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FINAL REPORT

Contract N00014-82-K-0523

R&T Code: 413a003-3

July 1, 1982 to March 31, 1989

HIGH TEMPERATURE SOLAR ELECTROTHERMAL PROCESSING

Edward A. Fletcher, Principal Investigator

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HIGH TEMPERATURE SOLAR THERMOCHEMICAL PROCESSING

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d. Brief Description of Project:

   Chemical transformation at a given temperature and pressure requires a total energy input, \(\Delta H\) of the chemical reaction. The minimum amount of energy which must be supplied as (electrical) work is \(\Delta G\) of the reaction. The rest may be supplied as process heat or as work. Since \(\Delta H\) of most chemical reactions is relatively independent of temperature, and \(\Delta G\) decreases with temperature, there is an energy advantage in conducting electrolytic separations at high temperatures. At sufficiently high temperatures all of the necessary energy may be solar process heat, replacing all of the electrical energy input, as we have experimentally observed. We conducted analytical and experimental studies of high temperature electrolysis in a highly concentrating solar furnace as well as in an electric furnace. We sought and found suitable materials for the construction of electrodes and cells and appropriate reactions which will acquire technological significance, designed and built receivers for sunlight and reactors which can interface with them, acquired operating experience with them, and conducted electrochemical and thermochemical measurements.

e. Significant Results

   During the course of this study we have demonstrated the solarthermal assisted electrolysis of zinc oxide using non-reacting anodes as well as graphite anodes and the direct solarthermal reduction of zinc oxide by graphite to produce zinc. We also studied the electroreduction of magnesium oxide in a solar furnace and in an electric furnace. We designed, constructed, and tested a new kind of solar receiver-reactor. Its material cost is 1/20 of previous devices. The labor cost is minimal. Since it has a very low thermal inertia it can quickly be brought to the operating temperature and is well suited for solar thermochemical studies. With it we have solarthermally produced titanium carbide by the solarthermal reduction of titanium dioxide with carbon, zinc by the direct reduction of zinc oxide with carbon, and magnesium and possibly magnesium carbide by the direct solarthermal reduction of magnesium oxide with
carbon. We have also constructed and studied an apparatus which makes use of a zirconia membrane for the electrolytic separation of oxygen from zinc oxide vapor for the production of zinc, and in the process measured the effective electrical conductances and their variation with temperature of slip cast zirconia tubes in the transport of oxygen, and are attempting to make a two membrane device for the solar thermochemical or solar thermoelectrochemical splitting of water into hydrogen and oxygen. In a related study, which was funded primarily by NSF but also received some support from ONR, we demonstrated the activation of glassy carbon anodes which made it possible to overcome the fouling of electrodes in the anodic oxidation of sulfide, a major roadblock to the development of a process for electrolyzing hydrogen sulfide for the production of hydrogen and sulfur from it. The work done under this contract has been reported in a series of 13 technical reports to ONR.


7. Aldo Steinfeld and Edward A. Fletcher, "A Solar Receiver-Reactor with Specularly Reflecting Walls for High-


g. Graduate students supported in whole or in part on this contract.

David Carlson, MS
Todd Kappauf, MS, PhD
Frank MacDonald, MS, PhD
Jean Murray, PhD
Robert Palumbo, MS, PhD
Aldo Steinfeld, working for PhD
Kent Scholl, working for MS

h. Post doctoral researchers supported in whole or in part on this contract.

Richard B. Diver
Todd Kappauf
Dennis Kunnerth
Donald Parks
Ludmila Stachovich

i. Presentations at Topical or Scientific/Technical Society Conferences.


j. Other invited presentations.


k. ONR Technical Reports emanating from the contract.


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