Nanostructured TiO_2 Sensor for Detection of Benzene

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Benzene is a significant health concern. It is one of the few known human carcinogens as identified by the International Agency for Research on Cancer. It is a common indoor and outdoor pollutant, with sources ranging from cigarette smoke to traffic. A recent EPA study found that measured benzene levels at a refinery fence line were 4 to 30 times higher than estimated. Consequently, US EPA recently implemented a rule requiring refineries to maintain benzene fence-line concentrations below 9 $\mu g/m^3$. Hence, there is an increasing need to detect low concentrations of benzene. Sensors based on metal oxide nanostructures like nanoparticles and nanotubes are attractive because these have high surface area to volume ratio, are easily customizable, sensitive, specific and efficient. Thin films based on titanium dioxide (TiO_2) have previously been shown to respond to benzene. However, these sensors run at high temperatures (160-200°C) and require a complex setup for operation. This poster presents the development of TiO_2 nanotube-based sensor array that has high surface area, is highly sensitive, and operates at room temperature using portable and simple instrumentation.

TiO_2 hollow nanotubes were synthesized through anodization in electrolytic solution of ammonium fluoride (NH_4F)-ethylene glycol (EG) and oxygen annealed for up to 500°C. The response of the synthesized nanotubes was studied at room temperature for different concentrations of benzene vapor. The response of the sensor to benzene vapor was measured using an amperometric technique. The results showed an increase in current that was directly proportional to the concentration of benzene in the sample, which suggests the quantitative nature of the sensor. A sensor mechanism based on Mott-Schottky analysis and electrochemical band-bending is proposed to explain the specificity of the sensor to benzene. With improvements in the sensitivity, these sensors could be placed in a portable system which can be deployed to potential contamination sites for real-time monitoring applications.