World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:15, No:04, 2021

Plasma-Assisted Decomposition of Cyclohexane in a Dielectric Barrier Discharge Reactor

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Abstract : Volatile organic compounds (VOCs) are atmospheric contaminants predominantly derived from petroleum spills, solvent usage, agricultural processes, automobile, and chemical processing industries, which can be detrimental to the environment and human health. Environmental problems such as the formation of photochemical smog, organic aerosols, and global warming are associated with VOC emissions. Research showed a clear relationship between VOC emissions and cancer. In recent years, stricter emission regulations, especially in industrialized countries, have been put in place around the world to restrict VOC emissions. Non-thermal plasmas (NTPs) are a promising technology for reducing VOC emissions by converting them into less toxic/environmentally friendly species. The dielectric barrier discharge (DBD) plasma is of interest due to its flexibility, moderate capital cost, and ease of operation under ambient conditions. In this study, a dielectric barrier discharge (DBD) reactor has been developed for the decomposition of cyclohexane (as a VOC model compound) using nitrogen, dry, and humidified air carrier gases. The effect of specific input energy (1.2-3.0 kJ/L), residence time (1.2-2.3 s) and concentration (220-520 ppm) were investigated. It was demonstrated that the removal efficiency of cyclohexane increased with increasing plasma power and residence time. The removal of cyclohexane decreased with increasing cyclohexane inlet concentration at fixed plasma power and residence time. The decomposition products included H_2, CO_2, H_2O, lower hydrocarbons (C_1-C_5) and solid residue. The highest removal efficiency (98.2%) was observed at specific input energy of 3.0 kJ/L and a residence time of 2.3 s in humidified air plasma. The effect of humidity was investigated to determine whether it could reduce the formation of solid residue in the DBD reactor. It was observed that the solid residue completely disappeared in humidified air plasma. Furthermore, the presence of OH radicals due to humidification not only increased the removal efficiency of cyclohexane but also improves product selectivity. This work demonstrates that cyclohexane can be converted to smaller molecules by a dielectric barrier discharge (DBD) non-thermal plasma reactor by varying plasma power (SIE), residence time, reactor configuration, and carrier gas.

Keywords : cyclohexane, dielectric barrier discharge reactor, non-thermal plasma, removal efficiency
Conference Title : ICAQEH 2021 : International Conference on Air Quality and Environmental Health
Conference Location : London, United Kingdom
Conference Dates : April 22-23, 2021