Biofuels-2015 - Recent progress in the thermo catalytic processing of biomass into advanced fuels- David Serrano - Rey Juan Carlos University

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A high interest has arisen in recent years in novel processes for the transformation of different types of biomass into advanced biofuels. The use of non-edible biomass sources and the overall sustainability of the process are very important factors to be considered in the development of new routes for the production of second-generation biofuels. In this way, lignocellulosic biomass appears as a very interesting source of biomass due to its independency with the food market, its low cost and high availability in the form of agriculture and forest residues or as energy crops. he "traditional domestic" use in developing countries (fuelwood, charcoal and agricultural residues) for household cooking (e.g. the "three stone fire"), lighting and space-heating. In this role-the efficiency of conversion of the biomass to useful energy generally lies between 5% and 15%. the "traditional industrial" use of biomass for the processing of tobacco, tea, pig iron, bricks & tiles, etc, where the biomass feedstock is often regarded as a "free" energy source. There is generally little incentive to use the biomass efficiently so conversion of the feedstock to useful energy commonly occurs at an efficiency of 15% or less. Modern industrial Industries are experimenting with technologically advanced thermal conversion technologies which are itemised below. Expected conversion efficiencies are between 30 and 55%. newer "chemical conversion" technologies ("fuel cell") which are capable of by-passing the entropy-dictated Carnot limit which describes the maximum theoretical conversion efficiencies of thermal units. biological conversion techniques, including anaerobic digestion for biogas production and fermentation for alcohol. In general, biomass-to-energy conversion technologies have to deal with a feedstock which can be highly variable in mass and energy density, size, moisture content, and intermittent supply. Therefore, modern industrial technologies are often hybrid fossil-fuel/biomass technologies which use the fossil fuel for drying, preheating and maintaining fuel supply when the biomass supply is interrupted.Three main pathways are being explored for the thermochemical conversion of lignocellulose: Gasification, pyrolysis and liquefaction. Biomass pyrolysis, depending on the temperature and the heating rate, yields gases, liquid and solid fractions with different proportions. The biomass feedstock is subjected to high temperatures at low oxygen levels, thus inhibiting complete combustion, and may be carried out under pressure. Biomass is degraded to single carbon molecules (CH_4 and CO) and H_2 producing a gaseous mixture called "producer gas." Carbon dioxide may be produced as well, but under the pyrolytic conditions of the reactor it is reduced back to CO and H_2O; this water further aids the reaction. Liquid phase products result from temperatures which are too low to crack all the long chain carbon molecules so resulting in the production of tars, oils, methanol, acetone, etc. Once all the volatiles have been driven off, the residual biomass is in the form of char which is virtually pure carbon. The maximum yield in the liquid fraction (bio-oil) is attained when working at temperatures of about 500ºC and high heating rates (fast and flash pyrolysis). Carbonisation. Gasification is a high temperatures and a controlled environment leads to virtually all the raw material being converted to gas. This takes place in two stages. In the first stage, the biomass is partially combusted to form producer gas and charcoal. In the second stage, the C02 and H_2O produced in the first stage is chemically reduced by the charcoal, forming CO and H_2. The composition of the gas is 18 to 20% H_2, an equal portion of CO, 2 to 3% CH_4, 8 to 10% CO_2, and the rest nitrogen. {Makunda, 1992}. These stages are spatially separated in the gasifier, with gasifier design very much dependant on the feedstock characteristics. This is an age old pyrolytic process optimised for the production of charcoal. Traditional methods of charcoal production have centred on the use of earth mounds or covered pits into which the wood is piled. Control of the reaction conditions is often crude and relies heavily on experience. The conversion efficiency using these traditional techniques is believed to be very low; on a weight basis Openshaw estimates that the wood to charcoal conversion rate for such techniques ranges from 6 to 12 tonnes of wood per tonne of charcoal. This is a relatively simple process that it is being implemented now at commercial scale in different countries. However, one of the unsolved problems is related to the complex composition of the bio-oil, which limits its use as fuel mainly in not very demanding applications, such as heating fuel. Bio-oil presents both high oxygen content and low calorific value. Moreover, it has an acidic pH, which provides it with undesirable properties. It requires either a catalyst or a high hydrogen partial pressure. Technical problems have so far limited the opportunities of this technology include a number of chemical transformations, such as catalytic pyrolysis, hydrodeoxygenation, ketonization, esterification, aldol condensation, alkylation, etc. functioning the bacteria convert about 90% of the feedstock energy content into biogas (containing about 55% methane), which is a readily useable energy source for cooking and lighting. The sludge produced after the manure has passed through the digester is non-toxic and odourless. Also, it has lost relatively little of its nitrogen or other nutrients during the digestion process thus, making a good fertiliser. In fact, compared to cattle manure left to dry in the field the digester sludge has a higher nitrogen content; many of the nitrogen compounds in fresh manure become volatised whilst drying in the sun. On the other hand, in the digested sludge little of the nitrogen is volatised, and some of the nitrogen is converted into urea. Urea is more readily accessible by plants than many of the nitrogen compounds found in dung, and thus the fertiliser value of the sludge may actually be higher than that of fresh dung. In most cases, the catalysts to be developed should combine bifunctional properties, for removing a large part of the oxygen contained in the bio-oil and to modify the chemical structure of the compounds for its use as transportation fuels, with a high accessibility to the active sites.

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