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# Wastes into Assets: A Reality

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Now, biomass is one of the major renewable energy sources, which is converted into useful products via thermal and biochemical conversion techniques. Fast pyrolysis is one among the techniques to convert bioresidues into a liquid product-biooil, where the biomass will be heated to higher temperatures and the vapors generated from the bioresidues will be cooled immediately to produce the biooil. It is used for heat and a source for valuable fuels and chemicals. In this paper, the availability of biomass, and its conversion through fast pyrolysis is discussed.

## Introduction

The energy generation pattern of India is 40% from coal, crude oil 24%, gas 8.96% and renewable sources 12%, *etc*., The required crude oil is obtained mostly (80%) by import and the demand is 159 million tons per annum. For the import of fossil fuels alone the government spending ₹ 9,57,000 millions. The demand for fossil fuel will increase by 53% of the country's total energy consumption [1]. As a remedy, the shortfall energy can be meet out from a sustainable energy source. Biomass is one of the most sustainable and vital energy sources in the renewable energy sector. It contributes about 14% of the world's energy supply [2].

Generation of the biomass is increasing every year but due to their lesser advantages, the residues have not found any remarkable application and have negative value [3]. Most of the biomass is dumped into fields, disposed as landfills, reused as fuel, paving materials in the animal husbandry and feed for animals. The in-situ burning of agricultural wastes cause air pollution, soil erosion and a decrease in soil biological activity, which eventually reduces the productivity.

Agriculture is one of the important backbones of the Indian economy and accounts for 18.5% of the country's gross domestic product. India is the world's largest producer over a range of commodities due to the encouraging agro-climatic conditions and rich natural resource base that leads to the generation of huge quantity of agro-residues and wastes [4]. The current availability of biomass in India is estimated about 120-150 million tons per annum.

## Conversion Technologies

Energy from biomass makes any country self-sustainable and less dependent on petroleum resources. The biomass can be converted into energy or value added products by different energy conversion technologies. Products from these technologies can progressively substitute the fossil fuel especially crude oil, fuel, energy and chemicals supply. The biomass can be treated in a number of ways and the conversion of biomass into useful energy primarily depends on the properties of biomass. The dry biomass can be subjected to thermo chemical conversion processes such as combustion, gasification, pyrolysis, thermal depolymerization and plasma arc gasification.

## Pyrolysis

The pyrolysis is an ancient technology investigated over the last three decades [5]. It mainly carried out in the absence of oxygen. It can produce solid (char), liquid (biooil) and gaseous products (producer gas). Yield of these three products depend on the feedstock composition, type of reactor, operating conditions such as pyrolytic temperature, residence time, heating rate and cooling system. Two streams are existing in this pyrolysis technology.

The conventional or slow pyrolysis was carried out at low temperature with long residence times at slow heating rates that produce mainly charcoal and high temperatures mainly produce gaseous products [6]. On the other hand, the short residence times, faster heating rates and moderate temperatures favor a high yield of condensable vapours, which is called as biooil [7].

### Fast Pyrolysis

It is a high-temperature process in which the finely grinded-dried biomass is rapidly heated to temperatures around 500°C in the absence of oxygen. This causes a release of huge amount of thermal degradation products consisting of vapors, aerosols, gas and char. The vapors are condensed within a few seconds to produce a liquid product called pyrolysis oil or biooil, which is a mixture of condensed organic compounds and water. The fast pyrolysis process produce 60-75$\%_{wt}$ liquid biooil, 15-25$\%_{wt}$ solid char and 10-20$\%_{wt}$ non-condensable gases, depending on the feedstock used [8]. The pyrolysis oil has the heating value of approximately half the heating value of fossil fuels.

For the fast pyrolysis, five conditions have to be considered including particle size, medium temperatures, faster heating rates, short vapor residence times, purge gas flow rate and fast condensation of vapors to obtain a relatively high bio-oil yield [9, 10]. Reactor is also a main component in fast pyrolysis system [8]. Number of reactor designs has been developed to attain high liquid-product yield. The reactors are categorized as fluidized bed reactors [11], transported and circulating fluidized bed reactors [12], ablative and vacuum reactors [13], tubular reactors [14], microwave pyrolytic reactors [15], auger system [8] and rotating cone reactors [16]. Among them fluidized bed reactors, vacuum pyrolysis reactors and ablative reactors are available for the commercialization of biooil as liquid fuel as reported by Scott *et al.,* [17]. The fluidized bed system is a proper technology that suitable for large-scale applications.

## Materials and Methods

In this study, different biomass was selected such as redgram stalk from agro-residues, cashew nut shell from plantation crops, rice husk and coir pith as the agro-industrial by products and prosopis wood from the energy crops. The biomass was dried and pulverized to a particle size of less than 2 mm. The characteristics of biomass and the assessment of biooil production from the selected biomass is presented in the paper [18].

### Fluidized Bed System

A fluidized bed pyrolytic system of 10 kg per hour was designed to produce pyrolytic oil from biomass. It has a reaction chamber, inert gas cum feed supply system, cyclone and cooling systems. The pyrolytic system was equipped with suitable instrument and control systems. The particle size of the biomass was categorized as less than 0.25 mm, 0.25-0.50 mm, 0.50-0.75 mm and 0.75- 1 mm. The tested pyrolytic temperatures were 400-425°C with 25°C increment.

Initially the hopper was filled with the required quantity of pulverized biomass. The desired pyrolytic temperature was set in the control unit. The inert gas was heated and passed into the reactor. After the arrival of temperature, the feeding was done. The vapor generated from the biomass degradation passed through the cyclone and cooling systems for the condensation of vapor into pyrolytic oil.

## Results and Discussion

The maximum pyrolytic oil yield of 52.8% was obtained from redgram stalk at 450°C, while using a particle size of 0.25 to 0.50 mm, may be due to the effective heat transfer between the smaller particles. 45.2% biooil was obtained from cashew nut shell at 500°C with the particle size of 0.25 to 0.50 mm. The higher degradation temperature might be due to the higher lignin content of the biomass. Rice husk of particle size 0.5 to 0.75 mm led to the maximum oil production of 42.50%. While comparing with other cases, the biooil yield from rice husk was maximum at larger particle size. It may be due to the more gas production from small particle of size less than 0.5 mm. The similar results were reported by Heo *et al.* [19] for the *Miscanthus sinensis.* The prosopis wood gave a biooil yield of 62.5% at 450°C with a particle size of 0.25 to 0.50 mm. Biooil yield of 46.1% was obtained from coir pith at 500°C using the particle size of 0.50-0.75 mm, similar to the rice husk. The maximum biooil production was obtained from prosopis wood. The pyrolytic oil yield in the descending order of prosopis wood > cashew nut shell > Redgram stalk > coir pith > rice husk.

On an average, the pyrolytic oil yield was 42.50 to 62.50 kg per hour. The char and gas were obtained as by-product. The fuel properties and the components in pyrolytic oil were studied.

## Conclusion

- The wastes generated from countries can be effectively utilized as a feed for the inborn fuel and chemicals through fast pyrolysis. This may facilitate to the establishment of decentralized fuel production units and refineries.
- The liquid product obtained from the fast pyrolysis of biomass has received considerable attention than gaseous fuels because these liquids have advantages in transport and storage.
- Its utilization as fuel or source for chemical feedstock requires some form of upgrading to improve storage stability and calorific value.
- The liquid fuel has the advantage of being able to substitute for or supplement transport fuels, in addition to its use for heat and power.
- The pyrolytic oil had more than 300 chemical components. Suitable separation and up-gradation techniques may increase their economic value.■

Redgram stalk Cashew nut shell Coir pith Rice husk

***Fig 1.*** *Biomass used in fast pyrolysis*

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