Waste Derived Carbons for Syngas Tar Removal

Amal. S. Al-Rahbi[1] and Paul. T. Williams [1]

Energy Research Institute, University of Leeds, Leeds, LS9 8BN, UK
Presenting author email: pmasalr@leeds.ac.uk

The utilization of waste materials as precursors for generating low-cost and effective carbonaceous materials, which can be used on a large scale, is very attractive and would help to solve the issues associated with waste disposal. In this work, scrap tyre, municipal solid waste in the form of refuse derived fuel (RDF) and date stones were selected for char production. The produced chars were investigated as a low-cost catalyst for the catalytic cracking of biomass pyrolysis gases during the two-stage pyrolysis/gasification of biomass. Biomass was used to generate a range of hydrocarbon gases typically found in biomass gasification tars through the pyrolysis of biomass. Wood pellets were pyrolysed in a fixed bed reactor at a heating rate of 40 ºC and a final temperature of 500 ºC, and the resultant pyrolysis vapours were then passed to a second stage reactor to undergo secondary cracking reactions over waste derived pyrolysis chars. The product gases were analyzed by gas chromatography and the condensed fraction was collected and analyzed and quantified using gas chromatography-mass spectrometry.

Among the investigated chars for bio-oil/tar decomposition, at a char cracking temperature of 800 ºC, tyre-derived pyrolysis char presented the highest activity resulting in a 70% reduction in bio-oil/tar yield compared to the non-char catalytic experiments. The results suggest that tar decomposition by char materials is mainly ascribed to the catalytic conversion of tar species, as the decrease of the hydrocarbon tar yields was accompanied with a consequent increase in total gas yield. For instance, at a cracking temperature of 800 °C, the hydrogen concentration increased markedly from 19.6 vol.% with no char to 25, 29 and 34 vol.% with the use of a hot bed of date stones, tyre, and RDF chars respectively in the second stage. Analysis of the tar composition showed the presence of naphthalene, fluorene and phenanthrene as the major polyaromatic hydrocarbon (PAH) components at the higher cracking temperature.

Further analysis is needed to investigate the tar conversion combined with char gasification. Therefore, tyre char was used as a sacrificial catalyst for the reforming/gasification of tars from the gasification of biomass to produce a hydrogen-rich syngas and also to contribute to the yield of biomass syngas through tyre char gasification reactions. The influence of tyre ash metals, catalyst bed temperature, steam to biomass ratio and reaction time were investigated. The metallic mineral content of tyre char has been shown to contribute significantly to the tar degradation. The maximum H_2 content of the product syngas of 56 vol. % was obtained at a reforming temperature of 900 ºC and with steam to biomass ratio of 6 g g^{-1}. Tyre char was also subjected to steam gasification during the process, whereby the tyre pyrolysis char catalyst is sacrificed to produce hydrogen and carbon monoxide to enhance the yield of the syngas.