Carbonaceous Products from Different Biomass Samples: A General Review

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Due to their low cost and high availability biomass is the world's most widely available renewable resource to be considered for production of organic fuels, chemicals, and new-generation materials. Lignocellulosic biomass is composed of mainly cellulose, hemicellulose and lignin. Cellulose is a highmolecular- weight (10^6 or more) linear polymer of β-(1→4)-D-glucopyranose units. Cellulose degradation occurs at 240-350 °C to produce anhydrocellulose and levoglucosan. A second major wood chemical constituent is hemicellulose, which is a mixture of various polymerized monosaccharides. Hemicellulose decomposes at temperatures of 200-260 °C, giving rise to more volatiles, less tars, and less chars than cellulose. The third major component of wood is lignin. Lignin decomposes when heated at 280-500 °C. Lignin pyrolysis yields phenols via the cleavage of ether and carboncarbon linkages. Lignin is more difficult to dehydrate than cellulose or hemicelluloses. Lignin pyrolysis produces more residual char than does the pyrolysis of cellulose. Biomass also contains a small mineral content that ends up in the pyrolysis ash. A fifth component is comprised of organic extractives [1-2].

The energy in biomass may be realized either by direct use as in combustion, or by upgrading into a more valuable and usable fuel such as fuel gas or fuel oil or higher-value products for the chemical industry. This upgrading may be physical, biological, chemical or thermal methods to give a solid, liquid or gaseous product [2,3].

There are four main thermochemical methods of converting biomass: combustion, liquefaction, gasification and pyrolysis. Each gives a different range of products and employs different equipment configurations operating in different modes. The burning of biomass in air,i.e. combustion,is used over a wide range of outputs to convert the chemical energy stored in biomass into heat, mechanical power, or electricity. Liquefaction in a reducing medium generates solids and gases. Gasification produces hydrogen, carbon monoxide, carbon dioxide, and water by partial combustion. Gasification also produces hydrocarbons, particularly in the lower temperature ranges in fluidized-bed reactors. The last thermochemical process, pyrolysis, converts organics to solid, liquid and gas by heating dry and comminuted biomass in the absence of oxygen. Depending on the process conditions the major product could be bio-oil, a liquid fuel, or substantial quantities of char, a solid fuel, or a non-condensible gaseous product which can also be burnt as fuel though its calorific value is rather low. The actual proportion of each of the above three products is dependent on the type and nature of the biomass input, the type of pyrolyser used, as well as on the details of the pyrolysis process adopted. Generally when the process is carried out at low temperatures and a slow heating rate, char yield is maximized. Conversely, at high temperature, low heating rate and extended gas residence time, the gas yield is maximized. Bio-oil yield on the other hand is maximized at medium temperatures (450 - 600°C), rapid heating rates and abbreviated residence times [2-6].

During pyrolysis of biomass samples a pyrolytic reaction occurs. The simplified form of the reaction can be shown as;

Biomass → Char + Gases + Bio-oil
$(C_xH_yO_z)$ + heat → C + CO_2 + CO + CH_4 + H_2 + hydrocarbons + heat

Biomass pyrolysis products are a complex combination of the products from the individual pyrolysis of cellulose, hemicellulose, lignin and extractives, each of which has its own kinetic characteristics. Char is the solid product, mainly contains carbon that remains after devolatilization. Uncondensable gases including CO_2, CO, CH_4, H_2 are the main gaseous products that can be determined by GC. Bio-oil is a complex mixture of many oxygenated hydrocarbons. Complete chemical characterization of bio-oil is difficult and many instrumental (GC, GC-MS, HPLC, HPLC-electrospray MS, NMR, FTIR, GPS) and analytical techniques are used for characterization [2, 8-11].

In this text, biomass pyrolysis at medium temperatures is discussed. Effect of biomass type and pyrolysis conditions on product yields and product quality is examined. Literature survey indicates that there have been many attempts to obtain carbonaceous products from organic wastes such as rice straw, corn stalks, sunflower shell, pinecone, rapeseed, cotton stalk, olive residues, sugar cane bagasse, almond shells, peach stones, apricot stones, cherry stones, peanut shell, nut shells, corn cob, hazelnut shells, rice husks and energy crops such as miscanthus, euphorbia rigida and etc. It was found that the nature of the carbonaceous products is strongly dependent on the type of feedstock and on the conditions applied during pyrolysis, i.e. pyrolysis atmosphere, heating rate, reactor type and etc. [7-11]. As a result it can be said that processing carbonaceous feedstocks to produce heat, chemicals, or fuels offers an alternative to landfills and provides a supplement to fossil fuel use.

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