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Production and Characterization of Biochars from Torrefaction of Biomass

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Abstract : Biomass is a CO_2-neutral fuel that is renewable and sustainable along with having very huge global potential. Efficient use of biomass in power generation and production of biomass-based biofuels can mitigate the greenhouse gasses (GHG) and reduce dependency on fossil fuels. There are also other beneficial effects of biomass energy use such as employment creation and pollutant reduction. However, most of the biomass materials are not capable of competing with fossil fuels in terms of energy content. High moisture content and high volatile matter yields of biomass make it low calorific fuel, and it is very significant concern over fossil fuels. Besides, the density of biomass is generally low, and it brings difficulty in transportation and storage. These negative aspects of biomass can be overcome by thermal pretreatments that upgrade the fuel property of biomass. That is, torrefaction is such a thermal process in which biomass is heated up to 300ºC under non-oxidizing conditions to avoid burning of the material. The treated biomass is called as biochar that has considerably lower contents of moisture, volatile matter, and oxygen compared to the parent biomass. Accordingly, carbon content and the calorific value of biochar increase to the level which is comparable with that of coal. Moreover, hydrophilic nature of untreated biomass that leads decay in the structure is mostly eliminated, and the surface properties of biochar turn into hydrophobic character upon torrefaction. In order to investigate the effectiveness of torrefaction process on biomass properties, several biomass species such as olive milling residue (OMR), Rhododendron (small shrubby tree with bell-shaped flowers), and ash tree (timber tree) were chosen. The fuel properties of these biomasses were analyzed through proximate and ultimate analyses as well as higher heating value (HHV) determination. For this, samples were first chopped and ground to a particle size lower than 250 µm. Then, samples were subjected to torrefaction in a horizontal tube furnace by heating from ambient up to temperatures of 200, 250, and 300ºC at a heating rate of 10ºC/min. The biochars obtained from this process were also tested by the methods applied to the parent biomass species. Improvement in the fuel properties was interpreted. That is, increasing torrefaction temperature led to regular increases in the HHV in OMR, and the highest HHV (6065 kcal/kg) was gained at 300ºC. Whereas, torrefaction at 250ºC was seen optimum for Rhododendron and ash tree since torrefaction at 300ºC had a detrimental effect on HHV. On the other hand, the increase in carbon contents and reduction in oxygen contents were determined. Burning characteristics of the biochars were also studied using thermal analysis technique. For this purpose, TA Instruments SDT Q600 model thermal analyzer was used and the thermogravimetric analysis (TGA), derivative thermogravimetry (DTG), differential scanning calorimetry (DSC), and differential thermal analysis (DTA) curves were compared and interpreted. It was concluded that torrefaction is an efficient method to upgrade the fuel properties of biomass and the biochars from which have superior characteristics compared to the parent biomasses.

Keywords : biochar, biomass, fuel upgrade, torrefaction
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