University of Florida

Solar Fuels from Thermochemical Cycles at Low Pressures

PI: Jörg Petrasch
Students: Midori Takagi, Ben Erickson

Description: The project focuses on the production of solar fuels from solar thermochemical cycles employing metal/metal oxide redox pairs. These thermochemical cycles consist of a high temperature endothermic solar driven reduction step and a low temperature, slightly exothermic water or CO_2 splitting step. The high temperature step typically proceeds at temperatures above 2000 K. Hence, it poses a range of material and design challenges. According to Le Chatelier's principle, the temperature for the solar dissociation reaction decreases as the pressure inside the reactor is reduced. The central hypothesis of the project is that operating the high temperature step of metal/metal oxide solar thermochemical cycles at reduced pressures will lead to significantly relaxed temperature requirements, while the work necessary to produce the pressure difference will not significantly reduce the overall efficiency of the process.
The main goal of the project is to demonstrate the feasibility of carrying out high temperature thermal reduction of metal oxides in rarefied conditions using high intensity solar radiation from UF's solar simulator.

Budget: $100,000.00
Universities: UF
External Collaborators: Wojciech Lipinski, University of Minnesota

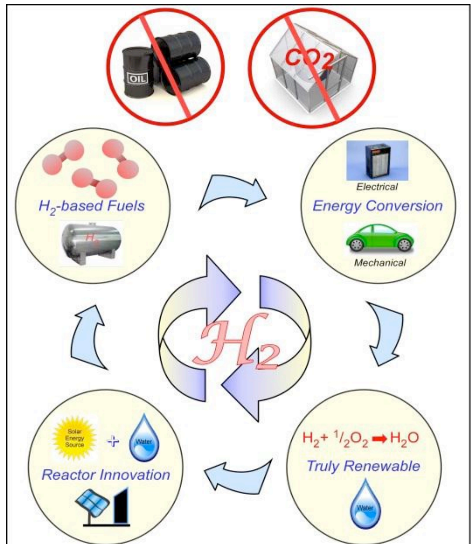
Executive Summary

This project has been acquired by David Hahn, and as such, the report has been included in the "***Solar Thermal Power for Bulk Power and Distributed Generation"*** final report.

University of Florida
Solar Thermal Power for Bulk Power and Distributed Generation

PI: David W. Hahn **Co-PIs:** James Klausner, Renwei Mei, Helena Weaver
Students: Richard Stehle (PhD); Michael Bobek (PhD); Kyle Allen (PhD); Justin Dodson (PhD), Like Li (PhD)

Description: While there are many different approaches to hydrogen generation, the most attractive means is to split water molecules using solar energy. The current approach is to develop highly reactive metal oxide materials to produce intermediary reactions that result in the splitting of water to produce hydrogen at moderate temperatures (<1000 K). It is envisioned that the metal oxide reactors will ultimately be mounted within a solar concentrating reactor, and irradiated via heliostats. This Task is structured toward the overall goals of solar-driven, thermochemical hydrogen production, with associated efforts toward the enabling surface science, catalysis, particle science, material synthesis, nano-structures, multiscale-multiphase physics modeling, and process simulation that will enable the realization of solar hydrogen-based fuels to power the transportation economy. Successful efforts as targeted in this project are a critical step toward increased renewable-resource based fuels and energy, reduction of greenhouse gas emissions, and establishment of a new power industry in Florida.



Carbon-neutral solar-driven hydrogen production

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Budget: $446,000
Universities: UF

Executive Summary

Our project efforts to date have focused on direct hydrogen splitting from water in support of our overall mission to conceive, design, and develop advanced reactor technologies that utilize concentrated solar energy and highly reactive materials to produce low cost hydrogen. These activities directly align with the National Academy of Engineering Grand Challenge and published DOE strategic goals.

High temperature thermochemical production of hydrogen that uses concentrated solar radiation for process heat has been suggested as a candidate technology for renewable hydrogen, taking advantage of Florida's sunlight. This process entails a two-step approach where endothermic dissociation of a metal oxide is driven in a solar furnace. Current technological hurdles to achieving successful hydrogen production are the high operating temperatures needed to achieve reasonable reaction kinetics, cyclic stability of the reactive material, non-uniform transient heating, and recuperation of thermal energy lost through high temperature operation. In order to overcome these technological hurdles, our FESC team has specifically initiated a plan to revolutionize thermochemical reactor design through the development of magnetically fluidized bed reactors. There are many technological advantages to operating such a reactor including, very high reaction surface area to yield rapid kinetics at more moderate operating temperatures (<1000 K), more spatially uniform temperature distribution during transient heating, and substantial control over the fluidization characteristics of the bed using magnetic fields. Activities for the past year have focused extensively on experimental characterization of key process kinetics and on reactor design, with supporting modeling efforts and fundamental catalysis studies.

Importantly, the FESC funds have provided very significant leveraging to date, playing a key role in the establishment of a significant high-temperature solar program at UF, with follow-on grants in excess of $4M from the Department of Energy. Current efforts are also underway to provide spin-off commercial ventures.

This Project has been completed. The final report can be found here.