# OXYGEN ELECTRODES FOR RECHARGEABLE ALKALINE FUEL CELLS

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The primary objective of this program is the investigation and development of electrocatalysts and supports for the positive electrode of moderate temperature single-unit rechargeable alkaline fuel cells. Viable candidate materials must meet the following requirements: (1) good electrical conductivity (a more demanding requirement for supports than electrocatalysts), (2) high resistance to chemical corrosion and electrochemical oxidation and/or reduction, and (3) electrocatalysts, in addition, must exhibit high bifunctional electrocatalytic activity ($O_2$ evolution and reduction). Advanced development will require that the materials be prepared in high surface area forms, and may also entail integration of various candidate materials, e.g., one or two electrocatalysts distributed on a less active support material.

Candidate support materials have been drawn from transition metal carbides, borides, nitrides (Ti, Zr, Hf, Nb) and oxides (La, Sr, Cr, Mo, W, Mn, Ni) which have high conductivity (>1 ohm-$cm^{-1}$). Candidate catalyst materials have been selected largely from metal oxides of the form $ABO_x$ (where A = Pb, Cd, Mn, Ti, Zr, La, Sr, Na, and B = Pt, Pd, Ir, Ru, Ni, Co) which have been investigated and/or developed for one function only, $O_2$ reduction or $O_2$ evolution. The electrical conductivity requirement for catalysts may be lower, especially if integrated with a higher conductivity support. For initial evaluation, materials have been purchased when available; subsequently, in-house preparations have been attempted, to affect surface area and composition, if necessary.

All candidate materials of acceptable conductivity are subjected to corrosion testing in three steps. Preliminary corrosion testing consists of exposure to 30% KOH at 80°C under oxygen for several days. Materials that survive chemical testing are examined for electrochemical corrosion activity; the material is held at 1.4 V versus RHE in 30% KOH at 80°C for 15 to 20 hours. An acceptable anodic current is on the order of a few microamps/mg of material. For more stringent corrosion testing, and for further evaluation of electrocatalysts (which generally show significant $O_2$ evolution at 1.4 V), samples are held at 1.6 V or 0.6 V for about 100 hours. The surviving materials are then physically and chemically analyzed for signs of degradation (visual examination, electron microscopy, X-ray diffraction).

To evaluate the bifunctional oxygen activity of candidate catalysts, Teflon-bonded electrodes are fabricated and tested in a floating electrode configuration. Many of the experimental materials being studied have required development of a customized electrode fabrication procedure. For preliminary testing, catalysts of interest should show <500 mV polarization (from 1.2 V) in either mode at 200 mA/$cm^2$. In advanced development, our goal is to reduce the polarization to about 300-350 mV.

Approximately six support materials and five catalyst materials have been identified to date for further development. The test results will be described.

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