Topic: 2. Sensor Systems

# Using Temperature Effects on Polymer-Composite Sensor Arrays to Identify Analytes

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## Summary

The analyte fingerprints across a polymer-carbon-black composite sensor array have been investigated as a function of temperature where the temperature range is 28-36 °C ($\Delta T$ is 4-8 °C). Using temperature as a sensor variable for analyte identification is not a new idea, however, previous investigations have focused on metal oxide sensors using much larger temperature ranges (~70-450°C).[1, 2, 3] In this study we tested the response of an 8-element array to water, methanol and methane from 28-36 °C. It was established that generally sensor response to an analyte decreases with increasing temperature. However, each sensor's response changes differently with temperature. This variation of response to temperature change creates distinct temperature-dependent fingerprints.

## Motivation

A miniature electronic nose (ENose) has been designed and built at the Jet Propulsion Laboratory; this ENose was designed to detect, identify and quantify ten common contaminants and relative humidity changes while monitoring air quality in an enclosed environment. In this first generation array of sensors, polymer-carbon black composite films were used as the sensing films and the sensors were held at a constant temperature, 2-4 °C above ambient. The selection of the polymer-carbon black sensors was optimized for a targeted list of compounds. This array selection works well for identifying single analytes and mixtures of two and sometimes three analytes.[4] We undertook this investigation to determine whether using temperature control on the sensors could

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[1] T. A. Kunt, T. J. Mcavoy, R. E. Cavicchi, and S. Semancik, "Optimization of Temperature Programmed Sensing for Gas Identification Using Micro-Hotplate Sensors," *Sensors and Actuators B-Chemical*, vol. 53, pp. 24-43, Nov 26, 1998.

[2] H. Kohler, J. Rober, N. Link, and I. Bouzid, "New Applications of Tin Oxide Gas Sensors - I. Molecular Identification by Cyclic Variation of the Working Temperature and Numerical Analysis of the Signals," *Sensors and Actuators B-Chemical*, vol. 61, pp. 163-169, Dec 14, 1999.

[3] P. Mielle and F. Marquis, "One-Sensor Electronic Olfactometer for Rapid Sorting of Fresh Fruit Juices," *Sensors and Actuators B-Chemical*, vol. 76, pp. 470-476, Jun 1, 2001.

[4] M. A. Ryan, M. G. Buehler, M. L. Homer, K. S. Manatt, B. Lau, S. Jackson, and H. Zhou, "Results from the Space Shuttle STS-95 Electronic Nose Experiment," in *The 2nd International Conference on Integrated MicroNanotechnology for Space Applications*, Pasadena, CA, USA, 1999.

improve either the identification of analytes with very similar array fingerprints or the identification of mixtures.

## Results

An array comprised of 8 polymer carbon-black composite sensors was tested for its response to varying analytes at different sensor temperatures. Sensor response to methanol [10-100ppm] and water [7.5-150 ppm] on the same set of sensors was measured at 28°C, 32°C and 36°C. All the polymer sensors show a characteristic decrease in sensor response with increasing baseline temperature for every exposure to the analytes.

Figure 1 shows the temperature-dependent fingerprints of the polymer-carbon composite sensor array to water and methanol. There are many similarities between the three water fingerprints, for example the ranking of the sensor responses doesn't vary much with temperature: s5>s3>s1>s4>s2>s7>s6>s8. However, within the three water fingerprints, the relative responses of the sensors to each other do change: for example, s5:s3 changes from ~1.3 at 28°C to 1 at 36°C. These data lead us to conclude that analytes can be distinguished based on how the response of the array changes as temperature changes.

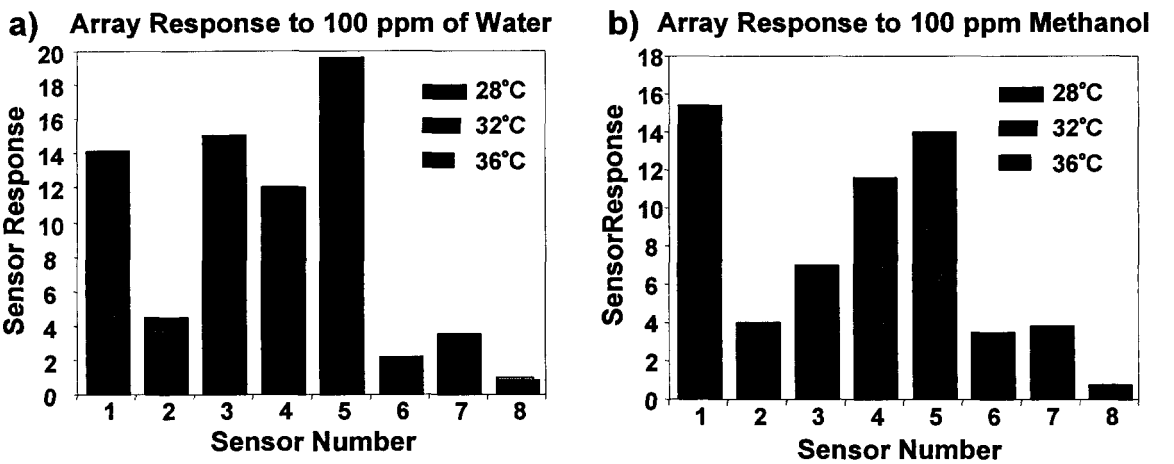


**Fig 1.** The pattern of response to across the 8-sensor array changes as the temperature of the sensor is changed. a) 100 ppm of water b) 100 ppm of Methanol. Response of polymer-carbon composite films to an analyte changes as temperature changes. The overall trend is that as temperature increases, response decreases, although the ratio of response for two temperatures is different for each polymer.