Bioremediation and Sustainable Environmental Technologies—2017. Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies (Miami, FL; May 2017). ©2017 Battelle Memorial Institute, Columbus, OH, www.battelle.org/biosymp. A. Barton and S. Rosansky (Chairs)

Optical Sensor for Real-Time Measurement of Chlorinated Solvents in Air

Sine Thorling Sørensen, Helena Hansen, Nancy Hamburger and Nina Tuxen (Capital Region, Denmark)
Mette Christophersen and Lars Bennedsen (Rambøll, Denmark)
Yu-Pei Tseng, Peter Tidemand-Lichtenberg and Christian Pedersen (DTU Fotonik, Denmark)

Background/Objectives. Today measurements of volatile organic contaminants (VOC) in indoor air, are performed in different ways (e.g. with sorption tubes or different kinds of canisters, which are quite difficult sampling methods). At present no simple, effective and inexpensive method for direct quantitative measurements of VOC in air exists.

After more than 5 years of intensive research DTU Fotonik have developed a revolutionary mid-infrared detector based on upconversion of the signal which reduces the noise significantly compared to alternative detectors. The measurements are performed by sending an infrared laser beam through a specified air volume. The bonds in VOCs will absorb specific wavelength of the light and by detecting changes in the light using the patented upconversion technology developed by DTU Fotonik it is possible to quantify very low concentrations of PCE, TCE and other VOCs in the air.

The purpose of this project is to build and test a system based on the optical sensor to measure PCE and TCE in soil air and indoor air related investigations of contaminated sites.

Approach/Activities. In the first experiments a system based of wavelength scanning of the illumination sources was tested allowing measuring the full spectral shape of the absorption peak associated to TCE and PCE. A second implementation was investigated using one fixed wavelength for each chemical compound. This system showed improved signal to noise ratio, resulting in improved sensitivity. Scanning of the QCL emission across the absorption spectrum of the compound gives specificity, allowing to identify compounds and eliminate cross contamination from other compounds, like water vapor. The absorption spectrums of TCE and PCE are separated which allows for individual measurement of the concentration of the two gas compound. One test measurement of PCE with the system showed a concentration of 1329 µg/m3 and reference measurement on sorption tubes showed 1.400 µg/m3.

To improve the sensitivity, specificity and stability of the system further, to detect concentrations down to few µg/m3, a self-referencing system was implemented in the 2nd generation setup. The correlation tested by varying power and wavelength of QCL and power of mixing laser showed that the amplitude noise and the power fluctuation to some degree can be compensated using a common mode rejection scheme.

Results/Lessons Learned. It is possible to measure the absorption of VOCs like TCE and PCE using the optical technique with short acquisition time. The self-referencing system (common mode noise reduction) reduced the noise significantly and it is expected that this detection principle can be further improved to a sensitivity in the µg/m^3 level for TCE and PCE (tests will be conducted in autumn 2017). The system can be reconfigured to measure other VOCs. It is expected that the method will improve investigations of indoor air quality, help identifying intrusion pathways for VOCs to buildings, and help in several other application where fast quantitative measurements of VOCs are needed. Transforming the system into a robust compact and portable unit for field measurements is considered to be a straight forward engineering task.