Texas Tech University
Department of Chemical Engineering
Seminar Series

Two-step Solar Thermochemical Water Splitting – The Path Forward

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Abstract
Using concentrated sunlight to drive water splitting for renewable hydrogen production is the ultimate goal for a truly green energy world. The seminal paper, "Hydrogen and Oxygen from Water," *Science*, 197, 1050 (1977), by E.A. Fletcher and R.L. Moen ignited a flurry of activity in the field of solar thermal water splitting. Focused research since then has resulted in substantial progress identifying particular chemical routes, perovskite and spinel active materials and various solarthermal reactor designs. Robust active materials demonstrating long lifetime reduction/oxidation (redox) processing have been developed. Reaction using a dual fluidized bed process operating on-sun at NREL with targeted H_2 productivity that exceeded the 2018 DOE Hydrogen Program goal will be discussed. The process is operated continuously in an isothermal (*Science*, 540-542; August 2, 2013) solar cavity receiver. Isothermal redox processing driven by chemical potential is an alternative to conventional temperature swing processing driven using large temperature differences (typically 500 to 800^{o}C). This presentation provides experimental results for an 800 X scaled-up demonstration of the isothermal redox process. A techno-economic analysis (TEA) for an integrated process shows that H_2 via solar thermal water splitting is competitive with costs from competing renewable H_2 processes. This presentation will review key findings and will focus on the path forward emphasizing active materials and processes and identifying key areas of interest for future research.

Bio
Alan (Al) W. Weimer is H. T. Sears Memorial Professor of Chemical and Biological Engineering at the University of Colorado (https://www.colorado.edu/lab/weimer/), joining the faculty in 1996 after a 16-year career with the Dow Chemical Company. He received Dow's coveted *Excellence in Science Award* in 1995 for his invention, development, and commercialization of the rapid carbothermal reduction process (RCR) for synthesizing ultrafine carbide ceramic powders. At CU, Al used concentrated sunlight to drive high temperature chemical reactions, replacing conventional electric resistive heating (like commercial RCR), to achieve temperatures above 1500^{o}C. His research group has published over 75 peer-reviewed research papers in the solar thermal chemical processing field. It is recognized as a leading global entity for the design of solar thermal chemical reactors, using concentrated sunlight to achieve the required ultra-high temperatures. A major focus of the research is using concentrated sunlight to split water producing renewable hydrogen. Al's research has resulted in papers published in the journal Science where he demonstrated the ability to carry out redox reactions under isothermal conditions using chemical potential to drive the process instead of a wide variation in the reduction and subsequent steam oxidation temperature. This finding changed the way researchers investigated the redox processing, which was done for decades. His research group is a leader in the development of active particulate materials for redox water splitting processing focusing on robust redox materials which function by generating and filling O-vacancies in a stable matrix. Al's research team is the largest academic solar thermal chemistry research group in the United States. He received the 2005 U.S. DOE *Hydrogen Program R&D Award* and the 2015 AIChE *Sustainable Engineering Forum Research Award* for his pioneering developments using concentrated sunlight for chemical engineering applications. He is named inventor on 38 issued U.S. Patents, has directed the research of 29 Ph.D. students, and published 200 peer-reviewed journal articles.

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