Utilization of sulfate additives in biomass combustion: fundamental and modeling aspects - DTU Orbit (09/11/2017)

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Sulfates, such as ammonium sulfate, aluminum sulfate and ferric sulfate, are effective additives for converting the alkali chlorides released from biomass combustion to the less harmful alkali sulfates. Optimization of the use of these additives requires knowledge on their decomposition rate and product distribution under high temperature conditions. In the present work, the decomposition of ammonium sulfate, aluminum sulfate and ferric sulfate was studied respectively in a fast-heating rate thermogravimetric analyzer for deriving a kinetic model to describe the process. The yields of SO2 and SO3 from the decomposition were investigated experimentally in a tube reactor under different conditions, revealing that the ratio of the SO3/SO2 released varied for different sulfate and the ratio could be influenced by the decomposition temperature. The proposed decomposition model of ferric sulfate was combined with a detailed gas-phase kinetic model of KCl sulfation and a model of K2SO4 condensation to simulate the sulfation of KCl by ferric sulfate addition. The simulation results showed good agreements with the experiments conducted in a biomass grate-firing combustor, where ferric sulfate and elemental sulfur were used as additives. The results indicated that the SO3 released from ferric sulfate decomposition was the main contributor to KCl sulfation and that the effectiveness of ferric sulfate addition was sensitive to the applied temperature conditions. Comparison of the effectiveness of different sulfates indicated that ammonium sulfate has clearly strongest sulfation power towards KCl at temperatures below 800oC, whereas the sulfation power of ferric and aluminum sulfates exceeds clearly that of ammonium sulfate between 900 and 1000oC. However, feeding gaseous SO3 was found to be most effective to destroy KCl with a comparable dosage. Overall, the models developed in this work would facilitate an optimal use of sulfate additives in biomass combustion.

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