Abstract

Greenhouse gas (GHG) emissions are a serious environmental issue that humankind must face soon. Bio-energy carbon capture technology (BioCCS or BECCS) that results in negative-CO_2 power generation will be a vital in the transition toward a sustainable economy. Due to the biogenic origin of a considerable part of carbon contained in municipal solid waste (MSW), implementing carbon capture in waste incineration plants can be classified as BioCCS. Nowadays, there are four incinerators, in which CO_2 capture is applied; however, they use the post-combustion technique since it is the most mature method and does not require many changes in the system. Nevertheless, the separation of CO_2 from the flue gas stream, which contains mostly nitrogen, is complex and causes a large drop in the system's total performance.

A more superior solution is oxy-fuel combustion technology. OFC involves the replacement of air as an oxidizer with high purity oxygen and recirculated exhaust gas. As a result, the produced gas is composed mainly of CO_2 and H_2O, which makes its sequestration more cost-effective. Nevertheless, changing the atmosphere from N_2 to CO_2 affects combustion behaviour. To study the impact of the atmosphere on combustion and for a better understanding of the process, the thermal degradation of representative types of municipal solid waste (MSW) under N_2, CO_2, and O_2/CO_2 atmospheres was analysed using a thermogravimetric (TG) instrument as well as a lab-scale experimental rig. Non-isothermal degradation experiments were conducted, and three heating rates were examined. Isoconversional methods were employed to determine kinetic data. The reported kinetic parameters provided fundamental information on the conversion of solid waste and were used in a mathematical modelling of oxy-waste combustion. The developed model includes all important stages of waste decomposition taking place within the chamber, such as moisture evaporation, pyrolysis, char burnout, and gas combustion over the grate.

The results of the work will contribute to the development of waste incineration plants integrated with carbon capture, expanding knowledge about the thermal degradation of waste in various conditions and will be useful for the design of oxy-waste combustion chambers.