Electron Beam and Pulsed Corona Processing of Volatile Organic Compounds in Gas Streams

B. M. Penetrante, M. C. Hsiao, J. N. Bardsley, B. T. Merritt, G. E. Vogtlin and P. H. Wallman
Lawrence Livermore National Laboratory,
Livermore, California 94550 USA

A. Kuthi, C. P. Burkhart and J. R. Bayless
First Point Scientific, Inc.
Agoura Hills, California 91301 USA

Non-thermal plasma processing is an emerging technology for the abatement of volatile organic compounds (VOCs) in atmospheric-pressure gas streams. Either electron beam irradiation or electrical discharge methods can produce these plasmas. The thrust of our work has been to understand the scalability of these plasma techniques by focusing on the energy efficiency of the process and identifying the byproducts. The electron mean energy in a plasma reactor determines the yields of radicals and other plasma generated species. Much of our work has been devoted to a characterization of the electron mean energy in the plasma. For most electrical discharge reactors our results suggest that the attainable electron mean energy is rather limited and cannot be easily enhanced by changing the electrode configuration or voltage pulse parameters. This has driven our efforts to improve the efficiency of the non-thermal plasma process by using a compact electron beam source. In this paper we present data on non-thermal plasma processing of various VOCs using an electron beam reactor and a pulsed corona reactor. The electrical energy consumption is characterized for the decomposition of a variety of VOCs, including carbon tetrachloride, trichloroethylene, methylene chloride, benzene, acetone and methanol. For most of the VOCs investigated, electron beam processing is more energy efficient than pulsed corona processing. For VOCs (such as carbon tetrachloride) that require copious amounts of electrons for its decomposition, electron beam processing is remarkably more energy efficient. For some VOCs the decomposition process is limited by their reaction rate with the plasma-produced radicals and/or by the occurrence of back reactions. In these cases, the energy consumption can be minimized by operating at high (but non-combusting) temperatures.