Doped Polyaniline for the Detection of Ethanol

K. M. E. Stewart and A. Penlidis
Institute for Polymer Research, Department of Chemical Engineering
University of Waterloo

A test system for sensing materials and sensors must be able to effectively evaluate both sensitivity and selectivity (among other response characteristics).

By testing potential sensing materials first, only the most promising sensing materials are deposited, which results in a reduction in time, effort, and cost.

Testing multiple gases at once allows for more realistic environmental conditions.

The test system below was used to identify possible sensing materials for ethanol at low concentrations.

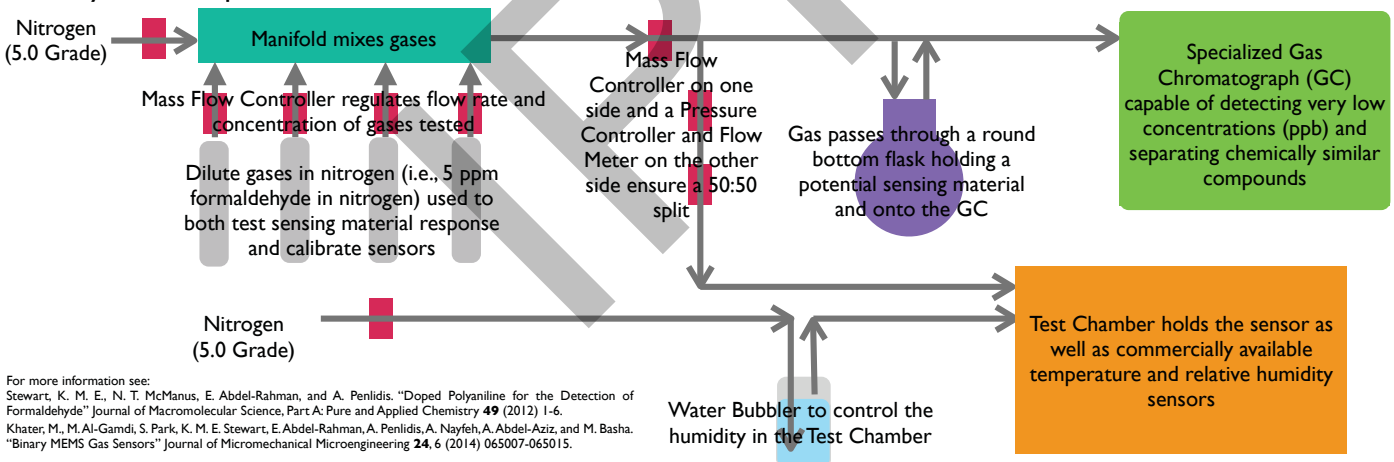
Two doped polymers were chosen from eight sensing materials tested.

A specialized gas chromatograph (GC) is used to evaluate the interaction between the gases tested for the sensing materials, as well as a standard for gas concentration when testing the full sensor.

A voltage vs. time graph is produced by the GC from which the concentration of each analyte can be determined.

The 50:50 split in gas between the GC and test chamber allows for precise and accurate verification of the concentration of multiple gases tested.

Humidity is added directly to the test chamber where a humidity sensor is placed for verification.

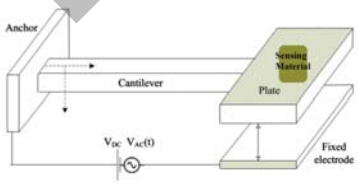


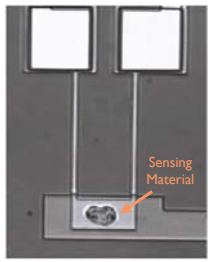
For more information see:
Stewart, K. M. E., N. T. McManus, E. Abdel-Rahman, and A. Penlidis. "Doped Polyaniline for the Detection of Formaldehyde" Journal of Macromolecular Science, Part A: Pure and Applied Chemistry **49** (2012) 1-6.
Khater, M., M. Al-Gamdi, S. Park, K. M. E. Stewart, E. Abdel-Rahman, A. Penlidis, A. Nayfeh, A. Abdel-Aziz, and M. Basha. "Binary MEMS Gas Sensors" Journal of Micromechanical Microengineering **24**, 6 (2014) 065007-065015.

Polyaniline (PANI) and PANI doped with NiO and/or Al_2O_3 were tested as possible sensing materials for ethanol at low concentrations. Three replicates were run and the average response for each sensing material is listed in the Table below. The sensitivity of each sensing material was measured as ppm sorbed per gram of sensing material.

From ten potential sensing materials, PANI doped with 10% NiO was chosen to be deposited onto the MEMS-based cantilever sensor for further testing.

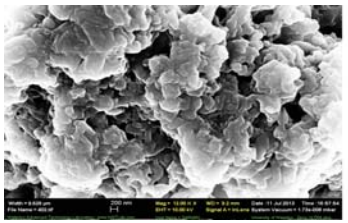
Sensing Material	Amount of Ethanol Sorbed (ppm/g)
PANI	13.08
PANI 5% NiO	10.20
PANI 10% NiO	13.48
PANI 15% NiO	8.55
PANI 20% NiO	11.52
PANI 5% NiO 15% Al_2O_3	6.45
PANI 10% NiO 10% Al_2O_3	12.40
PANI 15% NiO 5% Al_2O_3	12.30



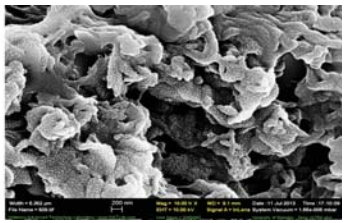


A MEMS-based cantilever sensor, shown above, was evaluated using PANI doped with 10% NiO. The sensor consists of a cantilever that ends in a plate, upon which the sensing material is placed. Ethanol sorbs onto the sensing material, increasing the weight on the plate, causing the plate to drop. When a threshold weight of ethanol is sorbed, the binary sensor triggers.

It was found that PANI doped with 10% NiO on this MEMS-based senosr had a detection limit of 50 ppm and was reponsive over the range of 50 to 1000 ppm.



Polyaniline (PANI)



PANI with 20% NiO

SEM images, above, show homogeneous dispersion of NiO throughout PANI. An even distribution of dopant increases the sensing properties of the senisng material.