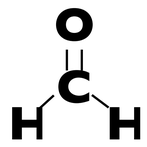
Doped Polyaniline as a Sensing Material for the Detection of Formaldehyde

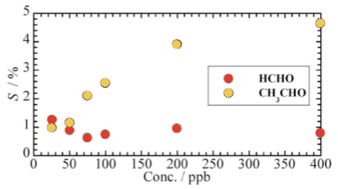
K. Stewart, N. McManus, and A. Penlidis
Institute for Polymer Research, Department of Chemical Engineering
University of Waterloo

Formaldehyde (HCHO)



Formaldehyde is used in a variety of manufactured products, including glues, fabrics, resins, plywood, and insulating materials. It can be absorbed through the skin and eyes or inhaled, which may cause eye, nose and throat irritation, breathing difficulties, coughing, sneezing, nausea, and potentially death (WHO, 2001).

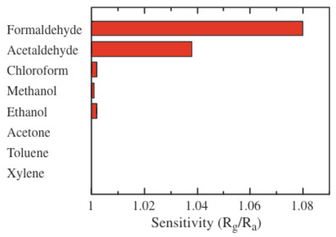
Sensitivity



(Itoh et al., 2007)

A sensitivity below 0.08 ppm is required for the detection of HCHO (WHO, 2001). The signal (S) is graphed versus concentration. The lower the concentration at which a signal is recorded, the more sensitive the sensor is.

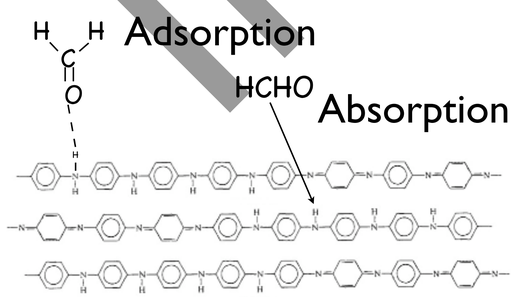
Selectivity



High selectivity is important for a sensor. Polyaniline (PANI)/MoO_3 hybrids had high sensitivity to HCHO, but also had moderate sensitivity to acetylaldehyde, thus the sensor had poor selectivity (Wang et al., 2006).

Absorption and Adsorption

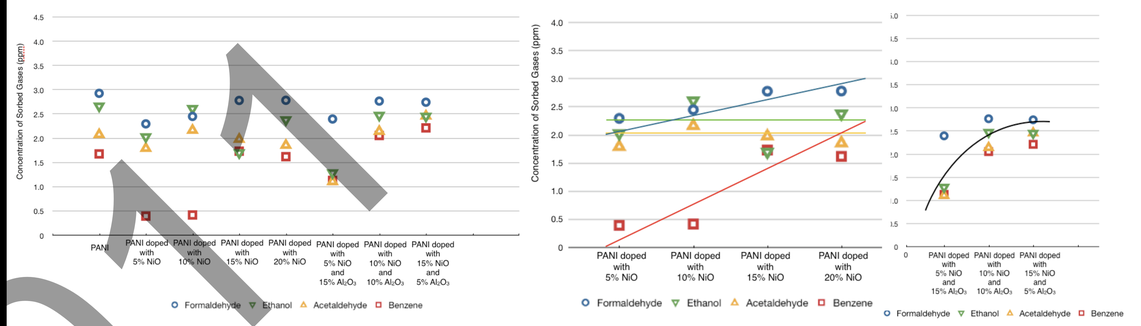
HCHO absorbs and adsorbs onto the sensing film. Both are forms of physical interaction.



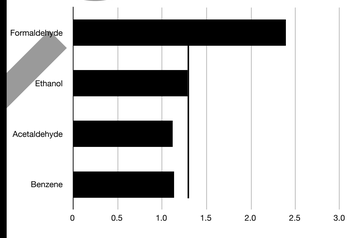
Desirable Sensing Material Features

For testing indoor air quality, a sensor must be able to selectively detect HCHO below 0.08 ppm, at room temperature, over a short period of time. The sensor should be able to be stored at room temperature and either not react with HCHO during storage or be able to be regenerated before use.

Sensitivity of Polyaniline and Doped Polyaniline

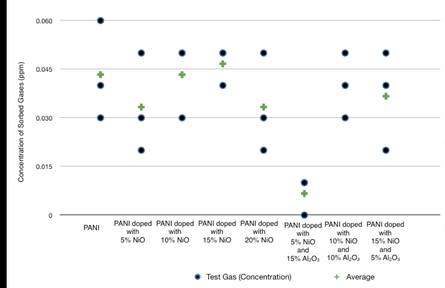


Sensing Material at High Concentrations of Formaldehyde (Above 1 ppm)

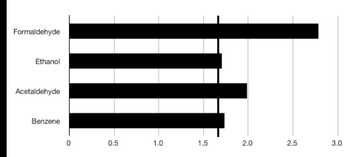


PANI doped with 5% NiO and 15% Al_2O_3 was the best sensing material for high concentrations of formaldehyde due to its selectivity, despite being less sensitive than some of the other polymers tested.

Sensing Material at Low Concentrations of Formaldehyde (Below 1 ppm)



PANI and various doped PANI were tested for sensitivity towards formaldehyde at a concentration of 0.09 ppm (or 90 ppb). PANI doped with 5% NiO and 15% Al_2O_3 did not detect at such a low concentration.



PANI doped with 15% NiO had both the best sensitivity and selectivity towards formaldehyde at a concentration of 0.09 ppm. Therefore, it was the best sensing material for low concentrations of formaldehyde.

Note: In collaboration with Prof. Abdel-Rahman, Systems Design

Itoh, T., I. Matsubara, W. Shin, and N. Izu. "Synthesis and Characterization of Layered Organic/Inorganic Hybrid Thin Films Based on Molybdenum Trioxide with Poly(*N*-methylaniline) for VOC Sensor" Materials Letters **61** (2007) 4031-4034.
Wang, J., M. Ichiro, N. Murayama, S. Woosuck, and N. Izu. "The Preparation of Polyaniline Intercalated MoO_3 Thin Films and its Sensitivity to Volatile Organic Compounds" Thin Film Solids **514** (2006) 329-333.
WHO Regional Office for Europe "Air Quality Guidelines: Second Edition" Copenhagen, Denmark, 2001.