Co-pyrolysis of Date Seeds and Plastic Waste for Bio-Oil Production via Fixed Bed Reactor

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INTRODUCTION

Our main objective is to replace fossil fuels which are the main contributor to air and water pollution that causes many serious diseases by using biomass that is considered as one of the most common alternative energies available. Using plastic wastes and date seeds to produce bio-oil which has been proven to be a competitive fuel compared to fossil fuels since it is biodegradable, safer and has lower emissions to the environment. Our project focuses on designing a system that produces bio-oil from a thermal process called pyrolysis that occurs with the absence of oxygen using a fixed bed reactor.

BACKGROUND

Biomass sources go through different processes to produce different types of energy and fuels. There are different types of biomass conversion process for energy production such as, chemical, biological and thermochemical. Biomass pyrolysis is considered as the most convenient thermochemical conversion process among all the conversion processes existing. It is defined as a thermal decomposition of biomass that occur at a certain temperature in a complete absence of air and oxygen. Biomass pyrolysis products are liquid bio-oil, solid bio-char and gases such as methane, hydrogen, carbon monoxide and carbon dioxide. Therefore a large range of biomass feedstock can be used in pyrolysis as long as it contains around 10% moisture content since the increase of moisture content leads to the risk of producing dust instead of oil. The amount of each product depends mainly on residence time, temperature, particle size and biomass used. There are three different pyrolysis technologies. Slow pyrolysis is an old process that occur at a very low heating rate which leads to producing high amount of solid char while fast pyrolysis is better for liquid bio-oil production since it happens at a higher heating rate than the slow pyrolysis.

CONCLUSION

By experimental approach, we can conclude that the production of bio-oil increases with the increase of plastic wastes used and operating temperature. Maintaining a constant feedstock ratio while increasing the temperature resulted in an increase in the bio-oil yield. We reached our goal which is replacing fossil fuels with better alternatives such as bio-oil since the heating value obtained was close enough to the fossil fuel's heating value, around 41 MJ/kg.

THEORY / METHODS

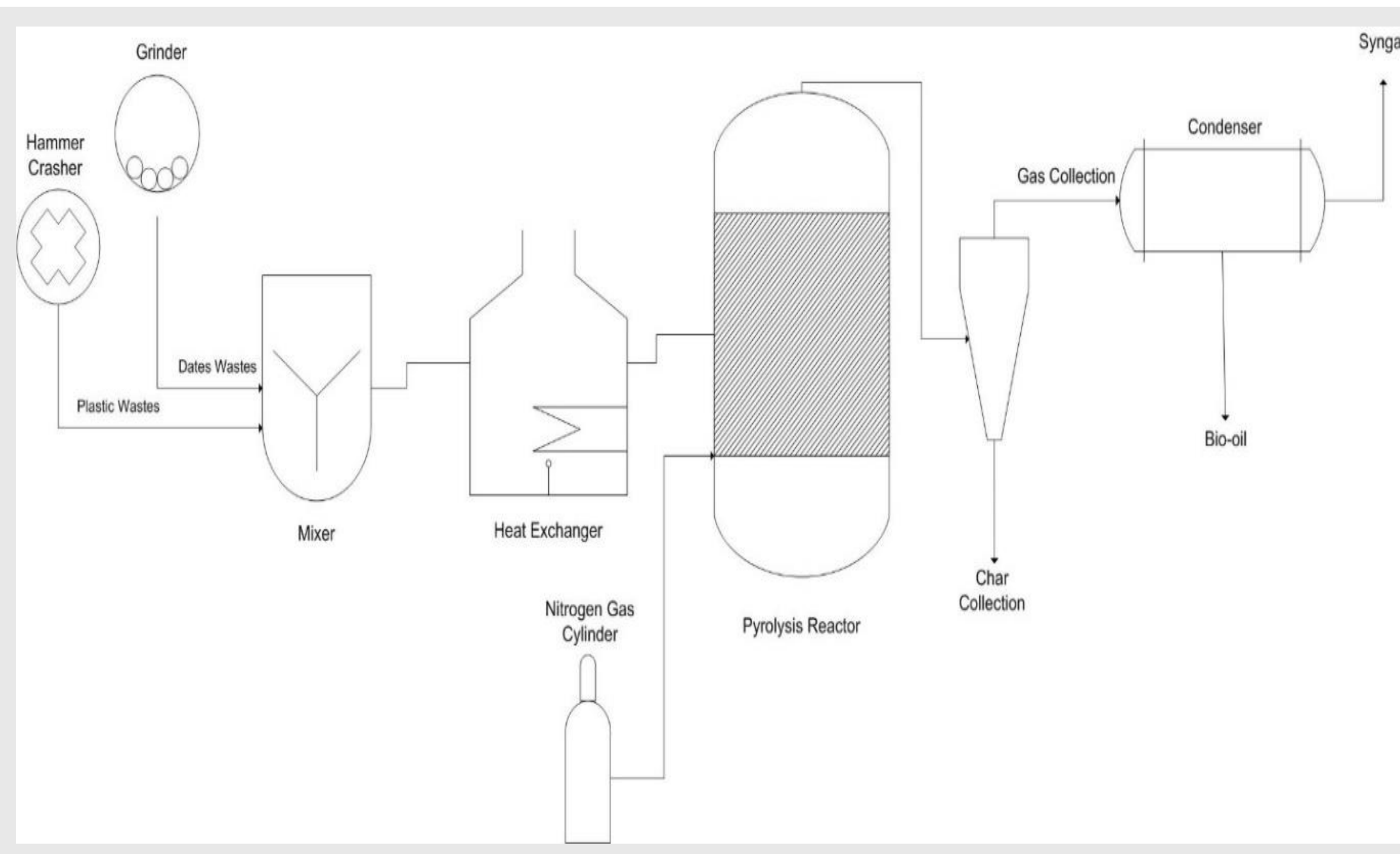
A fixed bed reactor was used to perform the experiment which is one of the conventional most common methods used for pyrolysis. A typical Fixed Bed reactor consists of the following basic units: drying, granulation, heating, and cooling. Fixed Bed reactors are usually made of steel, firebricks, or concrete. They are suitable for production of fuels that are uniform in size and have low fines content, also they are mostly used for charcoal making. We designed a list of five experiments that we will perform via fixed bed reactor. We chose the parameters that we will conduct our experiments according to the change of them with response to products yield. The two parameters are: Operating Temperature (Celsius) and Plastic Ratio (%). Since we will use fast pyrolysis; the temperature range from 300-500 degrees and the plastic ratio is from 30% to 70%.

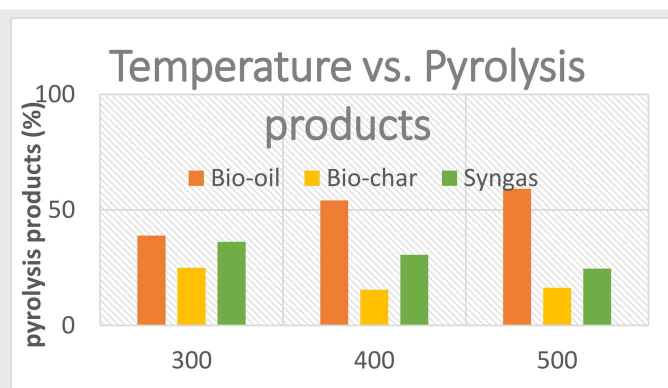
SETUP, EXPERIMENTAL

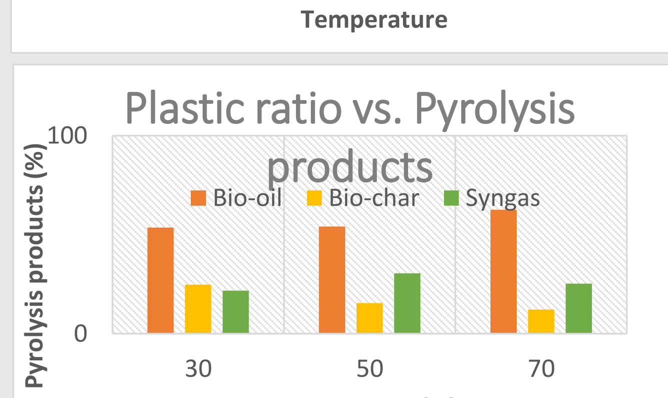
The first step in the process is to reduce the size of the feedstock. For the date seeds we will use a grinder and a crasher will be used for the plastic wastes size reduction. The second step is to remove the moisture content from the biomass by drying it. The plastic wastes and date seeds will be used as a blend to produce bio-oil, so a mixer is needed. The torrefaction process will be performed in a heat exchanger working with solar energy to enhance the biomass properties. The biomass will be introduced in the reactor that works with fixed bed technique and further optimization of the parameters will occur to produce the highest yield of our main product which is bio-oil.

RESULTS

The first three experiments were operated at 50% feedstock ratio and from a temperature of 300 to 500 degrees Celsius. The results showed that the bio-oil produced increased with the temperature and the percentage of the bio-oil produced in the first three experiments is equal to 38.85%, 54.06%. and 59.16% accordingly. As for the 4th experiment it was operated at temperature of 400 degrees Celsius, and the feedstock ratio was changed to 70% date seeds and 30% plastic and this resulted in a bio-oil yield of 53.5% while the 5th experiment was operated at 400 degrees Celsius and the feedstock ratio was changed once more to 30% date seeds and 70% plastic. This resulted in the obtaining the highest bio-oil yield compared to all the experiments with 62.6%.







	Bio-oil (%)	Bio-char (%)	Syngas (%)
Exp 1	38.85	24.97	36.17
Exp 2	54.05	15.40	30.54
Exp 3	59.16	16.29	24.54
Exp 4	53.53	24.68	21.77
Exp 5	62.57	12.14	25.28

DISCUSSIONS

The chart illustrates the effect of temperature on the pyrolysis products with a constant ratio of plastic 50%. As the temperature increases the amount of bio-oil yield increases while the bio-char content decreases. From the chart the highest bio-oil yield and the lowest bio-char content occurred at 500°C and 50% ratio of plastic. Also, the syngas decreased as the operating temperature increased. The second char studies the effect of ratio of plastic wastes on the pyrolysis products at a constant temperature equal to 400°C. The bio-oil yield increased by increasing the ratio of plastic and the highest bio-oil yield occurred at 70% ratio while the highest amount of bio-char occurred at the lowest ratio of plastic which is 30% so we can say that higher amounts of date seeds produce high amounts of bio-char and lower amounts of bio-oil. Moreover, to increase the amount of bio-oil we have to increase the ratio of plastic wastes and operate at high temperatures. To sum up, increasing the temperature while maintaining a constant feedstock ratio resulted in an increase in the bio-oil yield, and increasing the plastic ratio while maintaining a constant temperature resulted in further increasing the bio-oil yield. The highest bio-oil yield was at 400 degrees Celsius and a 70% plastic waste ratio with a value of 62.57%

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