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A Novel Energy-Efficient Plasma Chemical Process for the Destruction of Volatile Toxic Compounds

Dr. Lal A. Pinnaduwage
Oak Ridge National Laboratory
Bldg. 4500-S, MS 6122
P.O. Box 2008
Oak Ridge, Tennessee 37831-6122
Phone: 423-574-6540
E-mail: llp@ornl.gov

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Research Objective

Removal of low-concentrations (below several percent) of volatile toxic compounds (VTCs) from contaminated air streams is encountered at DOE waste sites in two instances:

(1) Off-gases resulting from air-stripping of contaminated soils; and
(2) Effluent from the incineration of highly-concentrated combustible hazardous wastes

The objective of our research program is to develop a novel plasma chemical process for the destruction of VTC's in low-concentration waste streams.

Research Progress and Implications

Within the past year and a half, the basic physics/chemistry involved in the dissociative electron attachment to highly-excited molecules was unraveled in a plasma mixing apparatus:


A methodology for the evaluation of VTC destruction in a plasma mixing apparatus was developed:


A baseline study on the destruction of VTC’s using a DC glow discharge apparatus was completed:


Two patent disclosures based on this work have been elected by the ORNL Technology Transfer Office to be filed:


These concepts still need to be tested.

In order to expedite the destruction efficiency measurements, quite recently we have developed a direct sampling mass spectrometric process which avoids the usage of the time consuming gas chromatographic analysis. We will be using this new analysis method in our pulsed discharge experiments.
Planned Activities

The studies conducted so far have indicated that a pulsed discharge would enhance the destruction of VTC’s compared to a DC discharge. We have purchased a pulsed power supply system and have just initiated pulsed discharge studies. (Anticipated time period: 1998-1999).

In order to clarify the mechanisms responsible for the enhanced destruction in pulsed discharges, we will conduct a diagnostic pulsed discharge experiment in a different apparatus. We believe that the additional enhancement observed in the pulsed discharges is due to two reasons:

1. The destruction of metastable states by electron impact is reduced in the post discharge period; and
2. Additional metastable states can be produced in the post discharge via dissociative recombination of electrons with dimer ions of the rare gas.

Therefore, the excitation transfer to the VTC molecules would be optimum in the post discharge period. If additional excitation of VTC molecules occurs in the post discharge period via the above processes, then dissociative electron attachment to those excited molecules will lead to an enhancement in negative ion formation in the post discharge. We will conduct a time resolved photodetachment experiment to verify the enhanced negative ion formation. (Anticipated time period: 1998-1999).

The studies we have conducted so far involved mixtures of VTCs in rare gases. In order to deal with realistic VTC mixtures in air, we will use the basic knowledge gained from the studies of 1 and 2 above in a plasma mixing scheme. In this case the rare gas metastable states produced will be mixed with VTC/N₂ mixtures first and then we will also study the influence of the humidity and the O₂ on the destruction process. Following these studies we will study contaminated air streams to assess the destruction efficiencies. (Anticipated time period: 1999-2002).