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Research Interests: fuel cells, solid state electrochemistry, functional materials, heterogeneous catalysis, electron microscopy, Electro-Active Polymers

Properties and Structure of Functional Materials

Functional materials possess unusual properties which are often of great technological interest. They may have novel optical, magnetic, electrical, catalytic or thermal properties, for example. These properties are governed to a large degree by their structure and composition at very small length scales. We study new functional materials in the areas of Electrochemistry and Catalysis. We are particularly interested in electrically-conducting and catalytically active materials for Solid Oxide Fuel Cells (SOFCs) and related electrochemical reactors. A more recent interest is in Electro-Active Polymer (EAP) actuators for novel applications in robotics and in medicine. Catalysts are used in about 70% of all industrial chemical processes and are increasingly important in recycling and environmental protection. Heterogeneous catalysts - vehicle exhaust catalysts, for example - are another strong interest of the group. We use powerful analytical techniques, such as Transmission Electron Microscopy (TEM) and Magnetic Resonance Imaging (MRI), to study the relationship between the behaviour of functional materials and their structure and composition, down to the atomic scale.

Materials for Solid State Electrochemical Reactors

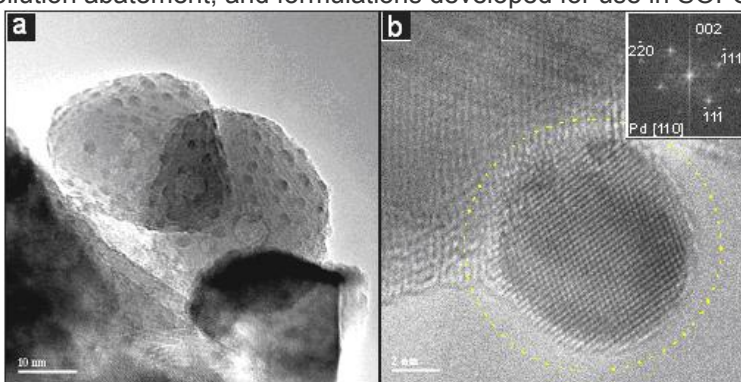
In a fuel cell, chemical energy is converted directly to electrical energy by the electrochemical oxidation of a fuel. SOFCs contain ceramic electrolytes such as the O^{2-} ion conductor, Ytria-Stabilised Zirconia (YSZ). SOFCs are able to use a wide range of fuels, including biofuels, and, if the excess heat from the SOFC is utilised, efficiencies of up to 80% can be attained. Recently, we studied the use of proton-conducting ceramics in a novel electrochemical reactor for combined chemicals synthesis and electrical power generation. [Ref. 4]

Electro-Active Polymers

EAPs are able to change shape dramatically and reversibly on the application of a small electrical potential. We study the diffusion of water within EAP materials using MRI to understand the mechanism of actuation. A working electrochemical cell is used within the MRI instrument - to our knowledge, the first time this has been done. [Ref. 2]

Heterogeneous Catalysts

Through academic and industrial links in the UK and abroad, we study both conventional supported metal catalysts, such as automotive catalysts for pollution abatement, and formulations developed for use in SOFCs (see Figure). [Refs. 1,3]



SELECTED RECENT PUBLICATIONS

1. Characterisation of the Metal Phase in $NM/Ce_{0.68}Zr_{0.32}O_2$ (NM = Pt or Pd) Catalysts Investigated by Hydrogen Chemisorption and HRTEM Microscopy: a Comparative Study, J.M. Gatica, R.T. Baker, P.Fornasiero, S. Bernal, and J. Kašpar, *J. Phys. Chem. B*, **105** (2001), 6, 1191-1199.
2. *In situ* Magnetic Resonance Imaging of electrically-induced water diffusion in a Nafion ionic polymer film, Richard T. Baker, Leila Najj, Karen Lochhead and John A. Chudek", *Chem. Commun.* 2003, **8**, 962-963.
3. Investigation of Sm_2O_3 - CeO_2 -supported palladium catalysts for the reforming of methanol: The role of the support, L.M. Gómez-Sainero, R.T. Baker, I.S. Metcalfe, M. Sahibzada, P. Concepción and J.M. López-Nieto, *Appl. Catal. A: General*, **294** (2005) 177.
4. Impedance studies on $Pt|SrCe_{0.95}Yb_{0.05}O_3|Pt$ under dried and humidified air argon and hydrogen, A.R. Potter, R.T. Baker, *Solid State Ionics*, **177** (2006), 1917-1924.