Detecting Airborne Mercury by Use of Palladium Chloride

Palladium chloride films have been found to be useful as alternatives to the gold films heretofore used to detect airborne elemental mercury at concentrations of the order of parts per billion (ppb). Somewhat more specifically, when suitably prepared palladium chloride films are exposed to parts-per-billion or larger concentrations of airborne mercury, their electrical resistances change by amounts large enough to be easily measurable. Because airborne mercury adversely affects health, it is desirable to be able to detect it with high sensitivity, especially in enclosed environments in which there is a risk of leakage of mercury from lamps or other equipment.

The detection of mercury by use of gold films involves the formation of gold/mercury amalgam. Gold films have a greater surface area. This is material because nanowires of a given material covering a given surface may exhibit greater sensitivity than does a film of the same material because nanowires have a greater surface area.

In preparation for experiments to demonstrate this sensor concept, sensors were fabricated by depositing gold nanowires, variously, on microhotplate or microarray sensor substrates. In the experiments, the electrical resistances were measured while the sensors were exposed to air at a temperature of 25 °C and a relative humidity of about 30 percent containing mercury at various concentrations from 2 to 70 ppb (see figure). The results of this and other experiments have been interpreted as signifying that sensors of this type can detect mercury at ppb concentrations in room-temperature air and can be regenerated by exposure to clean flowing air at temperatures ≤40 °C.

The responses of the experimental sensors were found to be repeatable over a period of about 4 months, to vary approximately linearly with concentration from 2 to 20 ppb, and to vary somewhat nonlinearly with concentration above 20 ppb. Although mercury concentrations were found to be measurable down to 2 ppb, the limit of sensitivity may be lower than 2 ppb: Experiments at lower concentrations had not yet been performed at the time of reporting the information for this article.

This work was done by Mar-garet R yan, Abhijit She vade, Adam Kis or, and Margaret Homer of Caltech; Jessica Soler of Glendale City College; and Nosang Myung and Megan Nix of the University of California, River-side, for NASA’s Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-44787
offer adequate sensitivity for detection of airborne mercury and could easily be integrated into an electronic-nose system designed to operate in the temperature range of 23 to 28 °C. Unfortunately, in order to regenerate a gold-film mercury sensor, one must heat it to a temperature of 200 °C for several minutes in clean flowing air.

In preparation for an experiment to demonstrate the present sensor concept, palladium chloride was deposited from an aqueous solution onto sets of gold electrodes and sintered in air to form a film. Then while using the gold electrodes to measure the electrical resistance of the films, the films were exposed, at a temperature of 25 °C, to humidified air containing mercury at various concentrations from 0 to 35 ppb (see figure). The results of this and other experiments have been interpreted as signifying that sensors of this type can detect mercury in room-temperature air at concentrations of at least 2.5 ppb and can readily be regenerated at temperatures <40 °C.

Four PdCl₂-Film Sensors were exposed to various concentrations of Hg in air at a temperature of 25 °C and a relative humidity of 31 percent.

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In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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