Abstract

The adverse effects of climate change have led to increased action to develop strategies to mitigate greenhouse gas emissions, including bioenergy and biochar applications. The combination of these two technologies has been proposed by our research group as a possible bioenergy with carbon capture and storage (BECCS) process, a concept that generates electricity while pulling CO_2 out of the atmosphere. Biowaste feedstocks are pyrolyzed to form energy-dense biochars that are converted to CO through the reverse Boudouard reaction, which powers a solid oxide fuel cell (SOFC) for energy production. The SOFC effluent is mostly CO_2, which can be sequestered to make the overall system carbon-negative.

In this thesis, the influence of inherent biomass inorganics and CO_2 co-pyrolysis were investigated to determine how these factors affect biochar production and use during the gasification reaction. Char yields and moisture capacities were lower for feedstocks with higher amounts of ash but the resultant char was more reactive in gasification at 800°C. The enhanced reactivity of biochars with high ash content was in line with previous work from the research group on a smaller set of feedstocks. Feedstock selection was a major factor that affected biochar formation after introducing CO_2 in pyrolysis. For CO_2 co-pyrolysis, nutshells did not experience any changes to char yields and moisture capacities whereas seeds, corncob, and sawdust were observed with higher char yields and/or moisture capacities after pyrolysis. Increases in moisture capacity, a proxy for surface area, did not translate to higher biochar reactivity, which suggested that surface area did not impact gasification performance. These results can be used in further process studies to investigate if it is more beneficial to have higher char yields or higher char reactivity for the proposed BECCS process.