Conversion of Waste Plastic to Energy by Pyrolysis Process: A Review

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Abstract— Recently many countries have started work for the replacement of fossil fuels. Many researchers have reported that vegetable oil and biodiesel can be used as a substitute of petroleum fuels. This review article deals about the state of art of energy extraction from waste material by thermochemical conversion methods. The world is facing lot of problem due to accumulation of different types of waste such as waste plastic, waste tires, waste lubricating oils, waste transformer oil etc. It is very much essential to find an efficient process as a potential solution of these wastes. Thermochemical conversion methods are the best way to convert this waste material into potential energy form. In this article the various methods such as direct combustion, liquefaction, pyrolysis, gasification has been discussed. This article also gives information about scope of use of the products obtained by these processes.

Keywords: Gasification; Liquefaction; Pyrolysis, Thermochemical Routes

I. INTRODUCTION

The present generation of human being is facing lot of problem due to depletion of fossil fuel. The crude oil reserve distribution and natural gas reserves are depicted in Fig.1 and Fig.2 respectively. It is not easy to replace fossil-based fuels in the transport sector; however, an appealing solution is to use biomass and waste to produce renewable alternatives. Thermochemical conversion of biomass for production of synthetic transport fuels using gasification is a promising way to meet these goals. In this context, biomass can be one of the potential feedstocks for fuel recovery. The term 'biomass' mentions to wood, woody crops, agricultural wastes, herbaceous species, wood wastes, bagasse, industrial residues, waste paper, municipal solid waste, sawdust, bio-solids, grass, waste from food processing, aquatic plants and algae animal wastes. Biomass is the name given to all the earth's living matter. Biomass, as the solar energy stored in chemical form in plant and animal materials, is among the most precious and versatile resources on earth. It is a rather simple term for all organic materials that originates from plants, trees, crops, and algae. The components of biomass include cellulose, hemicelluloses, lignin, extractives, lipids, proteins, simple sugars, starches, water, hydrocarbons, ash, and other compounds.

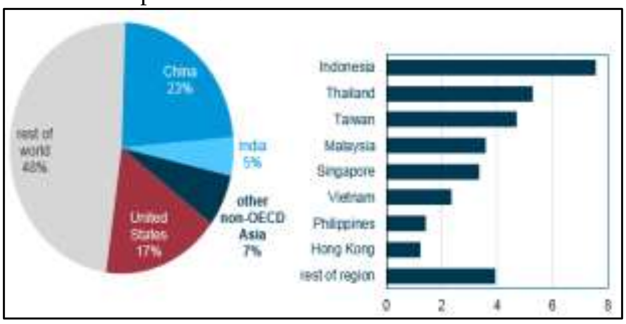

Fig. 1: Energy Consumption world scenario [1]

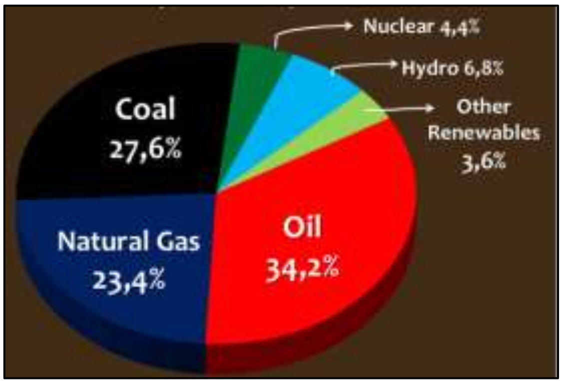

Fig. 2: Energy consumption by source [2]

II. THERMOCHEMICAL ROUTES

There are many pathways to obtain energy from biomass, the question that emerges from this wide range of possibilities is: What is the best pathway to produce bioenergy? Several authors have studied the implementation of biochemical and/or thermochemical pathways for energy production using lignocellulosic raw materials [3-5]. The famous technique of conversion of biomass into usable form of energy is thermochemical ways which are also reported in many literature reports that deal with the valorization of biomass to produce energy through thermochemical routes. The schematic diagram of different thermochemical methods is shown in Fig.3.

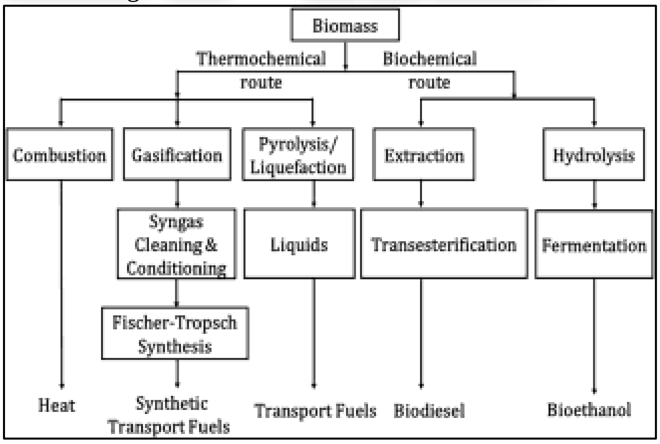

Fig. 3: Thermochemical and biochemical pathways [6]

III. PYROLYSIS

The "pyrolysis" is known as a thermal degradation in the absence of oxygen, which changes a raw biomass into solid (char), liquid (Heavy molecular weight compounds) and gaseous products (light molecular weight gases) [7-8]. The pyrolysis involves two steps. The first step mainly involves dehydration, dehydrogenation, decarboxylation reactions. The second steps involves processes such as cracking (thermal or catalytic), where heavy compounds further break into gases, or char is also converted into gases such as CO,

CO_2, CH_4 and H_2. Pyrolysis process can provide three end products: gas, oil and char, which all have the potential to be refined further if required. When microwave heating is applied to a pyrolysis process different chemical profiles of the volatiles in both heating systems are obtained allowing for modification of final pyrolysis products. Conventional heating means that heat is transferred from the surface towards the center of the material by convection, conduction and radiation. microwave heating represents the transfer of electromagnetic energy to thermal energy. Because microwaves can penetrate materials and deposit energy, heat can be generated throughout the volume of the material, rather than from an external source (volumetric heating). Therefore, microwave heating is energy conversion rather than heat transfer. In microwave heating the material is at higher temperature than the surrounding area, unlike conventional heating where it is necessary that the conventional furnace cavity reach the operating temperature, to begin heating the material. The differing performance between conventional and microwave heating is also translated into differential heating rates of the material. Microwave heating reveals higher heating rates since microwave energy is delivered directly into the material through molecular [9].

One of the efficient type of pyrolysis is Fast pyrolysis where the rapid thermal decomposition of organic compounds in the absence of oxygen to produce liquids, gases and char. The distribution of products depends on the biomass composition and other reaction conditions including residence time, temperature, etc. The resulting bio-oil is a complex mixture of oxygenated organic compounds including carboxylic acids, alcohols, aldehydes, saccharides and phenolic compounds. This bio-oil has been used as fuel for both boilers and gas turbine engines, although its production cost, corrosiveness and instability during storage have impeded its commercial deployment. Bio-oil can be upgraded to transportation fuels through a combination of steam reforming of light oxygenates in the bio-oil to provide hydrogen and hydrocracking lignin oligomers and carbohydrate to synthetic diesel fuel or gasoline.

IV. Gasification

Thermal gasification is the method of conversion of solid, carbon-rich materials at elevated temperatures (typically 750 – 1500 ˚C) and under oxygen-starved conditions into syngas, a flammable gas mixture of CO, H_2, CH_4, N_2, CO_2 and smaller quantities of hydrocarbons [10]. Thermal conversion of organic materials at elevated temperature and reducing conditions to produce primarily permanent gases, with char, water, and condensable as minor products Primary categories are partial oxidation and indirect heating. One of the best features of this process is its flexibility of application, including thermal power generation, hydrogen production and synthesis of fuels and chemicals. This offers the prospect of gasification-based energy refineries, producing a mix of energy and chemical products or allowing the staged introduction of technologies as they reach commercial viability.

V. Direct Combustion

The production of heat by the direct combustion of biomass is the leading bioenergy application throughout the world and is often cost competitive with fossil fuel alternatives [11]. The bioenergy conversion technologies are explore based on three important factors such as, the available feedstock, technology for conversion and product requirement. Basically, there are four types of conversion technologies are currently available, each appropriate for specific biomass types and resulting in specific energy requirement.

VI. Conclusion

Thermochemical conversion technologies are promising ways for producing fuel from waste which are environmentally benign, sustainable biofuels and value-added chemicals from biomass. However, there are many difficulties to implement these kinds of technology in commercial manner, behind these technologies such as pyrolysis and solvolysis of biomass are very complex. Contributing to the complexity are the many factors that could affect the reaction mechanisms. This research focuses on an external effect on thermal decomposition and internal reaction chemistry to provide an insight into the biomass decomposition for better performance.

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