Combustion Study of DDGS Char From Steam-O2 Blown CFB Gasifier and Charcoal Using Thermogravimetric Analysis and COMSOL Multiphysics®

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Abstract

To obtain reliable kinetic data for the modeling of Dried Distiller's grains with Soluble (DDGS) gasification using a 100 kWth steam-O2 blown circulating fluidized bed (CFB) gasifier, the combustion behavior of partially gasified residual DDGS char and pure charcoal as a comparison has been investigated using thermogravimetric analysis (TGA). The aim of this work is to study the influences of several important factors, such as combustion temperatures (400-600, 750-900 °C), heating rates (10, 30, 50 °C min-1) and O2 concentrations (7.5, 10, 15, 21vol. %), on the combustion behavior of DDGS char and pure charcoal. Two conversion models, volume reaction model (VRM) and shrinking core model (SCM), were applied to interpret the experimental data. To provide a better insight into heat transfer and fluid flow profiles within the TG furnace for the case of char combustion, the used TG furnace was modeled using COMSOL Multiphysics®. Within the higher temperature range of 750-900 °C, it was impossible to determine kinetic parameters for combustion of DDGS char, but it was well possible for charcoal under 15vol.% O2 (Ea ca.120 kJ mol-1 using the SCM model), and the Ea value obtained from DDGS char was around 60 kJ mol-1 using the VRM model within the lower temperature range of 450-600 °C. The lower Ea value was probably because of high ash content in the DDGS char. Results predicted from the 3D TG furnace model agreed fairly well with the experimental data. Compared to DDGS char combustion, the heat released from pure charcoal combustion obviously has less effect on the temperature distribution within the TG furnace, which largely is due to the lower combustion rate of pure charcoal. The velocity profile within the furnace was affected by the furnace temperature and vice versa, and they both were also affected by the heat produced from char combustion.

Keywords: Circulating fluidized bed; thermogravimetric analysis; char combustion; shrinking core model; volume reaction model; COMSOL Multiphysics®.