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Platinum/Carbon Nanotubes in PEMFCs

Proton exchange membrane fuel cells (PEMFCs) generate electric power efficiently without producing exhaust gases, so are very desirable for use in LEVs or ZEVs (low or zero emission vehicles) and as power sources for small portable electronics. However, achieving minimised metal content with the costly platinum group metals catalysts is one of the challenges to their commercialisation.

Now, researchers at the University of California, Riverside, U.S.A., have investigated increasing Pt utilisation in PEMFCs by using carbon multiwalled nanotubes (MWNTs) as the Pt support (C. Wang, M. Waje, X. Wang, J. M. Tang, R. C. Haddon and Y. Yan, *Nano Lett.*, 2004, **4**, (2), 345–348; DOI: 10.1021/nl034952p).

MWNTs were grown directly onto C paper by chemical vapour deposition. The Pt catalyst was then electrodeposited onto the MWNTs. The Pt particles had an average diameter of 25 nm (commercial Pt/C catalysts are 2–3 nm). There was good electrical contact between the MWNTs and the C paper and excellent adhesion. The surface area of the MWNT-C paper composite was ~ 80–140 $m^2\ g^{-1}$ (< 2 $m^2\ g^{-1}$ for the C paper alone).

A membrane electrode assembly was prepared with two of the composite electrodes and tested in a fuel cell station. Its performance was lower than that of a conventional PEMFC, but its robustness was confirmed. It is suggested that reducing the Pt particle size to ~ 2.5 nm, improving MWNT yield and reducing tube diameter will give C nanotube-based fuel cells of superior performance.

Optical Hydrogen Sensors Using Palladium-Silicon

Hydrogen (H_2) can be detected in several ways but the technique chosen must take into account the conditions of its use, other impurities likely to be present and the physical demands upon it. The methods include semiconductor metal oxides, electrochemical methods, pellistors, palladium and optical means. Response time and the threshold limit are important factors. As H_2 becomes more widely used, reliable detectors able to detect hydrogen before it gets to explosive amounts in air (> 4.65 vol.% H_2) are increasingly important.

Now scientists at the University of California, San Diego, U.S.A., have used optical interferometry to detect H_2 using Pd-coated porous Si (H. Lin, T. Gao, J. Fantini and M. J. Sailor, *Langmuir*, 2004, **20**, (12), 5104–5108; DOI: 10.1021/1a04974lu). Thin porous Si films were immersion plated with Pd. On exposure to H_2, the wavelength and intensity of their Fabry-Pérot fringes, obtained from the interferometric reflectance spectrum were simultaneously measured. The intensity of the fringes depends on the reflectivity of the Pd/porous Si composite and their wavelength depends on the refractive index of the Pd film. H_2 expands the Pd lattice and this shifts the optical fringes and decreases the intensity of the reflected light.

The set-up used by the researchers gave a detection limit of H_2 at room temperature of ~ 0.2% (by volume) in nitrogen, with the lowest concentration detected being ~ 0.17%. The response time was a few seconds. This sensor design reliably detects H_2 concentrations well below the explosive limit. The sensor is safe, sensitive, selective, reproducible and can operate at room temperature. However, as CO impedes the adsorption and desorption of H_2, the response time is longer, if CO is present.

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