



Faster, More Efficient Redox Cycle to Split Water or Carbon Dioxide

UNIVERSITY OF
COLORADO
TECHNOLOGY
TRANSFER
OFFICE

Boulder + Colo. Springs
4740 Walnut Street
Suite 100

Campus Box 589
Boulder, CO 80309

(303) 492-5647

Denver + Anschutz
Medical Campus
12635 E. Montview Blvd
Suite 350
Campus Stop F411
Aurora, CO 80045

303-724-0221

www.cu.edu/techtransfer

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Case Manager:

MaryBeth Vellequette

Email

Ref # CU3054B

Background

Various redox (reduction-oxidation) processes are used industrially to split gas-phase reactants; for example, they may be used to split water (to produce hydrogen fuels) or CO₂ (to reduce harmful pollution). These reactions are typically run with reduction temperatures hundreds of degrees Celsius above the corresponding oxidation temperatures. The ceria cycle is typically reduced at 1500°C and then oxidized at 850-1000°C, the standard ferrite cycle is reduced at 1450°C and then oxidized between 900-1100°C, and the standard hercynite cycle is reduced at 1200-1400°C (significantly lower than the other competing cycles) and then oxidized at 900-1100°C.

Running the oxidation and reduction steps of the redox cycles at substantially different temperatures causes significant heat loss with each temperature change, requires additional time to heat or cool the system, and causes materials to degrade more quickly than if the reaction could be run at substantially isothermal conditions.

Technology

A University of Colorado research team led by [Alan Weimer](#) has developed a technique for a substantially isothermal hercynite cycle, in which the entire reaction cycle is performed isothermally at 1200-1400°C (though the cycle can be performed at temperatures as low as 940°C). Because no significant heating or cooling is required between the respective cycles, the hercynite cycle allows faster, more efficient cycling and less wear on the equipment and materials used for the process. Furthermore, any materials degradation that might be associated with high/low temperature cycling will be eliminated.

Additionally, Dr. Weimer's group has developed a process for simultaneously conducting both steps of the water- and/or carbon dioxide-splitting process, using concentrated solar energy to provide thermal energy to the reaction, reducing latent heat loss. The time required to carry out rapid redox cycling is decreased, providing for higher productivity.

Furthermore, use of this concurrent two-step process can eliminate the need to perform high-temperature separation of gaseous reaction products: since the oxidation reaction of the isothermal redox reaction is typically much faster than the reduction reaction, product gas(es) of the oxidation stage are produced first and/or can easily be separated from gas(es) produced during the reduction reaction. The newly discovered process can be used to split gasses in a timely, energy-efficient, and economical manner.

P [torr]	Thermal Reduction Temperature [°C]	CO ₂ Oxidation Temperature [°C]	Total CO released during oxidation [μmoles CO/g]
600	1310	1000	41.5
600	1460	1000	82.5
75	1460	1000	42.4

Table 1: Summary of CO Production after oxidation by 50% CO₂; "hercynite cycle"

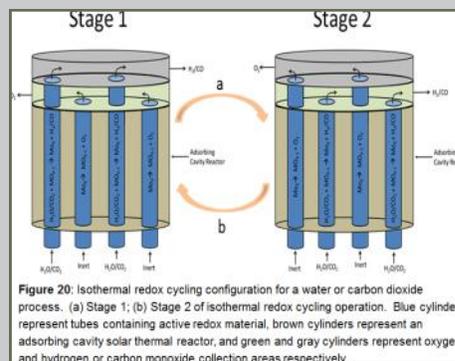


Figure 20: Isothermal redox cycling configuration for a water or carbon dioxide process. (a) Stage 1; (b) Stage 2 of isothermal redox cycling operation. Blue cylinders represent tubes containing active redox material, brown cylinders represent an adsorbing cavity solar thermal reactor, and green and gray cylinders represent oxygen and hydrogen or carbon monoxide collection areas respectively.



Key Documents

[Methods and Apparatus for Gas-Phase Reduction/Oxidation Processes.](#)
U.S. regular application filed April 5, 2013.

[Efficient Generation of H₂ by Splitting Water with an Isothermal Redox Cycle.](#)
Science 341 (2013): 540-542. PDF available upon request.