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Ruthenium and Palladium in Hydrogen Detection

DOPED LEAD PHTHALOCYANINE WITH HIGH SENSITIVITY

In recent years metal phthalocyanines have been investigated for use as host materials in gas sensors. These organics are *p*-type semiconductors with very high resistivity, and sensors made from them are generally only suitable for detecting oxidising gases, including nitrogen dioxide and chlorine.

Now researchers at the College of Industrial Technology, Nihon University, Japan, have reported the results of a study made to overcome the difficulties that may be associated with the use of organic semiconductors as sensors for reducing gases such as hydrogen and carbon monoxide ("The Detection of H_2 Gas by Metal Phthalocyanine-Based Gas Sensors", S. Kanefusa and M. Nitta, *Sens. Actuators B*, 1992, **9**, (2), 85–90).

Sensors were fabricated on high-purity alumina substrates printed with gold electrodes. Cobalt, lead, magnesium, nickel and zinc phthalocyanines were tested and sensors based on lead phthalocyanine were found to exhibit the highest sensitivity to hydrogen gas. Adding palladium black to the phthalocyanine increased its sensitivity and responsivity, by catalytic reaction. It also decreased the resistance, which was lowered still further by adding ruthenium oxide to the lead phthalocyanine and by building up the thickness of the sensor film to about 40μm.

The sensitivity of the sensors was found to be dependent on both the additions and the operating temperature, increasing with increasing sensor temperature and reaching a maximum at about 160°C. The highest sensitivity was exhibited by sensors doped with 10 weight per cent ruthenium oxide and one weight per cent palladium. For a sensor doped with 10 per cent ruthenium oxide and two per cent palladium the highest sensitivity and hydrogen response occurred at 120°C.

When the hydrogen concentration was 8000 ppm, the resistivity of lead phthalocyanine doped with ruthenium oxide and palladium was 10 times lower than it was in air, at 120°C.

Although pure lead phthalocyanine behaves as a *p*-type semiconductor, doping it with ruthenium oxide and palladium changes its semiconductor properties to that of an *n*-type semiconductor. This change in behaviour is considered.

The lead phthalocyanine sensors doped with ruthenium and palladium can be used at lower temperatures than ceramic sensors, but in practice they should be used above 100°C as atmospheric humidity can disturb the sensitivity at lower temperatures.

Towards a Viable Fuel Cell

Fuel cells to be used for traction purposes would advantageously be powered by a liquid fuel supplied from the existing oil distribution network; the properties of methanol make it attractive for this purpose. Interestingly, the only effective catalysts for the electro-oxidation of methanol are based upon platinum, although the mechanism of this reaction remains controversial.

Ways of increasing the effectiveness of platinum based catalysts for methanol oxidation are considered in a recent paper (A. Hamnett and G. L. Troughton, *Chem. Ind. (London)*, 1992, (13), 480–483). Superior catalysts based on ternary alloys, better ways of using existing solid proton-conducting membranes and new membrane materials may all contribute to the development of a commercially viable fuel cell.