NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NREL is a national laboratory of the U. S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

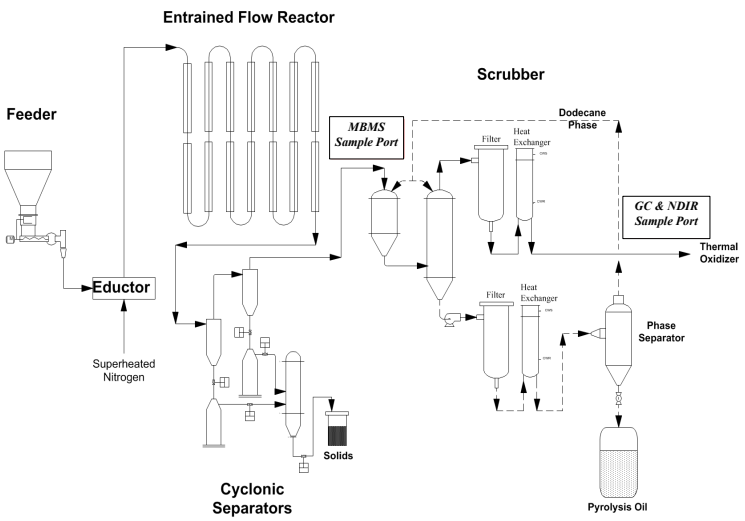
# Comparing effects of feedstock and run conditions on pyrolysis products produced at pilot-scale

Esther Wilcox, Katie Gaston, Tim Dunning
National Renewable Energy Lab

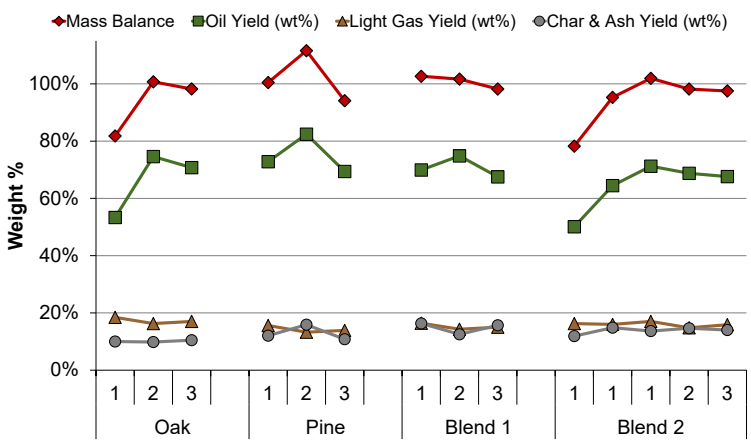
## Abstract

Fast pyrolysis is a promising pathway for mass production of liquid transportable biofuels. The Thermochemical Process Development Unit (TCPDU) pilot plant at NREL is conducting research to support the Bioenergy Technologies Office's 2017 goal of a $3 per gallon biofuel. In preparation for down select of feedstock and run conditions, four different feedstocks were run at three different run conditions. The products produced were characterized extensively. Hot pyrolysis vapors and light gasses were analyzed on a slip stream, and oil and char samples were characterized post run.

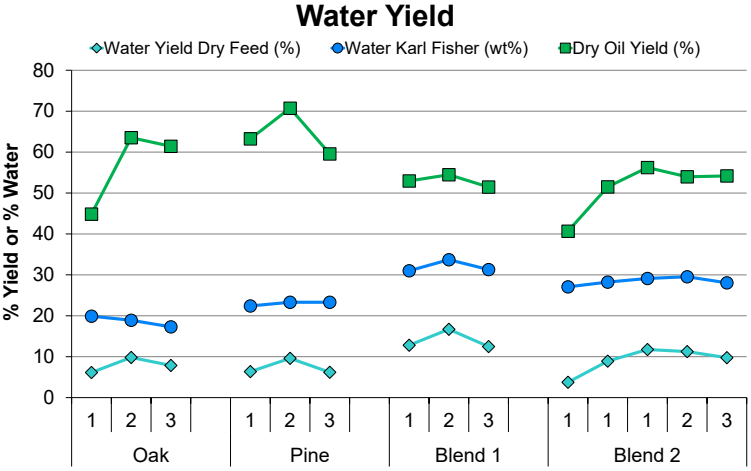
## TCPDU Process Flow Diagram – Fast Pyrolysis




## Mass Balance & Product Yield Results




## Water Yield




## Experimental Description

Prior to each feedstock tested, the scrubber was drained and loaded with fresh dodecane. The runs conducted lasted ~2-4 hours, sufficient time to collect 5 gallons of pyrolysis oil and MBMS spectra. After each condition, the scrubber was allowed to circulate overnight and remaining oil in the vessels and low points was collected prior to the next run.

Each of the 12 zones of the entrained flow reactor are independently controllable. To achieve different residence times while maintaining a 15 kg/hr biomass and nitrogen feed rate, the first zones were set to the reaction temperature, while the remaining zones were lowered to 400°C, the temperature of the downstream heat-tracing.

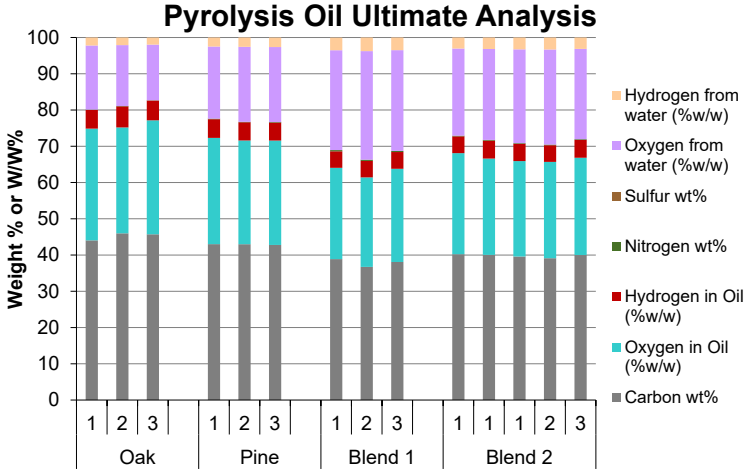
## Feedstock Properties

| Feedstock | %Volatile | %Ash | %Carbon | %Oxygen |
|---|---|---|---|---|
| Oak | 85.3 | 0.57 | 48.7 | 44.9 |
| Clean Pine (CP) | 83.7 | 0.65 | 51.4 | 41.8 |
| Switchgrass (SG) | 76.2 | 7.60 | 45.1 | 40.8 |
| C&D material (C&D) | 83.3 | 0.99 | 50.4 | 42.0 |
| Forest Residues (FR) | 74.7 | 4.03 | 51.4 | 38.6 |
| Blend 1 $CP_{30}FR_{35}C\&D_{25}SG_{10}$ | 79.7 | 2.61 | 50.5 | 40.6 |
| Blend 2 $CP_{45}FR_{25}C\&D_{30}$ | 81.3 | 1.60 | 51.1 | 41.1 |

## Operating Conditions

| Condition Number | Reaction Temperature (°C) | Number of Reactor Zones | Residence Time (s) |
|---|---|---|---|
| 1 | 500 | 12 | ~3.5 |
| 2 | 480 | 12 | ~3.5 |
| 3 | 500 | 9 | ~2.6 |

## Pyrolysis Oil Ultimate Analysis




## Conclusions

These runs demonstrated that the TCPDU system can be effectively used for a variety of feedstocks and operating conditions. All oil yields were above 50%. The results indicate that the pyrolysis oil properties are affected more by the feedstock used, rather than operating conditions.

The replicate tests conducted show an increase in oil yield for each test. It is likely that the short run time results in oil collecting in filters and other locations within the condensation train. More recent extended runs showed a high consistency in oil yield from day to day, further indicating that the condensation train requires several hours to reach stable operation.

This work was funded through Department of Energy's Bioenergy Technology Office WBS 2.4.1.301


*Advanced Materials, Technologies, Systems and Processes*
*San Francisco, California*
*April 2-6, 2017*
NREL/PO-5100-70215