Bioenergy value chains 4: pyrolysis and torrefaction

Feedstock

For pyrolysis any lignocellulosic material is suitable as feedstock. The term lignocellulosic covers a range of plant biomass containing cellulose, with varying amounts of lignin, chain length, and degrees of polymerization. This includes wood from forestry, short rotation coppice (SRC), crops residues (such as straw), and lignocellulosic energy crops, such as energy grasses and reeds. Biomass from dedicated felling of forestry wood is also lignocellulosic but is not considered sustainable.

Torrefaction

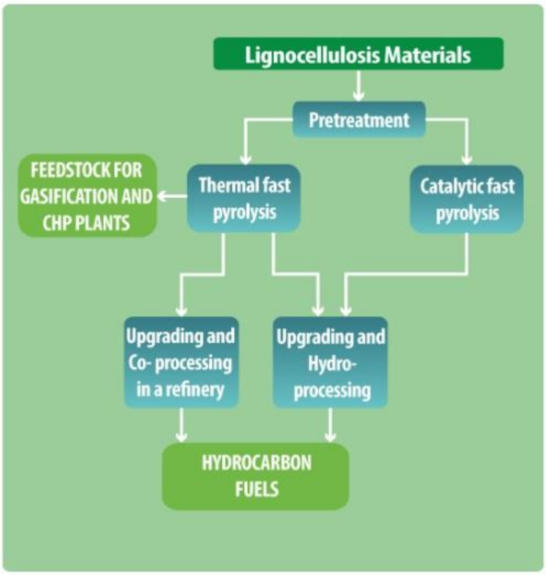
Torrefaction is a thermochemical process typically at 200-350 °C in the absence of oxygen, at atmopsheric pressure with low particle heating rates and a reactor time of one hour. The process causes biomass to partly decompose, creating torrefied biomass or char, also referred to as “bio-coal”. Bio-coal has a higher energy content per unit volume, and torrefaction followed by pelletisation at the harvest sites facilitates transport over longer distances. It also avoids problems associated with decomposition of biomass during storage. Hence the benefits of torrefaction may outweigh the additional cost in many cases.

Pyrolysis

Pyrolysis is the chemical decomposition of organic matter by heating in the absence of oxygen. The biomass decomposes into vapour, aerosols, and char; the proportions of these three states depend on temperature and duration of the pyrolysis. Two alternatives are thermal and catalytic pyrolysis.

The decomposition into a liquid fraction is of particular interest currently as the liquids are transportable and storable. The highest yield of liquid fraction is obtained by thermal fast pyrolysis.

Figure 1: Pyrolysis and torrefaction value chain



Intermediate products

Char coal (also called bio-coal)

Torrefied pellets

Bio-oil (also called bio-crude oil)

Fast pyrolysis takes 1 to 2 seconds at around 500°C. In preparation, the biomass needs to be dried to typically less than 10% water and crushed to particles of less than 5 mm. The heating medium is typically sand, but also catalyst has been used. The biomass decomposes into organic vapours, non-condensable gases, pyrolysis water, and char. When the gaseous components cool down and condensate, a dark brown mobile liquid is formed, called bio-oil. Organic bio-oil is obtained in yields of up to 65%wt on dry feed basis. The by-products char and gas are used within the process to provide the process heat requirements so there are no waste streams other than flue gas and ash. Lower yield but a higher quality bio-oil is generated in catalytic fast pyrolysis, where catalyst in-stead of sand is used as a heating media.

Bio-oil has a heating value about half that of conventional fuel oil. It can currently be used to replace natural gas or heating oil. In the future it may be upgraded and co-fed in existing refineries into advanced biofuels that have the same combustion properties as conventional fossil transport fuels.

Further information

Read up-to-date information about the thermochemical conversion technology at www.biofuelstp.eu.

Example projects torrefaction and pyrolysis

Pilot

Bioliq	Fast pyrolysis of biomass followed by gasification; producing biogasoline via DME; run by Karlsruhe Institute of Technology (Germany); operational since 2014
PYTEC	German company working on development of pyrolysis since 2002. 1st pilot plant started in 2006 delivering bio-oil to a block CHP
UPM/ Metso/ Fortum/ VTT	Finnish consortium testing a pilot reactor; delivering bio-oil to a district heating plant; operated in 2009-2011

Demo

Topell Energy	Dutch plant constructor offering torrefaction technology; running a demo plant in the city of Duiven since 2010

First-of-a-kind commercial

Fortum	producing bio-oil in the Finnish city of Joensuu; delivered to heating plants since 2013
Empyro	producing bio-oil; run by BTG-BTL (Netherlands); production since 2015
Ensyn	producing bio-oil in Ontario, Canada since 2008