Thermal conversion of Biomass

W. Kwapinski, E. Kryachko, F. Melligan, J.J. Leahy, M.H. B. Hayes

Department of Chemical and Environmental Sciences, University of Limerick, Limerick, Ireland

Recently there is a growing interest in the uses of biomass waste as an alternative source of chemicals and fuel. Uses of biomass waste rather than fossil fuels to produce fuels and chemicals could play essential roles in reducing the world's dependence on oil and coal. The structures in biomass are very different from those in coal and oil from which hydrocarbons are derived. Thus it will be necessary to utilise different technologies to produce from biomass the products that we have heretofore obtained from oil.

Our integrated approach would involve the biorefining of biomass and lignocellulose wastes to give the platform chemicals furfural, hydroxymethylfurfural, and levulinic acid, as well as formic acid. The biorefinery residuals, which amount to about 50% of the starting material would then be thermochemically converted by pyrolysis and gasification processes. In this communication we focus on the pyrolysis/gasification of biomass. These processes convert organic/biological materials into mixtures of combustible gases (hydrogen, carbon monoxide, methane, ethylene, etc), bio-oil, and biochar. Biomass pyrolysis has come to be regarded as a potentially competitive and sustainable process that exhibits environmental advantages for the development of a clean conversion from waste to energy without increasing the accumulations of greenhouse gases in the atmosphere.

Our studies with biomass crops (Miscanthus and Willows) have shown that the biochar formed, after pyrolysis at up to 600°C, when added to soil advanced the germination of maize seedlings by several days, and enormously enhanced plant growth over a three week period. Significant amounts of carbon and plant nutrients are in animal manures that are sources of pollution of surface waters and sources of greenhouse gases emissions (methane, carbon dioxide), of ammonia and of odours. Complexation of fertilizers with biochar will allow the economic utilisation of plant nutrients such as nitrogen in fertilizers (whose synthesis is energy demanding) and phosphate (which is a diminishing resource, at least in mines), and will provide measures to conserve plant nutrients essential for the supply of food for an expanding global population. It will be important to determine how plant nutrients in organic manures are contained in the chars, and if, and how, these become available to plants. Moreover, the main product of pyrolysis is bio-oil. Experimental work on bio-oil upgrading will be presented.

The focus of this research is to develop and to test novel, economically viable, and efficient technologies for the utilisation of biomass as feedstocks for the gereration of energy and of platform chemicals in second generation biorefining processes. Uses of lignocellulose and of organic wastes feedstocks, including forest thinnings, animal wastes, straws, stovers, bagasse, would avoid competition with food products for energy fuels. The main objectives at this stage are to investigate:

- ~~o~~ the slow, intermediate, and fast pyrolysis and gasification of the biomass and of waste feedstocks for the production of gases, bio-oil and biochar; ~~and~~
- o the development of techniques to give high yields of cost-effective transport fuels that can fuel (mixed with petroleum fuels) conventional engines;
- o the possibility of generating environmentally friendly and economically viable technologies to provide products that would utilise substrates to give lower emissions of greenhouse gases, and would, for example, provide complexes that give rise to slow release, environmentally friendly nitrogenous and other fertilizers; and
- o the role of biochar in carbon sequestration. Quantitative studies will determine the amounts of atmospheric carbon stored in plants which are contained in the biochar, in the bio-oils, and in the utilisable gases evolved during the pyrolysis.