# Slow Pyrolysis Of Coconut Shell To Produce Crude Oil

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**Abstract- Bio-energy is considered as having the potential to provide the major part of the projected renewable energy provisions of the future. Pyrolysis is one of the three main thermal routes, with gasification and combustion, for providing a useful and valuable crude oil. Pyrolysis of coconut shell was carried out at temperature 875°C to produce crude oil. The raw coconut shell was crushed in particle size less than 5-50 mm and heated in glass reactor with the help of flame. The parameters varied were reactor temperature, running time, and feed particle size and were found to influence the product yields significantly. The maximum liquid yield was 25 wt% at 875°C for a feed size of 5 mm with running time of 7 minute. Acquired pyrolyzed oil at these optimal process conditions were analyzed for of their fuel properties as an alternative fuel. The kinematic viscosity of the derived fuel was 1.03 cSt and density was 1095 kg/m3. The higher calorific value was found 21.4 MJ/kg which is comparable with other biomass derived fuel.**
**Keywords: Renewable energy, Pyrolysis, Crude oil, Coconut Shell.**

## I. INTRODUCTION

Coconut is a popular plantation and is grown in more than 95 countries worldwide on about more than 10 million hectares. Indonesia, Philippines and India account for almost 75% of world coconut production with Indonesia being the world's largest coconut producer. The world production of coconut sums up to around 65 million tonnes annually. Coconut production plays an important role in India. India accounts for 28.54 per cent of the world's coconut production and is one of the major players in the world's coconut trade.

Coconut shell is an agricultural waste and is available in plentiful quantities throughout tropical countries worldwide. In many countries, coconut shell is subjected to open burning which contributes significantly to $CO_2$ and methane emissions. Coconut shell is widely used for making charcoal. The traditional pit method of production has a charcoal yield of 25–30% of the dry weight of shells used. The charcoal produced by this method is of variable quality, and often contaminated with extraneous matter and soil. The smoke evolved from pit method is not only a nuisance but also a health hazard.

The coconut shell has a high calorific value of 20.8MJ/kg and can be used to produce steam, energy-rich gases, bio-oil, biochar etc. It is to be noted that coconut shell and coconut husk are solid fuels and have the peculiarities and problems inherent in this kind of fuel. Coconut shell is more suitable for pyrolysis process as it contain lower ash content, high volatile matter content and available at a cheap cost. The higher fixed carbon content leads to the production to a high-quality solid residue which can be used as activated carbon in wastewater treatment. Coconut shell can be easily collected in places where coconut meat is traditionally used in food processing. The coconut shells generated from oil industry and various user points need to be utilized properly.

Pyrolysis is the thermochemical decomposition of organic matter in the absence of oxygen and produces a wide range of useful products. The word is coined from the Greek-derived elements pyr "fire" and lysis "breakdown/separation" emphasizing the disintegration of matter because of heat. Pyrolysis is a standalone process or one of several reaction steps in the gasification combustion processes and is considered as the basic thermochemical process to produce valuable fuels and energy from biomass. Pyrolysis is also known as thermolysis, thermal cracking, dry distillation, destructive distillation, etc. During pyrolysis, complex macromolecules of biomass break down into relatively smaller molecules producing, three major products that can be classified as follows:

1. A solid residue (consisting mainly of carbon and ash) known as char
2. Gases (mainly CO, $CO_2$, $CH_4$, $H_2$ and other light hydrocarbons) and
3. Vapours/liquids known as bio-oil or bio-crude (mainly oxygenates, aromatics, water, products of low degree of polymerization, tars, etc.)

Depending on the operating condition, pyrolysis can be classified into three main categories: Conventional/Slow, fast and flash pyrolysis. These differ in process temperature, heating rate, solid residence time, biomass particle size, etc. However, relative distribution of products is dependent on pyrolysis type and pyrolysis operating parameters.

## II. MATERIAL AND METHODS

*2.1 Coconut shell sample preparation*

The waste coconut shells collected from nearby temples were used for the study. Before putting coconut shells for co-pyrolysis, they are processed to be reduced to fine particles. Coconut shells were dried in open sun, and then hand crushed toparticle size less than 5-50 mm. The samples were dried in oven at 105°C for removal of moisture (fig. 1 and fig.2).

Fig 1:Raw coconut shell under study

Fig 2: Crashed coconut shell under study

The characterization of coconut samples were studied in term of proximate component, ultimate component and compounds composition. The results obtained are summarized in table 1.

Table 1: Characterization of coconut shell samples

| Sr.No | Compounds | Value |
|---|---|---|
| Proximate | M.C. | 11.7% |
| | V.M. | 66.2% |
| | Ash | 0.6% |
| | Fix-C | 21.6% |
| | S | 0.02% |
| Ultimate | C | 47.6% |
| | H | 6.4% |
| | N | 0.1% |
| | O | 45.2% |
| | Cl | 0.11% |
| Composition | Cellulose | 33.61 |
| | Lignin | 36.51 |
| | Pentosans | 29.27 |

*2.2 Selection of Pyrolysis methods*

Pyrolysis processes can be categorized as slow or fast depending upon the residence time and heating rate. Slow pyrolysis takes minutes to complete and results in 30 % bio oil. On the other hand, fast pyrolysis yields 60% bio-oil and takes seconds for complete pyrolysis.Fast pyrolysis is currently the most widely used pyrolysis system.

Table 1: Typical operating parameters and products for pyrolysis process

| Pyrolysis Process | Solid Residence Time (s) | Heating Rate (K/s) | Particle Size (mm) | Temp. (K) | Oil | Char | Gas |
|---|---|---|---|---|---|---|---|
| Slow | 450–550 | 0.1–1 | 5–50 | 550–950 | 30 | 35 | 35 |
| Fast | 0.5–10 | 10–200 | <1 | 850–1250 | 50 | 20 | 20 |
| Flash | <0.5 | >1000 | <0.2 | 1050–1300 | 75 | 12 | 13 |

*2.3 Experimental Setup*

250 gm of coconut shells (50 mm size) were subjected for the pyrolysis.

A 1000 ml conical flask was used as pyrolysis chamber.

The outlet of pyrolysis was connected to liquid collection flask with the help of pipe and rubber cork.

The liquid collection flask was placed in a silica gel desiccator to provide the rapid cooling effect.

The coconut shell samples were heated at a temperature of 875 ˚C for 7 minutes and 8 minutes to complete the pyrolysis process.
The released smoke during pyrolysis was collected in the liquid collection flask. The condensable matter was treated as bio oil and the non-condensable matter was released in the atmosphere.
The pictorial view of experimental setup is shown in plate 1.

Fig 3: Experimental Setup

## III. RESULT AND DISCUSSION

Test conducted: A. 7 minutes duration, 875ºC temp., 5mm shell size
B. 8 minutes duration, 875ºC temp., 5mm shell size

*3.1 Product yield*

The products obtained from the pyrolysis of coconut shell are liquid crude oil, solid char and gas. At an operating temperature of 875 ºC for a feed size 5 mm diameter with a running time of 7 minute, liquid production is found to be the maximum (25 wt%) of the dry feedstock.
Initial weight of coconut shell was 250gm after burning it reduces to 227.06gm.Coconut shell was burnt for 7 min duration; 10ml crude oil was obtained from 250gm sample.
It was observed that for 7 minutes duration at an operating temperature of 875ºC for a 5 mm shell size obtained 10 ml of crude oil.

| Sr.No. | Time, minutes | Particulars | Observed Value |
|---|---|---|---|
| 1. | 7 | Weight of dish | 3.15gm |
| 2. | | Weight of sample | 250gm |
| 3. | | Weight of bottle | 16.91gm |
| 4. | | Weight of oil | 10gm (10ml) |
| 5. | | Weight of bottle + oil | 26.91gm |
| 6. | | Weight of sample after burning | 227.06gm |
| 7. | 8 | Weight of dish | 3.15gm |
| 8. | | Weight of sample | 200gm |
| 9. | | Weight of bottle | 16.91gm |
| 10. | | Weight of oil | 19.99gm(19.99ml) |
| 11 | | Weight of bottle + oil | 36.90gm |
| 12. | | Weight of sample after burning | 160.37gm |

Initial weight of coconut shell was 200gm after burning it reduces to 160.37gm.Coconut shell was burnt for 8min duration; 19.99ml crude oil was obtained from 200gm sample.
It was observed that, for 8 minutes duration at an operating temperature of 875ºC for a 5 mm shell size obtained 19.99 ml of crude oil. It was observed that, time of pyrolysis process increase so that increase the production of crude oil.

*3.2 Physical properties of pyrolysis oil*

The physical characteristics of the pyrolysis oil are shown in Table 4. The energy content of the oil is 21.397 MJ/kg. The oil is found to be heavier than water with a density of 1095.5 kg/m3. The flash point of the oil is 121ºC and hence precautions are not required in handling and storage at normal atmosphere. The low viscosity of the oil of 1.03cSt is a favorable feature in the handling and transportation of the liquid.

Table 6: Physical properties of coconut shell pyrolysis oil with diesel fuel

| Analysis | Coconut shell Oil | Diesel | Heavy fuel oil |
|---|---|---|---|
| Kinematic viscosity (cSt) | 1.03 | 2.61 | 200 |
| Density (kg/m3) | 1095.5 | 827.1 | 980 |
| Flash Point (0C) | 121 | 53 | 90-180 |
| HHV of liquid(MJ/kg) | 21.40 | 45.18 | 42-43 |

Table 7: Comparison of coconut shell pyrolysis oil with biomass derived pyrolysis oil

| Analysis | Coconut shell | Date seed oil | Tamarind seed oil | Jute stick oil |
|---|---|---|---|---|
| Kinematic viscosity(cSt) | 1.03 | 6.63 | 6.51 | 12.8 |
| Density (kg/m3) | 1095.5 | 1042 | 1150 | 1224 |
| Flash Point (ºC) | 121 | 126 | 100 | >70 |
| HHV(MJ/kg) | 22.83 | 28.6 | 19.10 | 21.09 |

## IV. CONCLUSIONS

1) The optimum process conditions for maximizing the liquid yield of slow pyrolysis of coconut shell: pyrolysis temperature 875 °C, particle size less than 5-50 mm, heating rate 7 and 8 min. The maximum liquid yield of 25 wt% was obtained.

2) The liquid yield increased when the heating rate was increased from 7 min to 8 min.

3) It also provides an opportunity for the processing of agricultural residues, wood wastes and municipal solid waste into clean energy.

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