Production of Bio-Oil using Renewable Bio Mass

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Abstract. In recent times, the dependence on fossil fuels has grown to an alarming rate. These fossils fuels such as coal, petroleum, natural gas are all being depleted at a much faster rate than they are being generated. Apart from the depletion, burning of these fossil fuels releases large amounts of pollutants such as CO_2 which have been found to cause global climate change. Research upon alternate fuel sources has always been important as our dependence cannot be completely cut off at once as our lives would come to a halt. Keeping this in light, my team has researched and developed bio-oil using coconut shells. We selected coconut shells as our raw material because utilisation of the bio-mass we produce helps us to reuse the waste that we produce and allows us to reuse it with the least utilization of man power while also giving us the best yield of bio oil. The bio-oil was produced from coconut shells using a combination of both unit operations and unit processes as well. The ease of availability and efficient extraction of oil can be obtained from the coconut shells with large possible surface area at 450°C and at 1 atmosphere pressure yields oil of 50%/kg of feed. The analysis of the produced bio-oil has also been done and the results obtained have been compared with conventional diesel.

1. INTRODUCTION

In almost all aspects of daily life, petroleum products play a major role in serving the demand for energy production. The growth in demand of these products has been increasing simultaneously with both time and population and fulfilling the demand has become a hassle due to the limited non-renewable resources [1]. The shift in interest towards the promising renewable and self-sufficient energy technologies is mainly due to crude oil reserve depletion and expensive barrel prices. Plant derived materials often referred to as biomass is an evolving source of renewable energy that needs to be explored because of its huge calorific valued products. Biomass consists of materials which can be decomposed at high temperatures for the production of energy and valuable end products. The source of biomass is usually from food and beverage industries [2].

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We have focused our attention on bio-oil developed from coconut shells. The coconut is mostly available in the South-East Asian countries [3]. Due to the presence of low moisture content in the coconut shells, higher yield of the oil is achieved by the slow pyrolysis method. Slow pyrolysis accompanies the ease of removal of oil [4]. Equipment loaded with finely grounded coconut shells are placed onto an electric furnace and is pyrolysed slowly. The vapours formed are slowly condensed with the help of a condenser facility surrounding the column by utilizing a jacket. At optimum temperatures of 450-575℃ and 1 atmosphere pressure, the oil is extracted with 50-55% of yield.

2. MATERIALS

The base material of the biomass used (coconut) is collected from a site of abundance i.e., temples. The coconut is then stripped of the pulp in the interior. The external surface of the shell is filed to remove the fibres so that yield of oil increases. Then it is grounded in a series of grinding processes using jaw crusher, roll crusher and ball mill which produce a finely grounded powder of various sieve sizes. The powder is then separated in a sieve shaker. The particles whose size ranges between 2.8mm-4.0mm are then collected and loaded into a crucible. Analysis of feed is shown below:

ELEMENTS	AMOUNT
Carbon	53.7
Hydrogen	6.18
Oxygen	38.45
Nitrogen	0.88
Sulfur	0.04
Calorific value	19.0
Moisture content	6.98

Table 1. Elemental Analysis

COMPONENTS	AMOUNT
Volatiles	78.22
Fixed carbon	19.48
Ash	0.32

Table 2. Component Analysis

The analysis of feed was done using gas chromatography by collecting a small sample of oil.

3. METHODS

The final prepared feed is conveyed into the stainless steel crucible having dimensions 7cm X 4cm. It is then pyrolysed at a temperature range between 475-600°C in an open hearth furnace which is

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fed with anthracite coal and burned with temperature maintained by using an IR thermometer. The heat is produced at a high constant discharge from the bottom which increases the temperature of the crucible and the contents within.

The scrubbed gases, vapours and aerosols then enter a direct quenching system where they are rapidly cooled to below 50°C with ice, which is immiscible in bio-oil. The bio-oil portion of the evolved vapours is condensed and collected in a product tank. Quench liquid recovered from this tank is cooled in a heat exchanger then recycled to the recovery system. The clean, inert gas is then recycled back to the bubbling fluid bed reactor. The non-condensable gas is vented out of the system. This medium calorific gas can be combusted to provide heat to the reactor sand. At 575°C, 44% of yield is obtained which is 44grams of oil per 100 grams of feed.

Liquid bio-oil separates from the quench liquid and is then transferred to product holding containers. The quench liquid is decanted from the tank and recycled to the bio-oil recovery system. A pictorial representation of the experimental set-up is as follows:

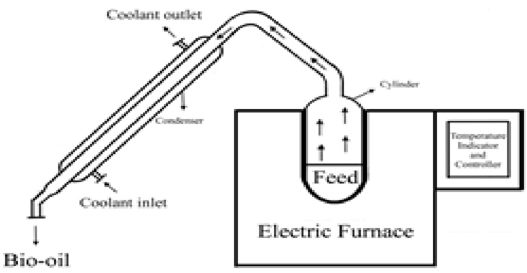

Figure 1. Experimental set-up for recovery of bio-oil

During the conduction of the experiment, the temperature of the crucible was kept as the variable to understand the effect of temperature on the yield of bio-oil. The temperature range taken was from 250°C to 370°C. A graph was plotted between temperature and the yield of oil obtained:

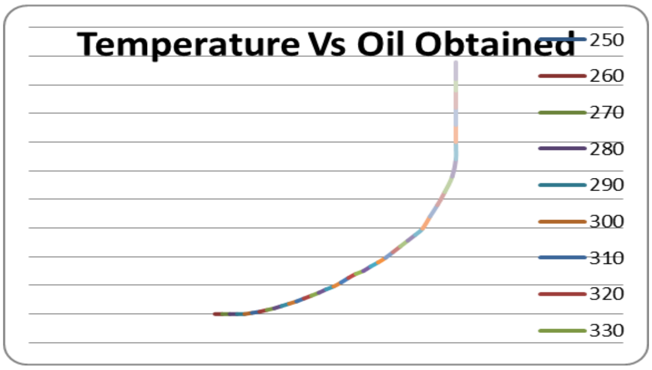

Figure 2. Plot showing effect of temperature on yield of bio-oil

As you can see from the above plot, higher temperature resulted in lower yields and yield was maximum for the temperature range between 260°C to 280°C.

4. ANALYSIS AND RESULTS

Multiple procedures of analysis of the final bio-oil were performed for accurate results of composition of the bio-oil. The primary analysis methods performed are GC-MS, component analysis and elemental analysis.

4.1 GC-MS

A 10 ml sample of bio-oil was collected and given to a third party analysis centre which is located in the Chemical Engineering Department, Osmania University College of Technology. The result obtained is tabulated and plotted below. After analysis, the main component of bio-oil was found to be cycloheptanepentanoic acid, 2-oxo-(CAS) cycloheptanevaleric acid, 2-oxo-5-(2’-oxocycloheptyl) 5. The plot obtained after the GC-MS analysis is shown below.

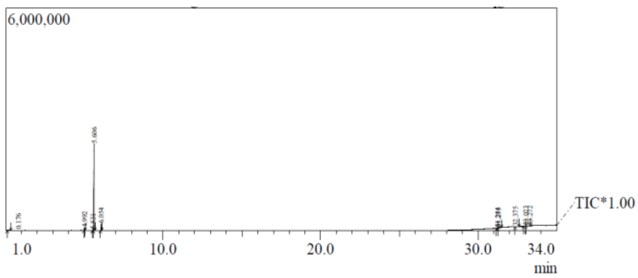

Figure 3. GC-MS analysis plot for bio-oil

When we consider these results in a tabular form, we obtain a more clear idea of the different components present and their concentrations within the bio-oil.

S.No.	R.Time	Area%	Name
1	0.176	2.33	(1RS,5SR,6SR)-6-Pentyl-2-oxabicyclo[3.3.0]octan-3-one 2H-Cyclopenta[b]furan-2-one, hexahydro-
2	4.992	1.71	.beta.-Myrcene 1,6-Octadiene, 7-methyl-3-methylene- (CAS) 2-METHYL-6-METHYLENE-
3	5.531	0.65	Benzene, 1-methyl-4-(1-methylethyl)- (CAS) p-Cymene 1-Methyl-4-isopropylbenzene p-
4	5.606	86.57	l-LIMONENE $$
5	6.054	5.21	1,4-Cyclohexadiene, 1-methyl-4-(1-methylethyl)- .gamma.-Terpinen .gamma.-Terpinene

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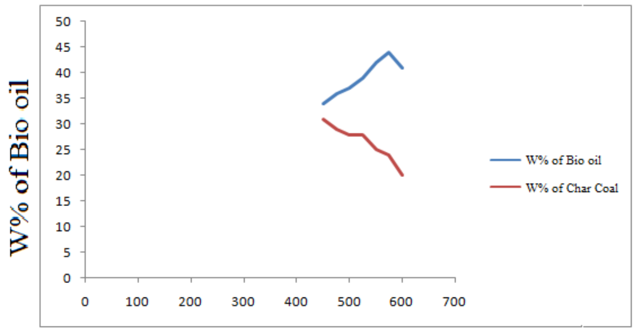
6	**31.244**	**0.48**	3,3-Difluoro-4,8-dimethyl-1,7-nonadien-4-ol 1,7-Nonadien-4-ol, 3,3-difluoro-4,8-dimethyl-
7	**31.275**	**1.12**	1-Propene, 3,3,3-trichloro-(CAS) 3,3,3-Trichloropropene 3,3,3-Dichloro-1-propene 3,3,3-
8	**32.375**	**0.82**	14-Methyl-13-oxa-15-aza-dispiro[5.0.5.3]pentadec-14-ene
9	**33.023**	**0.52**	9-Decen-2-ol
10	**33.272**	**0.59**	Cycloheptanepentanoic acid, 2-oxo- (CAS) Cycloheptanevaleric acid, 2-oxo- 5-(2'-OXOCYCLOHEPTYL)5

Table 3. Composited obtained from GC-MS Plot

4.2 Thermo-Gravimetric Analysis

From the oil obtained, thermo-gravimetric analysis is done for the temperatures 450, 475, 500, 525, 550, 575 and 600°C. The yields obtained at these temperatures increases up to 575°C. A further increase in temperature to 600°C causes a steep decrease in the yield due to the temperature-pore distribution relation in the plot mentioned below.



W% of Char Coal

Figure 4. Thermo-gravimetric Analysis

4.3 Ultimate Analysis of Bio-oil

In the table below elemental composition of coconut shell pyrolytic oil is compared with conventional diesel.

S.No	Element	Coconut shell Pyrolytic Oil	Diesel
1	Carbon	59.14	85.72
2	Hydrogen	3.47	13.2
3	Nitrogen	4.21	0.18
4	Sulphur	2.34	0.3
5	Oxygen	30.84	0.6

Table 4. Ultimate analysis of obtained bio-oil

From the analysis it can be observed that the carbon content in bio-oil is much less than the carbon content in diesel. The bio-oil however has higher sulphur and oxygen content than what is desired.

5. CONCLUSIONS

The biomass for the production of the bio-oil used in our experiment is coconut shells which are grounded and de-moisturized for better surface area and higher pore formation for the production of bio-oil vapours.

Bio-oil processing is cheaper and easier than that of the petroleum products. Its processing safety index is higher than that of any other fuel energy production. At higher temperatures of 480 to 560°C, oil is condensed onto the shell side and is collected. The oil obtained is then further purified by activated charcoal process to improve the colour and to adjust the viscosity. Bio-oil has medicinal uses other than fuel and energy utilisation. Utilization of bio-oil as feedstock at FMCG and Bio-technologies has a major impact on product quality.

6. DISCUSSIONS AND FUTURE WORK

Our project mainly focused on the motto of waste to value added product. By taking the waste generated from one source and chemically modifying it into a valuable product, we solve 2 problems with a single solution.

By utilizing the spent coconut shells we neutralize the shells which would otherwise end up in landfills and along with this, we convert the shells into bio-oil which can be used for our own needs or be sold for a profit.

With the soaring price of petroleum-based products, bio-oils are becoming an increasingly affordable alternative. Extensive research is being done because these bio-fuels are the most promising alternative. Other various benefits of bio-oils include less greenhouse gas emissions when used in engines, cleaner refineries are used for refining of bio-oils, bio-degradable and non-toxic and reducing the dependence on foreign oil.

With proper purification of the product oil, we can thus bring down the sulphur and oxygen content of the bio-oil making it a better fuel compared to conventional diesel.

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