

reliability. It means that if one cell fails completely the others are able to increase their proportion of current and an entire stack can remain in operation. It was also observed for sulphuryl chloride electrolyte during open circuit phases that reverse currents were passing between cells (when diodes were not used). This did not appear to be detrimental, and no lithium dendrites were observed (we generally do not observe lithium dendrite formation with our electrolyte, a study of dendrite formation will be reported at a later date). Only sulphuryl chloride can tolerate this, recharging being theoretically possible.

In conclusion, it is considered that the ‘‘parallel before series’’ arrangement, whilst maintaining the simplicity of pile type construction, appears to have an advantage over ‘‘series before parallel’’, not only because of lower heat output, but also because the burden of poorly functioning cells may successfully be taken by other cells without the overall performance of an entire stack being compromised.

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Fuel cells for vehicular applications — hydrogen storage and simulation aspects

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This work has been carried out by an industrial and research laboratory consortium and is now supported by an EU contract. State-of-the-art solid polymer fuel cell (SPFC) technology shows two main difficulties with this power source: On-board hydrogen storage and taking into account all the parameters which affect the global efficiency.

For the first point the technologies of hydrogen storage are reviewed here, including gaseous, liquid, hydride, adsorption or glass microsphere systems. For each technology, advantages, disadvantages, efficiency are presented in term of optimal applications (ship, plane, automobile...). From this review, gaseous technology has been selected and we report about the most promising compromise (H_2 pressure to use, materials for tanks, manufacturing technology) for a short term development. A carbon composite/coiled wire tank has been designed for a 70 MPa pressure of use.

First tests show that the main problems are the liner and the end piping.

The second major problem in designing a fuel cell stack concerns the interaction between the current density, the cell's voltage, the output voltage, the heat transfer system, the management of water, the oxygen feed... Computing tools have been successfully developed to simulate the operation of an elementary cell and allow for instance a satisfactory

correlation between calculation and experimentation on Nafion[®] membrane.

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High performance membrane electrode assemblies for solid polymer fuel cells

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Solid polymer electrolyte fuel cell performance is restricted by factors associated with membrane, electrode and hardware components. We have extensively evaluated a number of Membrane Electrode Assemblies (MEAs) and applied the resulting data to optimise the overall power capabilities. We show how electrodes with a low platinum loading (0.35 mg cm^{-2}) can provide comparable performance with electrodes containing a much greater quantity of the electrocatalyst. The key factors governing this high platinum utilisation involve efficient employment of the three dimensional reaction zone, to avoid using superfluous material and to limit problems associated with mass transport.

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Activity and stability tests in phosphotungstic acid electrolyte fuel cell

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A 40 cm^2 cell based on phosphotungstic acid (PWA) electrolyte has been constructed and tested at the Institute CNR-TAE, Messina. The cell works at room temperature, fed with hydrogen and oxygen as reactant gases. A through-flow design has been used in order to avoid excessive dilution of the electrolyte with water produced in electrochemical reaction. The influence of the hydrophobic-hydrophilic characteristics of different electrodes on the activity and stability of the cell has been investigated. Pairs of gas diffusion electrodes (cathode and anode), each having the same composition of diffusional and catalytic layer, with $0.50 \text{ mg Pt cm}^{-2}$ have been prepared.

The pairs differed among themselves by the PTFE loading in the catalyst layer. Each pair of electrodes was tested in the monosell for at least 70 hours under cycling conditions and at current density of 400 mA cm^{-2} . The monosell tests were conducted with the reagent gases at atmospheric pressure and without external heating. The results of the experiments dem-

onstrate that under these conditions the highest monocell activity and stability was obtained with the electrodes having 40 wt.% PTFE in the catalyst layer. The activity of the cell with electrodes having lower PTFE content decreased with time, while the activity of the cell with electrodes having higher PTFE contents increased with time, but did not reach the level of activity of the cell with electrodes having 40% PTFE in catalyst layer.

The different activities and activity trends in the functioning of the PTFE have been explained by the role played by pores in the catalyst layer during fuel cell operation. The pores have a double function, to supply the catalytic sites with the reagent gas and, to retain the electrolyte for the electrochemical reaction and ionic conduction. Varying the PTFE loading, the ratio of hydrophilic and hydrophobic pores and so the ratio of pores available for electrolyte and gas transport into the catalyst layer changes. The ratio of electrolyte- and gas-filled pores obtained with 40% of PTFE has shown a relatively large electrochemical active volume within the catalyst layer.

This is the consequence of large inter-penetration and sufficient concentration of both liquid electrolyte and reacting gas. When the volume of one of these two phases in the catalyst layer prevails over the other due to different PTFE loading or to the modification of hydrophobic-hydrophilic character of the pores during cell operation, the electrochemical active volume decreases and so does the cell activity.

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Fabrication of polymer based flexible electrodes for application in fuel cells

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In recent years, research into fuel cells has been given considerable attention because of their attractive features like high conversion efficiency, medium temperature of operation and above all no adverse effect on the environment.

A major area of fuel cell research is on electrode fabrication with inexpensive materials that are light in weight and flexible in nature, fulfilling the requirement of fuel cells for space programmes.

This poster reports the fabrication of polymer based flexible cathodes and their application to the oxygen reduction reaction (ORR) in alkaline medium.

The electrodes were prepared using the polyvinyl chloride (PVC) sheet used as lead-acid battery separators from Exide. These have a thickness of 0.5 mm. A one sq. cm sheet with a connector strip was cleaned with distilled water. For electrodeless deposition of silver film on the polymer sheet, a solution of ammoniacal AgNO_3 , containing a suitable reducing agent of appropriate concentration, was placed over the sheet

which was bounded with Araldite. The sheet containing the solution was placed over a watch glass and heated to 35°–40°C on a water bath for 10 minutes. A uniform thin film of blackish silver was deposited over the polymer sheet. The electrode so formed was washed thoroughly with distilled water repeatedly and kept in vacuum for drying for 48 hours.

The surface of the electrode was examined under SEM. The electrode was further modified by coating with a very thin film of conducting (poly)phenylene oxide. The conducting polymer coating was made by electro-polymerisation using 50 mM phenol in 3M KOH containing 0.1M potassium ferricyanide. The electro-polymerisation was carried out potentiostatically at 1.6 V versus SCE using a computerised potentiostat/galvanostat (Vibrant model VSMCS 3, Lab., India). The film thickness was controlled by regulating the polymerisation time.

Different electrode-kinetic parameters like apparent exchange current, apparent rate constant and oxygen reduction current at a specific potential for ORR in alkaline medium have been determined from CV studies of these systems at different scan rates.

The results indicate improved electro-catalytic behaviour of modified silver electrodes compared to bare electrodes. Because of extremely lightness of the electrode, effective utilisation of catalytic materials has been found. It seems that increased roughness factor of the electrode arising out of the microporous structure of the polymer net over a spongy silver matrix is probably the reason for enhanced catalytic activity of the electrode.

Possible applications of these electrodes to fuel cells for space programmes are likely.

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Continuous production of gas diffusion electrodes for fuel cells by a filtration method

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A novel filtration method for preparing PTFE bonded gas-diffusion electrodes for fuel cells was recently proposed by the authors. The method was to make PTFE bonded Raney-Ni anodes for alkaline fuel cells. The method eliminates the problem of structure to a certain extent and has the merits of conventional wet and dry methods. The gas diffusion electrodes can be prepared continuously using this method. A slurry of milled PTFE-metal catalyst is made. The slurry is poured onto an endless moving belt of synthetic felt, continuously fed at a constant and controlled volumetric flow rate through a weir. A vacuum system underneath the felt is used to remove water and thus form a uniform web of PTFE-metal catalyst agglomerates. The web is further dried as it moves.