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NASA REDOX STORAGE SYSTEM TECHNOLOGY PROJECT

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The objective is to develop and validate the iron–chromium redox technology to establish the basis for system design and evaluation. During 1982 work was undertaken to:

- Develop an understanding of the solution chemistry of the chromium chloride reactant and its relationship to cell performance characteristics;

- Determine the effect of elevated temperature (about 150 °F) on cell performance characteristics;
- Continue the optimization of membrane resistance, selectivity, and cost;
- Complete specifications and procedures for the reproducible treatment and preparation of electrodes meeting electrochemical performance requirements;
- Complete cost studies for the mass production of the redox reactants from chromite ore, ferrochrome, or chemical intermediates;
- Experimentally evaluate 'four-tank' operations and the use of iron and chromium chloride solution mixtures as reactants.

Two chromic (discharged) ion species have been identified, one being electrochemically active, the other, not. At room temperature, the equilibrium concentrations of these species are about equal, and the equilibration rate is slow. Elevated temperature has been shown to increase both the equilibrium concentration of the active species and the rate equilibration. The effect on cell performance is to greatly improve charge acceptance rates, permit full utilization of the theoretical capacity, and increase energy efficiency. Elevated temperature also reduces cell resistivity, further improving efficiency.

Membrane modifications presently being evaluated in terms of resistivity and selectivity improvement include thinner substrates, laminar structures, heterogeneous compositions, and reformulations of the standard ion exchange resin chemistry.

A pyrolysis temperature of about 1650 °C, for the conversion of rayon felt to a carbon/graphite felt substrate for the chromium redox electrode, has been shown to be optimum in terms of chromium reaction activity versus hydrogen evolution. Contract studies indicate that redox reactants ($CrCl_3$, $FeCl_2$ and HCl) can be produced in large quantities in the price range of \$10 to \$21/kW h, depending on the starting materials and the process.

Single-cell studies show that four-tank operation can result in an efficiency improvement, relative to the more common two-tank configuration. These single-cell studies also indicate that cells can perform well when using an iron and chromium chloride solution mixture as the reactant for both half-cells. The advantages are lower resistivity (more 'open' membranes can be used) and the elimination of reactant cross-mixing and osmotic solvent transfer as operational considerations. The penalties are increased reactant cost and a reduced coulombic efficiency. Studies show, however, that osmotic transfer of solvent through cell membranes can be greatly reduced or eliminated by minor reactant concentration adjustments to make the two reactant solutions isotonic.

During 1983

- The performance and endurance of cells and cell components at temperatures around 150 °F will be evaluated.

- The contract efforts for membrane and electrode development will be completed.

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RESEARCH AND DEVELOPMENT OF A RECHARGEABLE ALKALINE ZINC/FERRICYANIDE HYBRID REDOX BATTERY

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Lockheed's research efforts over this reporting period were focused on assessing the technical feasibility of the alkaline zinc/ferricyanide rechargeable battery for utility load leveling and solar-photovoltaic applications.