Thermal Conversion of Inedible Vegetable Oils to Aromatics

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1. Introduction

- Global demand of aromatic compounds like Benzene, Toluene and Xylene (BTX) could rise ~25% in the next 6 years.
- BTX is highly valuable because the compounds wide variety of applications including styrene and nylon
- A renewable and sustainable feedstock for BTX is preferable to using indefinite fossil fuel feedstocks
- Vegetable oils could be a potential source, as literature suggests they could yield aromatics via catalytic thermal conversion.
- In literature using catalytic pyrolysis with Jatropha oil in tubular, batch, and fixed bed reactors yielded liquid products containing between 33 and 78 wt.% aromatics.
- However, no studies have been found using continuous fluidised bed systems to process inedible oils.

2. Aims and Objectives

- Commissioning of a fluidised bed reactor, to pyrolyse Jatropha oil.
- Characterisation of *Jatropha* oil feedstock.
- Characterisation of pyrolysis products, focusing on identification of compounds that could yield aromatics.

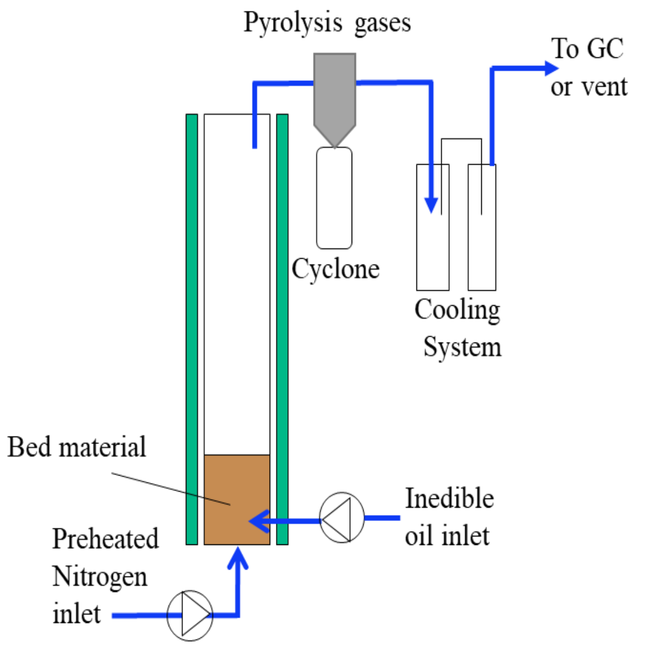

Figure 1. Schematic of Fluidised Bed Fast Pyrolysis Reactor

3. Materials & Methods

Pilot tests, pyrolysing *Jatropha* oil took place in a bubbling fluidised bed reactor (**Figure 1**).
Reactor conditions were 450ºC, 90 g h^{-1} flowrate with a silica sand bed material (250-355 µm) for ~30minutes. Characteristics of *Jatropha* oil and pyrolysis products including pH, viscosity, and heating value were determined and compared. The composition of *Jatropha* oil and pyrolysis liquids were determined by GC-MS analysis.

4. Results and Discussion

Figure 2 shows the mass balance results from 2 experiments. The product distribution was liquids (~88.4%), followed by a small fraction of gas (~6.0%) and minor solids fraction (~1.0%). A comparison of some initial characteristics of the properties of raw *Jatropha* oil and pyrolysis liquid products is in **Table 1**.

Table 1. Jatropha oil and pyrolysis liquid properties

Characteristic	Jatropha Oil	Pyrolysis Liquids
Viscosity (mPa.s)	56.4	21.0
Higher Heating Value (MJ/kg)	39.73	40.74

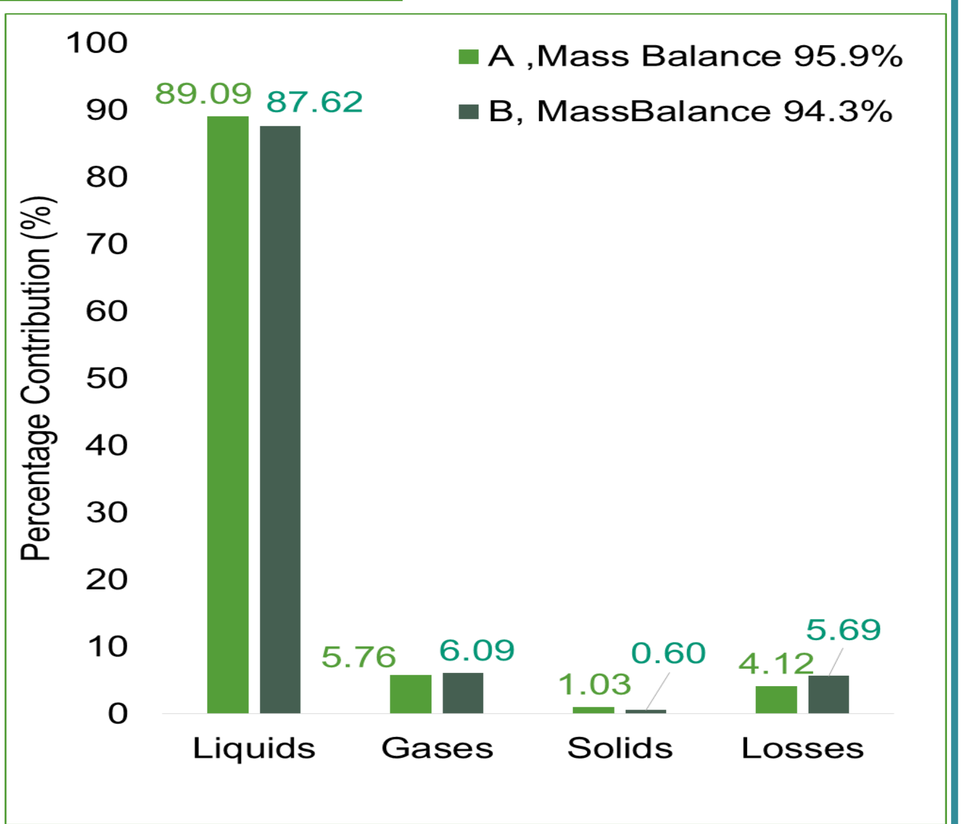

Figure 2. Mass balance and pyrolysis product distribution

The evident changes are decrease in viscosity and marginal increase in higher heating value. The changes have been attributed to cracking of large molecules in *Jatropha* oil such as palmitic, oleic, and linoleic acids and a potential decrease in oxygen content respectively.

The GC-MS analysis of the pyrolysis liquid product is in **Figure 3**, whereas components of interest such as esters, fatty acids and aldehydes are listed in **Table 2**.

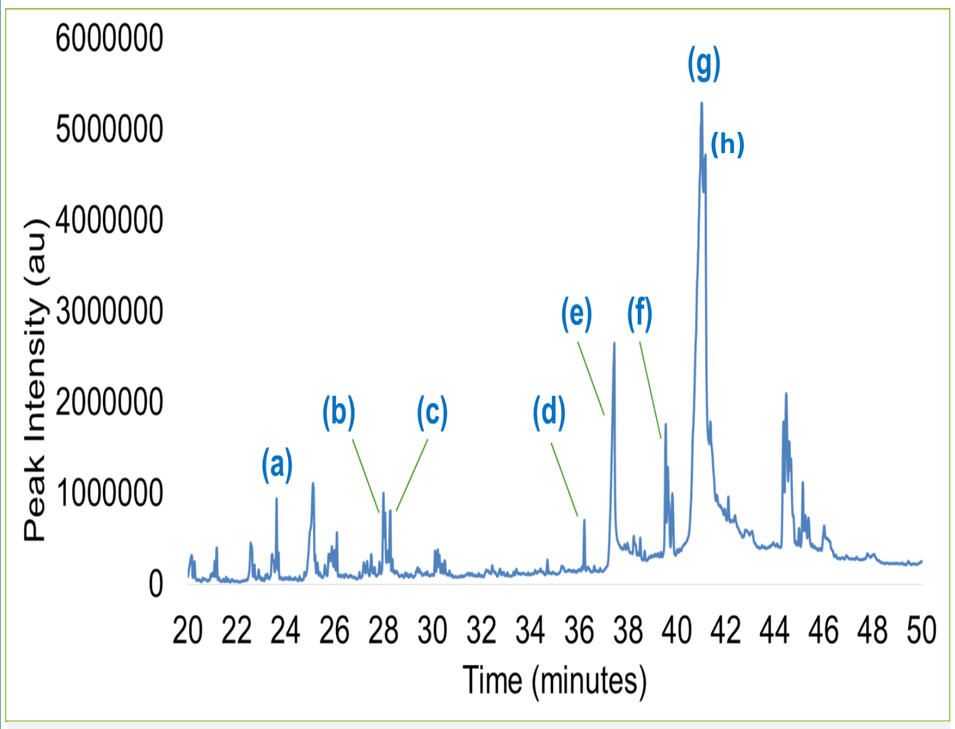

Figure 3. GC-MS Analysis of Liquids from Jatropha Oil Pyrolysis at 450 °C

Table 2. Significant GC-MS compounds Identified From Pyrolysis Liquids

Peak	Compound	Group/ Formulae
a	Oxirane-Dodecyl	Epoxide, $C_{14}H_{28}O$
b	Linoelaidic acid	Fatty Acid, $C_{18}H_{32}O_2$
c	(Z)-13-Octadecenal	Aldehyde, $C_{18}H_{34}O$
d	cis-13-Eicosenoic acid	Fatty Acid, $C_{20}H_{38}O_2$
e	**Palmitic Acid**	Fatty Acid, $C_{16}H_{32}O_2$
f	Z-7-Octadecen-1-ol acetate	Acetate Ester- $C_{20}H_{38}O_2$
g	**Oleic Acid**	Fatty Acid, $C_{18}H_{34}O_2$
h	**Linoleic Acid**	Fatty Acid, $C_{18}H_{32}O_2$

These components shown in **Figure 3** and **Table 2**, have the potential to yield aromatics including Benzene, Toluene and Xylene, via reactions promoted by the use of zeolite-based catalysts during pyrolysis.

5. Conclusions and Future work

- Esters, fatty acids and aldehydes were identified in the liquid product from pyrolysed Jatropha oil, some of these compounds could give aromatics, including BTX in the presence of catalyst.
- Further investigations will focus on catalytic pyrolysis using ZSM-5 zeolites over a varied temperature range.
- Pyro/GC-MS will use linoleic or oleic acid as model compounds to depict decomposition routes

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