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Removal of a tar analogue from synthetic fuel gas using a non-thermal plasma dielectric barrier discharge reactor

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Cleaning of product gas from biomass gasification is one of the major challenges for the application of biomass as a renewable energy source for power generation and value-added chemical synthesis. Non-thermal plasmas are a novel alternative technology for decomposing the tar compounds. In this research, a dielectric barrier discharge (DBD) reactor was used to decompose toluene (a tar surrogate) and its performance was investigated under different reaction conditions. The effect of parameters including residence time, plasma power, and temperature, were investigated. It was demonstrated that the percentage removal of tar increased with increasing plasma power and residence time. 99%+ removal of toluene was observed at a plasma power of 40 W (the highest power used) and a residence time of 4.23s (the highest residence time used). The toluene decomposition products include CO, lighter hydrocarbons, and solid residue. At ambient temperature, the maximum selectivity of gaseous products, CO and lower hydrocarbons (C_1-C_5), reached 45% and 27% respectively. Unfortunately, there was also substantial solid residue formation (28%-33%). The synergetic effect of temperature and plasma was investigated to decrease the selectivity to the residue. It was found that solid residue completely disappeared at 400oC and selectivity to lower hydrocarbons increased with operating temperature. However, the selectivity to CO decreased, due to the termination of radicals through the combination of CO and O at higher temperatures. Overall, this work demonstrates that toluene can be almost completely converted by a DBD non-thermal plasma, and that a degree of control can be established by varying power, residence time and tempera.

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