Effects of Flow Rate and Temperature on MPN-coated Chemiresistor-Array Micro-GC Detectors for Explosive Marker Compounds

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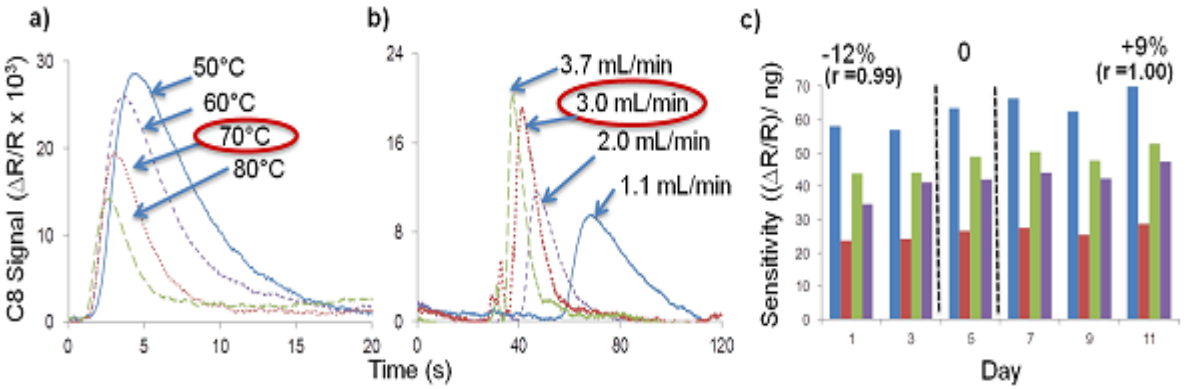

Responses from one representative MPN-coated sensor (C8) to 2,4-DNT as a function of (a) temperature and (b) flow rate. Normalized response patterns for toluene at 70°C (80 hrs, 3 mL/min) demonstrating low drift (%) and good pattern stability/fidelity (r). MPNs, from left to right: C8 (blue), DPA (red), OPH (green), HME (purple).

This project investigates thiolate-monolayer protected gold nanoparticle (MPN)-coated chemiresistor (CR) arrays as detectors for explosive marker compounds in a microscale gas chromatograph (μGC). Chromatographic resolution can be enhanced by increasing the temperature of, and flow rate over, the array, but at the cost of reduced sensitivity. Characterizing these tradeoffs is necessary in order to optimize performance. Representative results are presented in the figures above. The markers 2,4-dinitrotoluene (2,4-DNT) and 2,6-dinitrotoluene (2,6-DNT) are natural byproducts of TNT that are found in the headspace above TNT, while the marker 2,3-dimethyl-2,3-dinitrobutane (DMNB) is a taggant added to TNT. The alkane, n-pentadecane (C15), is used here as a representative interference. Tests show that, while increasing the array temperature from 50-70°C leads to a sensitivity decrease of 2-5 fold and an increase in the limit of detection (LOD) of up to 2-fold, the chromatographic resolution between any pair of test compounds increases by 3-6 fold (3 mL/min). By varying the flow rate from 1-3 mL/min (70°C), sensitivity decreases up to 3-fold for the marker compounds, but the LOD decreases (improves) by up to 2-fold for 2,4-DNT and 2,6-DNT due to increases in peak height. For DMNB, however, peak height reaches a maximum at ~2 mL/min and then starts to gradually decline, resulting in slight increase in the LOD at 3 mL/min. The array of sensors was operated at 70°C for 80 hours (~7 hr/day for 11 days) and the sensitivities showed only minimal drift (toluene, < 2% per day) and no significant change in the array response pattern (correlation coefficient, $r \geq 0.99$). These findings are being used to guide the operating conditions used in a fieldable prototype μGC (INTREPID) employing these arrays as detectors. This work was funded by the Department of Homeland Security, Science and Technology Directorate.

Research Thrust: Environmental Sensors and Subsystems
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