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Case ID:M21-115P
Published: 12/14/2022

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Thermochemical Labyrinth Reactor

-Thermochemical reactors provide an effective means for water splitting and carbon dioxide splitting. These reactors are able to produce energized chemicals (e.g., hydrogen and carbon monoxide), which can subsequently be used in other chemical reactions (e.g., to reduce, add functionality, etc.) or from which other chemicals can be made (e.g., hydrocarbon fuels, ammonia, etc.). These reactors employ thermochemical cycles, which combine heat sources with chemical reactions to split bonds and generate a desired product stream.

In order for thermochemical reactors to be economically competitive with other competing technologies, they must be efficient while remaining sufficiently inexpensive to manufacture and operate. In water splitting, the main competing technologies are steam-methane reforming (which is not renewable) and electrolysis. The advantages thermochemical reactors may provide over electrolysis include a potentially much lower capital cost and improved robustness to impurities in the feedstock water. In carbon dioxide splitting, thermochemical reactors are the most advanced technology.

Researchers at Arizona State University have developed a two-step thermochemical labyrinth reactor for water and carbon dioxide splitting. In the first step, a reactive material (typically metal oxide) is heated to high temperatures to remove some of the oxygen from the compound. In the second step, the partially reduced oxide is exposed to water or carbon dioxide, typically at a temperature lower than the first step, from which it removes the oxygen, yielding hydrogen or carbon monoxide.

This thermochemical labyrinth reactor can use electric heating instead of concentrated solar flux for power. Conventional thermochemical reactors employing concentrated solar flux inherently have to leave the reactive material somewhat exposed, or at least exposed enough that it can be reached by the solar flux. This limits the degree to which the reduction chamber can be shielded, and thus limits the efficiency and the ability to mitigate thermal losses. Advantageously, the use of electric heating permits the thermochemical labyrinth reactor to position the hottest part of the reactor, the reduction zone, near the center of the reactor, surrounding it with insulation as well as the other zones of the labyrinth, reducing loss and also reclaiming heat that would otherwise be wasted.

Potential Applications:

- Water splitting
- Carbon dioxide splitting
- Carbon dioxide re-utilization processes

Benefits and Advantages:

- Inexpensive, compact, modular design
- Agnostic with respect to source of electrical power (i.e., can use, but does not require direct solar flux)
- Able to thermally reduce a reactive material at temperatures exceeding 1600° C
- Operable with a wide range of reactive metal oxide