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Temperature dependence of non-thermal plasma assisted hydrocracking of toluene to lower hydrocarbons in a dielectric barrier discharge reactor

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Abstract

Non-thermal plasma (NTP) is an attractive method for decomposing biomass gasification tars. In this study, the removal of toluene (as a gasification tar analogue) was investigated in a dielectric barrier discharge (DBD) reactor at ambient and elevated temperatures with hydrogen as the carrier gas. This study demonstrated that higher temperature in the presence of a DBD opens up new (thermal) reaction pathways to increase the selectivity to lower hydrocarbons via DBD promoted ring-opening reactions of toluene in H_2 carrier gas. The effect of plasma power (5 – 40 W), concentration (20-82 g/Nm^3), temperature (ambient-400 ^oC) and residence time (1.43-4.23 s) were studied. The maximum removal of toluene was observed at 40 W and 4.23 s. The major products were lower hydrocarbons (C_1-C_6) and solids. The synergetic effect of power and temperature was investigated to decrease the unwanted solid deposition. It was observed that the selectivity to lower hydrocarbons (LHCs) increased from 20 to 99.97 %, as temperature was increased from ambient to 400 ^oC, at 40 W and 4.23 s. Methane, C_2 (C_2H_6 + C_2H_4), and benzene were the major gaseous products, with a maximum selectivity of 97.93% (60 % methane, 9.93 % C_2 (C_2H_6 + C_2H_4), and 28% benzene). It is important to note that toluene conversion is not a function of temperature, but the selectivity to lower hydrocarbons increases significantly at elevated temperatures under plasma conditions.