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Biofuels 2015: Upgrading liquids from fast pyrolysis of biomass - Anthony Bridgwater, Aston University in Birmingham

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Fast pyrolysis for production of high yields of liquids (bio-oil) has now reached commercial reality, and there continues to be considerably increasing activities at the R&D level to develop processes and improve the quality of the liquid. Biomass pyrolysis is the thermal decomposition of biomass occurring in the absence of oxygen. It is the fundamental chemical reaction that is the precursor of both the combustion and gasification processes and occurs naturally in the first two seconds. The products of biomass pyrolysis include biochar, bio-oil and gases including methane, hydrogen, carbon monoxide, and carbon dioxide. Depending on the thermal environment and the final temperature, pyrolysis will yield mainly biochar at low temperatures, less than 450 0C, when the heating rate is quite slow, and mainly gases at high temperatures, greater than 800 0C, with rapid heating rates. At an intermediate temperature and under relatively high heating rates, the main product is bio-oil. Pyrolysis can be performed at relatively small scale and at remote locations which enhance energy density of the biomass resource and reduce transport and handling costs. Pyrolysis offers a flexible and attractive way of converting solid biomass into an easily stored and transported liquid, which can be successfully used for the production of heat, power and chemicals. A wide range of biomass feedstocks can be used in pyrolysis processes. Virtually any form of biomass can be considered for fast pyrolysis. Most work has been performed on wood, because of its consistency and comparability between tests. However, nearly 100 types of biomass have been tested, ranging from agricultural wastes such as straw, olive pits, and nut shells to energy crops such as miscanthus and sorghum. Forestry wastes such as bark and thinnings and other solid wastes, including sewage sludge and leather wastes, have also been studied. In this review, the main (although not exclusive) emphasis has been given to wood. The literature on wood/biomass pyrolysis, both fast and slow, is surveyed and both the physical and chemical aspects of the resulting bio-oils are reviewed. The effect of the wood composition and structure, heating rate, and residence time during pyrolysis on the overall reaction rate and the yield of the volatiles are also discussed. Although very fast and very slow pyrolyses of biomass produce markedly different productsThe pyrolysis process is very dependent on the moisture content of the feedstock, which should be around 10%. The technology of fast pyrolysis is described followed by a comprehensive examinationof the characteristics and quality requirements of biooil. This considers all aspects of the special characteristics of bio-oil – how they are created and the solutions available to help meet requirements for utilisation. Particular attention is paid to chemical and catalytic upgrading including,for example, incorporation into an oil refinery, production of hydrocarbons, chemicals, synthesis gas and hydrogen production which have seen a wide range of new research activities. An appreciation of the potential for bio-oil to meet a broad spectrum of applications in renewable energy has led to a significantly increased R&D activity that has focused on addressing liquid quality issues both for direct use for heat and power and indirect use for biofuels and green chemicals. This increased activity is evident in North America, Europe and Asia with many new entrants as well as expansion of existing activities. The only disappointment is the more limited industrial development and also deployment of fast pyrolysis processes that are necessary to provide the basic bio-oil raw material. The efficiency and nature of the pyrolysis process is dependent on the particle size of feedstocks. Most of the pyrolysis technologies can only process small particles to a maximum of 2 mm keeping in view the need for

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rapid heat transfer through the particle. The demand for small particle size means that the feedstock has to be size-reduced before being used for pyrolysis. Pyrolysis processes can be categorized as slow pyrolysis or fast pyrolysis. Fast pyrolysis is currently the most widely used pyrolysis system. Slow pyrolysis takes several hours to complete and results in biochar as the main product. On the other hand, fast pyrolysis yields 60% bio-oil and takes seconds for complete pyrolysis. In addition, it gives 20% biochar and 20% syngas. Bio-oil is a dark brown liquid and has a similar composition to biomass. It has a much higher density than woody materials which reduces storage and transport costs. Bio-oil is not suitable for direct use in standard internal combustion engines. Alternatively, the oil can be upgraded to either a special engine fuel or through gasification processes to a syngas and then biodiesel. Bio-oil is particularly attractive for co-firing because it can be more readily handled and burned than solid fuel and is cheaper to transport and store. Bio-oil can offer major advantages over solid biomass and gasification due to the ease of handling, storage and combustion in an existing power station when special start-up procedures are not necessary. In addition, bio-oil is also a vital source for a wide range of organic compounds and speciality chemicals

Biography:

Anthony Bridgwater is Professor of Chemical Engineering at Aston University in Birmingham UK. He has worked at Aston University for most of his professional career and is currently director of the European Bioenergy Research Institute. He has a world-wide research portfolio focussing on fast pyrolysis as a key technology in thermal biomass conversion for power, heat, biofuels and biorefineries. He is a Fellow of the Institution of Chemical Engineers and a Fellow of the Institute of Energy. He was technical Director of the UK Flagship SUPERGEN Bioenergy programmes for 8½ years until the end of 2011. In addition he has led and coordinated nine major EC research anddevelopment projects in bioenergy and has an active current
involvement in six further research and development projects.
He has attracted funding from national research funding
councils in Canada, Holland, Norway and the USA. He formed
and led the IEA Bioenergy Pyrolysis Task – PyNe from 1994 to
2008 with parallel European networks on pyrolysis, gasification
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