A New Real-Time Technique for the Determinations of Mixed Organic Vapors in Occupational Setting

Lu, Hao-Yu¹ ; Tsai, Shih-Wei¹ ; Tsai, Shih-An² ; Huang, Chien-Lin² ; Chu, Shih-Chi² ; Chou, Tsung-Kuan A³ ; Wang, Li-Peng³

1. Institute of Environmental Health, National Taiwan University, Taipei, Taiwan.
2. TRICORNTCH Corporation, Taipei, Taiwan.
3. TRICORNTCH Corporation, San Jose, CA, United States.

Background

TCT-MiTAP is a miniaturized complex-mixture gas analysis device, which leverages advanced electronic technologies, nano-materials, and innovative sensing architecture to have state-of-the-art performance among portable gas sensors: limit of detection (LoD) of 0.35 parts per billion by volume (ppbv) and better VOC separation than conventional 15m-long GC. It has combined merits of high sensitivity/specificity like GC/MS and portability like eNose. (Figure 1).

To determine the levels of mixed organic vapors in occupational settings, adsorption tube coupled with personal pump was often used for the sampling first, followed by the desorption with solvent and analysis with GC/MS. However, real-time data could not be collected usually, due to the limitation of instrumental sensitivity.

Objectives

In this study, a new miniaturized complex-mixture gas analysis device was validated for the measurements of mixed organic vapors. Four commonly used solvents in the industries, including 1,4-dioxane, tetrahydrofuran (THF), trichloroethylene(TCE) and tetrachloroethylene(TetraCE) was validated for the measurements of mixed organic vapors.

Methods

Eight different concentrations of the mixed vapors around the permissible exposure limits (PELs) levels were prepared by the standard gas generation system. The temperatures and relative humidities (RHs) tested were 25, 30, 35°C, and 8, 40, 80%, respectively. One hour air sampling was conduct by charcoal tube and MiTAP simultaneously for comparing the real-time concentration with average concentration. MiTAP sampled three times per hour, charcoal tube sampled one time per hour and then be analyzed by GC/MS.

Results

The results shows that with sampling for only 1min, followed by the pre-processing for 4min, and analysis for 10min, the four mixed organic vapors can be detected simultaneously with method detection limits (MDLs) as low as 1.92ppb, 6.05ppb, 1.02ppb, and 0.28ppb, for 1,4-dioxane, THF, TCE and TetraCE, respectively.

For the various concentrations tested, the results from all the mixed vapors showed good linearity (R²>0.995) with coefficient of variations (CVs) all <10% (Figure 2). When compared the results obtained from RHs equal 8% and 80%, the variation was within 10%. On the other hand, no statistical difference was found when sampling at different temperatures (Figure 3, 4). The result of simultaneous air sampling showed that there was no large difference between real-time concentration and average concentration. (Figure 5).

Conclusion

This portable gas sensors performed in this study has demonstrated a better VOCs separation than conventional GC. The technique has also combined merits of high sensitivity/specificity like GC/MS and portability like eNose, those are critical to meet rigorous requirements of on-site applications of occupational and environmental monitoring.

Figure 1. The appearance and principle of MiTAP

Figure 2. Calibration curve of four compounds conducted by MiTAP

Figure 3. Concentration of four compounds under different RH

Figure 4. Concentration of four compounds under different temp.

Figure 5. Comparison of real-time conc. with average conc.