CORROSION-RESISTANT CATALYST SUPPORTS FOR PHOSPHORIC ACID FUEL CELLS

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INTRODUCTION

High-surface-area carbon blacks such as Vulcan XC-72 (Cabot Corp.) and graphitized carbon blacks such as 2700°C heat-treated Black Pearls 2000 (HTBP) (Cabot Corp.) have found widespread applications as catalyst supports in phosphoric acid fuel cells (PAFCs). However, due to the operating temperatures and pressures being utilized in PAFCs currently under development, the carbon-based cathode catalyst supports suffer from corrosion, which decreases the performance and life span of a PAFC stack.

The feasibility of using alternative, low-cost, corrosion-resistant catalyst support (CRCS) materials as replacements for the cathode carbon support materials was investigated. The objectives of the program were to prepare high-surface-area alternative supports and to evaluate the physical characteristics and the electrochemical stability of these materials. The O_2 reduction activity of the platinized CRCS materials was also evaluated.

The CRCS materials were prepared using a low-cost, energy-efficient, self-propagating high-temperature synthesis (SHS) method. Originally developed to produce dense, hard ceramics (1), the SHS technique can also be used to prepare loose powders (2). The general method of manufacture is to ignite a pressed pellet of the mixed reactant powders with a resistance heated coil inserted at one end of the reaction vessel; a drawing of the apparatus is shown in **Figure 1**. The reaction proceeds through the pellet from one end to the other spontaneously, due to the heat generated by the exothermic combustion. The process generally results in a nearly complete transformation with 0.2 wt% or less unreacted residue. An inert atmosphere is usually used to preserve product purity. Several variables, including the molar ratio, type, purity and particle size of the reactant powders affect the properties of the CRCS materials. In our work, the molar ratios of select corrosion-resistant reactant powders were varied. Subsequent to preparation, the CRCS materials were evaluated for surface area, electrical conductivity, particle size, corrosion resistance, and after catalyzation, oxygen reduction activity.

RESULTS

The surface areas (BET method), conductivities and particle sizes of the CRCS materials were measured and compared with similar properties of Vulcan XC-72 and HTBP, two state-of-the-art catalyst supports. As expected, surface areas of the CRCS materials were lower than those of Vulcan and HTBP, but respectable surface areas as high as

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20 m^2/g were obtained. Particle sizes of the CRCS materials were comparable to those of Vulcan and HTBP, while electrical conductivities of the CRCS materials were higher by a factor of six.

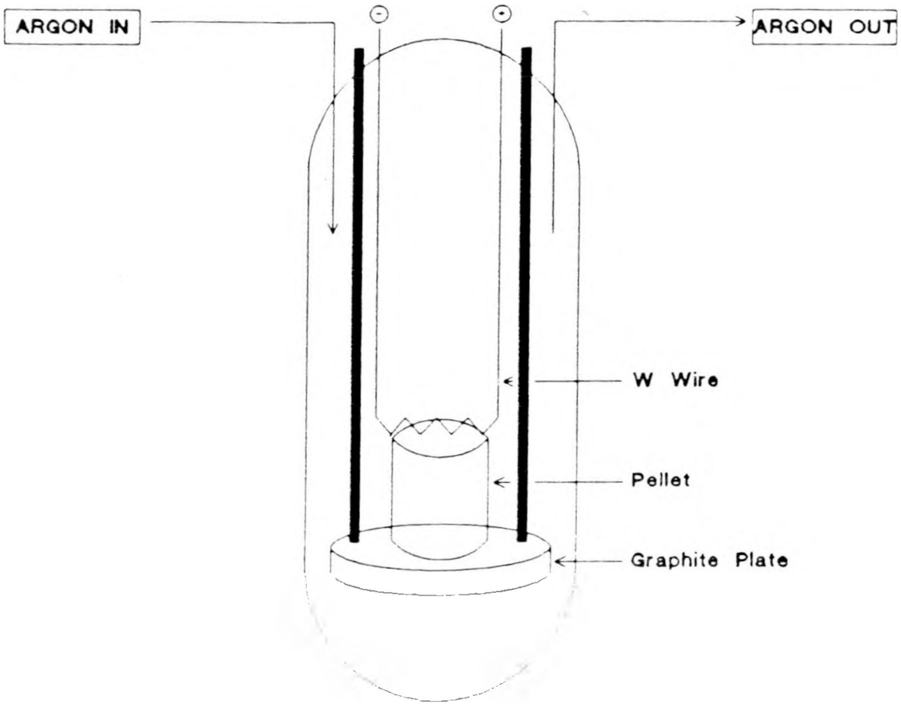

FIGURE 1. SHS REACTOR ASSEMBLY

Corrosion currents of the CRCS materials were measured at 1.0 V vs. a Dynamic Hydrogen Electrode (DHE) for 1,000 minutes in N_2 saturated, 190°C, 100% H_3PO_4. Typical results are shown in **Figure 2**. For several of the CRCS materials, duplicate samples were soaked overnight in air-saturated, hot, concentrated H_3PO_4 prior to the corrosion current measurements to leach out any unreacted starting materials; typical results are also shown in Figure 2. Corrosion currents for Vulcan and HTBP were also measured and plotted in Figure 2 as reference points.

The lowest corrosion current for the CRCS materials was observed for sample CRCS-8; a slightly lower current was observed for a duplicate sample which had been pre-soaked in H_3PO_4. However, this difference in corrosion currents was not considered to be significant. Corrosion currents of samples CRCS-8 and H_3PO_4 leached CRCS-8 were comparable to those observed for HTBP after 1,000 minutes and much lower than those observed for Vulcan.

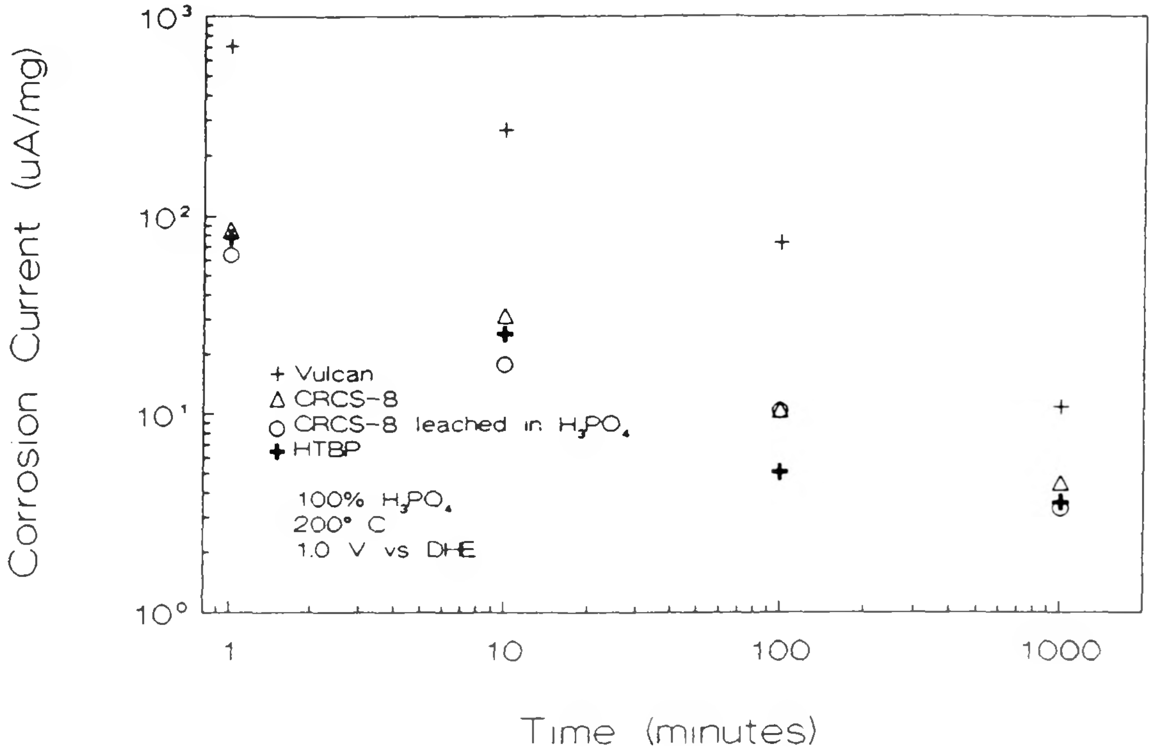

FIGURE 2. COMPARISON OF CORROSION CURRENTS OF CRCS-8, HTBP AND VULCAN

Samples of CRCS-8 and CRCS-16 were catalyzed with Pt and evaluated for O_2 reduction activity using a floating-electrode half-cell apparatus. Results are shown in **Figure 3**. At current densities below 100 mA/cm^2 the performance of Pt/CRCS-16 was superior to that of Pt/Carbon; below 20 mA/cm^2 the performance of the two CRCS materials was essentially identical. The drop-off in performance at the higher current densities was due to the use of unoptimized electrode structures which were partially flooded.

CONCLUSIONS

High-surface-area, conductive, corrosion-resistant catalyst supports can be prepared by the simple, efficient, SHS technique. The electrochemical stability of a CRCS material in hot, concentrated H_3PO_4 was greater than that of Vulcan and equivalent to that of HTBP. The O_2 reduction activity of platinized CRCS was superior to that of platinized carbon at low current densities.

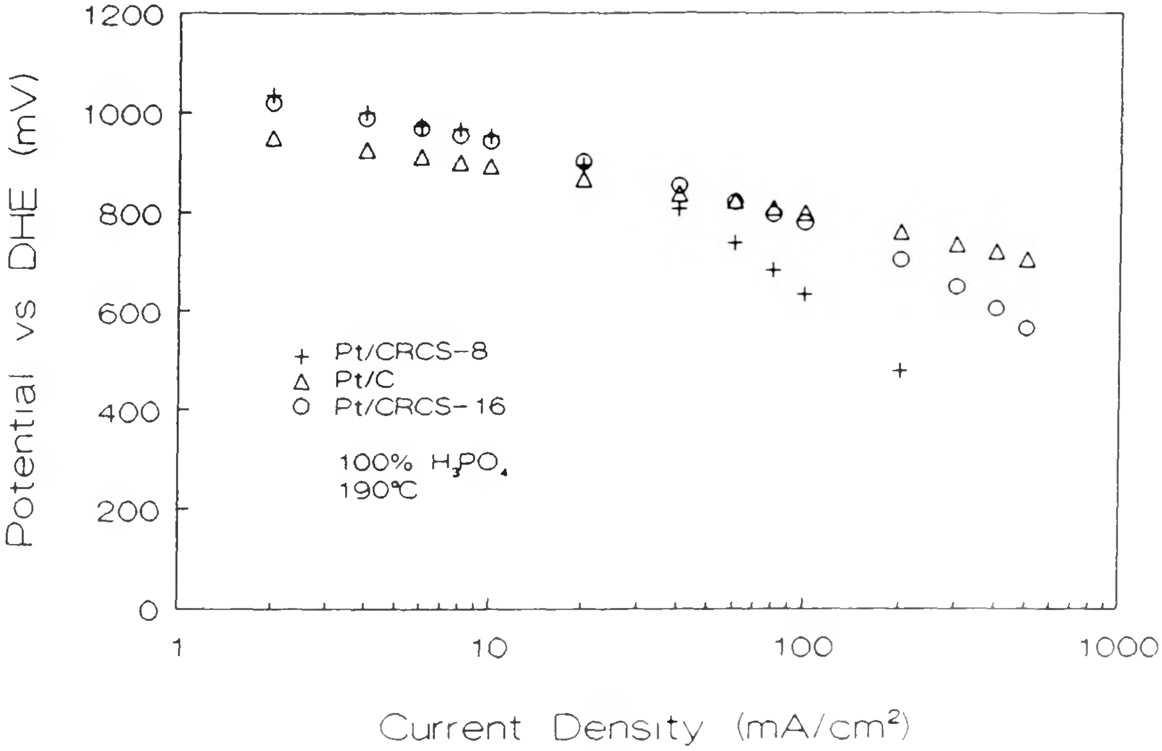

FIGURE 3. COMPARISON OF OXYGEN REDUCTION ACTIVITY OF PT/CRCS TO PT/CARBON

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