OZONE AND ACID PRE-TREATMENT OF EMPTY FRUIT BUNCHES FOR REDUCTION OF ALKALI METALS AND CHLORINE

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INTRODUCTION

The shift from fossil fuel sources for power generation to renewable sources for climate change mitigation has necessitated the alternative use of biomass worldwide in the form of residues from the agricultural, plantation or wood industry. A serious commitment to addressing the global warming issue caused by power plants has seen the government of South Korea, among the first few countries, start imposing penalties on the major power generation companies for their huge anthropogenic carbon emissions [1]. To avoid being penalised substantially, the generation companies concerned have started embracing low-carbon green economic growth by utilising biomass as an alternative fuel. Countries like Denmark, Poland, China and Japan have also followed suit to use biomass combustion to produce heat and power [2]-[6].

One of the agricultural industries producing abundant lignocellulosic biomass feedstock to be processed into renewable energy as a potential fossil fuel substitute is the palm oil industry of great economic importance in Southeast Asia. In Malaysia, the oil palm biomass totalling ~80 million tonne dry basis [7] is available from palm oil mills and oil palm plantations. Of particular

interest, empty fruit bunches (EFB), is abundantly generated during the palm oil milling activities together with mesocarp fibre and palm kernel shell (PKS). The annual production of EFB is estimated at 22 million tonnes (or 7.26 million dry tonnes [7]-[8]), and has been identified as a potential alternative fuel source to generate heat and power but is less attractive compared to mesocarp fibre and PKS due to some inherited inferior characteristics [7].

One of the shortcomings, i.e., the alkali metal (K + Na) and chlorine (Cl) contents of EFB, are higher than other types of biomasses such as PKS and wood. The respective K + Na concentration is in the range of 17000 to 30000 ppm, and the Cl concentration is 5000 to 7000 ppm [7],[9]-[10], compared to that of PKS, which has a K + Na concentration of 2000 to 4000 ppm and Cl concentration of 2000 to 7000 ppm [7],[9]. The higher K + Na and Cl concentrations in EFB could cause operational issues such as slagging and fouling in the boilers and furnaces when utilised or co-fired as a mixed fuel [9]-[11] at high temperatures. Similar observations were reported for ashes from agricultural and energy crops, such as mixed cereal straws, corn straws, miscanthus, etc. The presence of alkali metals compounds (KCl, K_2CO_3, K_2SO_4, Na_2O) in biomass is problematic as they reduce the fusion temperatures of the ashes, the lowest being KCl-K_2SO_4 with a melting point of 694°C [12]-[13].

Pre-treatment (or leaching) of the intended biomass is required to reduce the alkali metals and chlorine content to reduce slagging and fouling. Using water as a means of pre-treatment, the alkali metals in biomass can be reduced by 70 to 80% [14]. For example, rice straw and wheat straw were leached at biomass to water mass ratio (BWMR) of 20, and the corresponding K + Na contents were reduced from 17000 to 4000 ppm (rice straw) and 19000 to 3800 ppm (wheat straw) [15]. In another separate experiment, EFB and PKS were also leached at a BWMR of 20. The K + Na content in the EFB was reduced from 24320 to 6800 ppm [10]. Though the reduction rate is high, it is not good enough if EFB is co-combusted in the power plants. Depending on the initial contents of the alkali metals and chlorine, further reduction of these elements is possible via additional or a combination of pre-treatment methods. Hydrothermal treatment of biomass is known to reduce K, Na, Cl and other inorganic elements to negligible levels. Still, the process is energy intensive as the water must be heated up to 200°C [16]-[17].