Report for 2001NJ1181B: Vapor phase UV Destruction of organic contaminants

- Conference Proceedings:
    - LEE, K. Y., J. KHINAST, J. J-Y. LEE, AND J. R. STENCEL, Design and construction of a field-scale photo-chemical remediation reactor,Thirty-Third Mid-Atantic Industrial and Hazardous Waste Conference, edited by N. Assaf-Anid, 256-263, Riverdale, NY, 2001.
    - LEE, J. J-Y., Design and construction of a photo-chemical remediation reactor, (Third place student poster presentation), presented at New Jersey Water Environment Association annual conference, May 2001 (Advisor Dr. Kenneth Y. Lee).

Report Follows:

PART II

Final Report:

Project Information:

Soil and groundwater contaminated with volatile organic compounds (VOCs) are often remediated using soil venting or pump-and-treat followed by air stripping, combined with carbon adsorption to treat off-gases (Hager et al., 2000). However, activated carbon simply changes the phase of the pollutant and generates contaminated carbon wastes. Another off-gas treatment method is thermal oxidation, but a fuel supply is needed to elevate the temperature up to 500^{o}C to initiate the reaction (Chen et al., 1995). In recent years, photo-chemical oxidation has been studied as an alternative remediation technology because of the numerous advantages compared to conventional technologies (Prager and Hartman, 2001). The technology is based on a synergistic effect obtained when UV photo-initiation is combined with a reducing gas (e.g., hydrogen), oxidative atmosphere (ambient air), or combination of both. The advantages of photo-chemical oxidation are: (1) Photo-chemical process can be operated at ambient temperature and pressure, (2) complete and efficient destruction of a broad range of pollutants can be achieved, which produce innocuous final oxidation products such as CO_2, H_2O, and/or HCl, and (3) no chemical additives are required. In this study, a pilot-scale photo-chemical remediation reactor is designed and constructed.

Methodology:

The design of the pilot-scale photo-chemical remediation reactor is based on extensive bench-scale studies (EPA, 1994; EPA, 1999) performed at Energia, Inc. (Princeton, NJ). Figure 1 shows a schematic diagram of the reactor and the vapor phase flow path. Stainless steel (type 304) is selected for the construction of the tubular reactor vessel because of cost considerations, ability to resist corrosion, and ease in fabrication. The reactor is insulated to minimize heat loss. The reactor has an inner diameter of 32 cm and a length of 105 cm. The reactor volume is approximately 84.1 liters and this volume is reduced to approximately 73.7 liters with the insertion of sixteen Suprasil glass sleeves and three internal baffles. The Suprasil glass sleeves are geometrically positioned to provide uniform UV exposure inside the reactor (see Figure 1). Each Suprasil glass sleeve holds a low pressure mercury amalgam UV lamp (Heraeus Inc.), which protects the UV lamp from contaminant vapor while allowing transmission of UV light into the reactor. Each Suprasil glass sleeves has a 25 mm inner diameter and 28 mm outer diameter with a length of 110 cm. Three thermocouples are mounted on the reactor to observe reactor temperature progression. The reactor and all associated hardware are mounted on a mobile frame for possible technology demonstration at a field site. Figure 2 shows a picture of the reactor with UV lamps installed.

Gas-tight sealing between each Suprasil sleeve and the stainless steel end plate is accomplished using the “stuffing-box” configuration, which two 6.35 mm (1/4 inch) thick flexible graphite compression seals (Garlock Sealing Technologies, Palmyra NY) are compressed by a circular aluminum gland to form the seal. A reactor leak test is conducted by pressurizing the reactor to 10 psig and the reactor pressure is observed over time. Results indicate that the leaks are insignificant especially if the system is operated at atmospheric pressure.

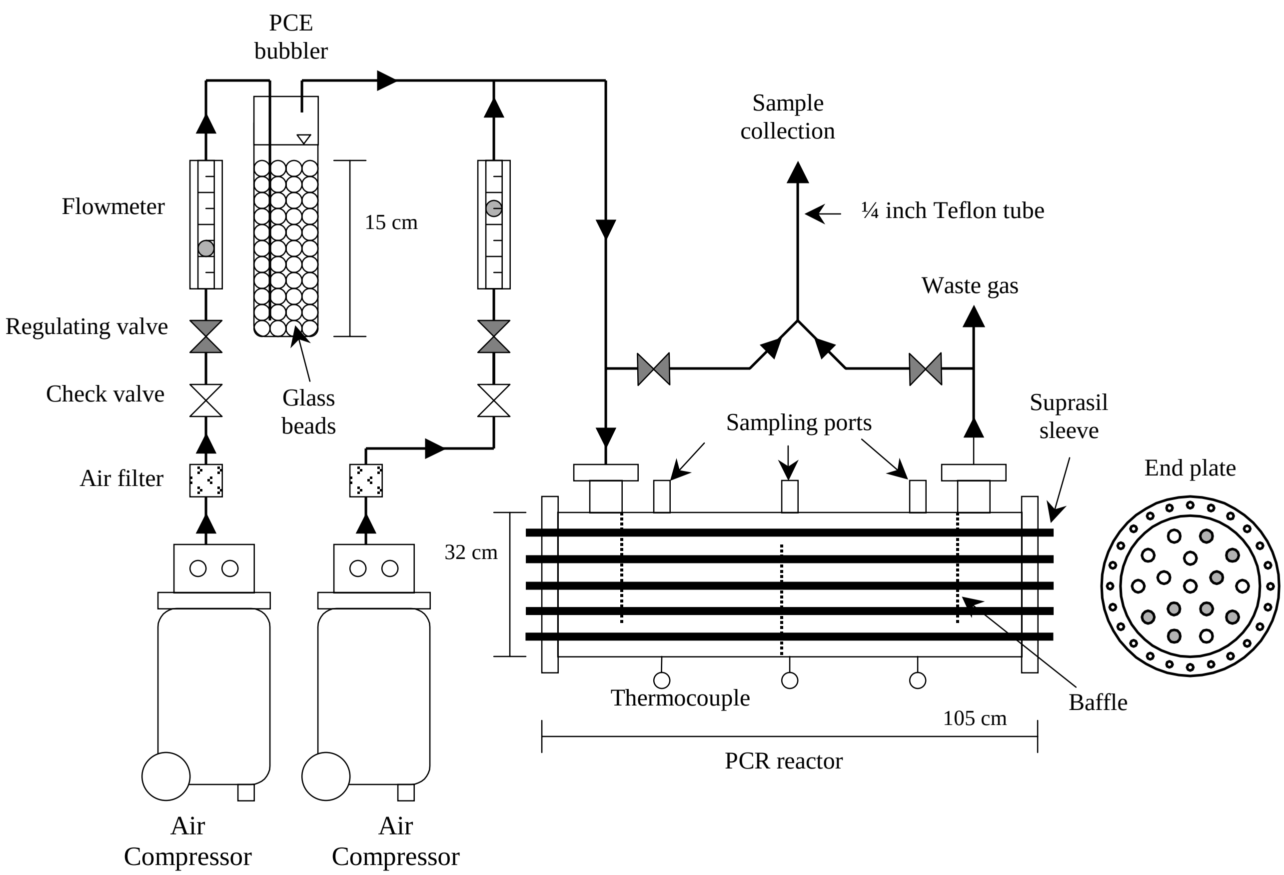

Figure 1: Design of reactor flow path.

Principal Findings and Significance:

A novel pilot-scale photo-chemical remediation reactor was designed and constructed. The reactor will be used to perform destruction experiments on volatile organic compounds such as PCE and TCE.

Figure 2: Photo of reactor.

Chen, C. T., Graham, J. L., and Dellinger, B. (1995). "Photothermal destruction of the vapor of organic compounds." *Waste Management*, 15(2), 159-170.

EPA, U.S. (1994). "Emerging technology bulletin, reductive photo-dechlorination (RPD) process for safe conversion of hazardous chlorocarbon waste streams." Energia, Inc. of Princeton, NJ, EPA/540/F-94/508, Cincinnati, OH.

EPA, U.S. (1999). "Superfund innovative technology evaluation (SITE) program: Emerging technology program, Vol. 2." pp. 38, 122, Energia, Inc. of Princeton, NJ, EPA/540/R-99/500, Cincinnati, OH.

Hager, S., Bauer, R., and Kudielka, G. (2000). "Photocatalytic oxidation of gaseous chlorinated organics over titanium dioxide." *Chemosphere*, 41, 1219-1225.