0
Char	12.8	6.0	5.4
Coke	--	--	9.0
Py-oil O (wt%)	25.2	20.6	8.9

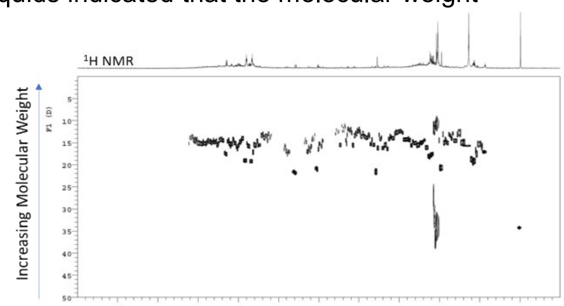

Figure 1. Diffusion NMR plot for pyrolysis oil produced from switchgrass/PE blend at 650 °C

A high pyrolysis temperature was chosen for the initial experiments to ensure complete depolymerization of the PE and avoid build up of wax in the system. This led to high cracking activity and a modest liquid product yield, but the quality was significantly enhanced compared with pyrolysis of biomass alone at this temperature. Further experimentation to be presented will optimize the balance of yield, operational efficiency and product quality. As part of this presentation, we will discuss not only the effect of process variables such as feedstock variation, temperature, catalyst, and loadings but also the lessons learned for operability of a fluidized bed reactor for mixed biomass and plastic waste applications. Detailed chemical and physical property analysis and assessment of the pyrolysis liquids for suitability for upgrading to sustainable aviation fuel and co-products will also be discussed.