ORNL LDRD
A Lower-Temperature Iodine-Sulfur Thermochemical Process For Hydrogen Production

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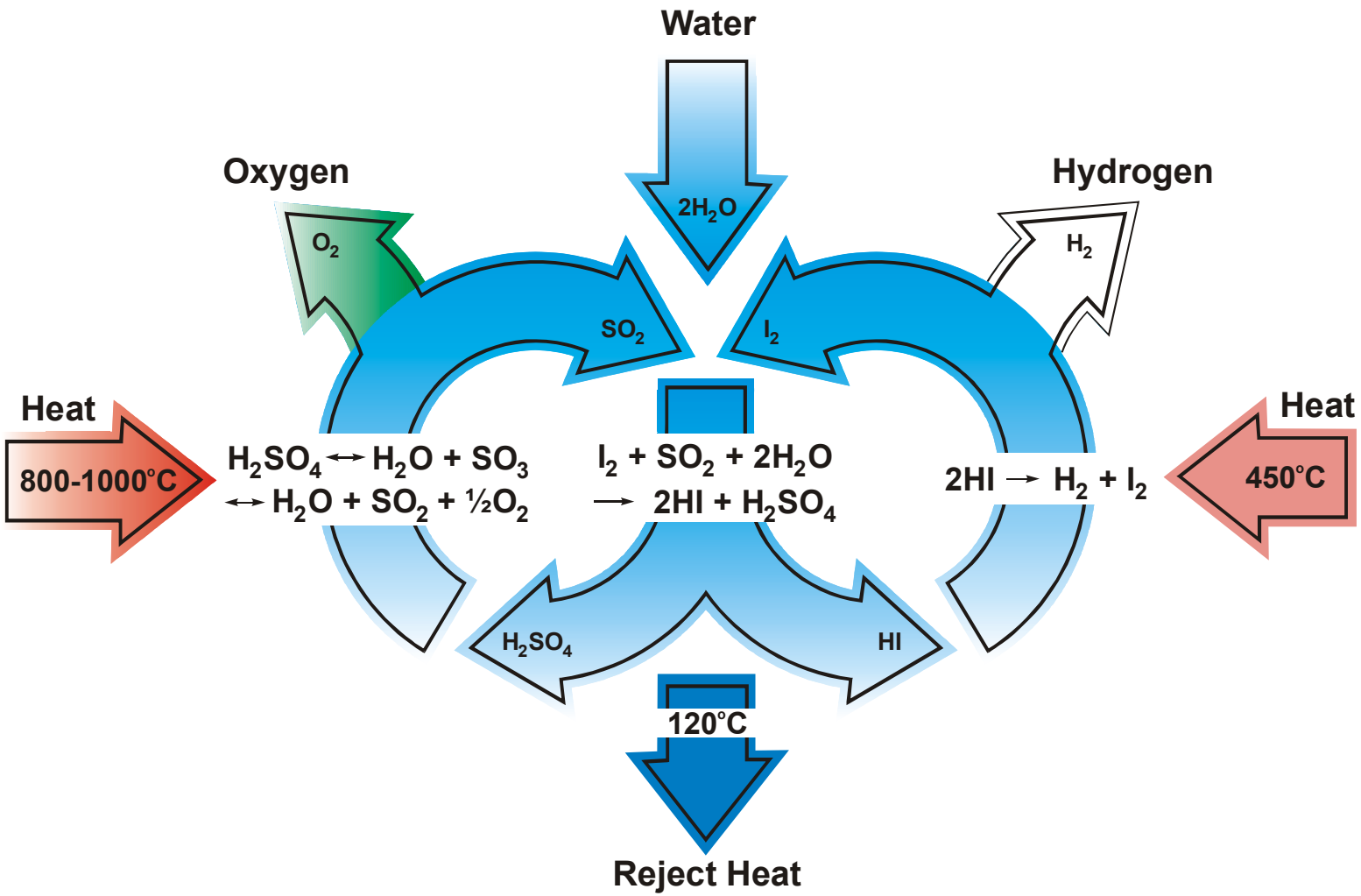
Sulfur-Iodine Process For Hydrogen Production

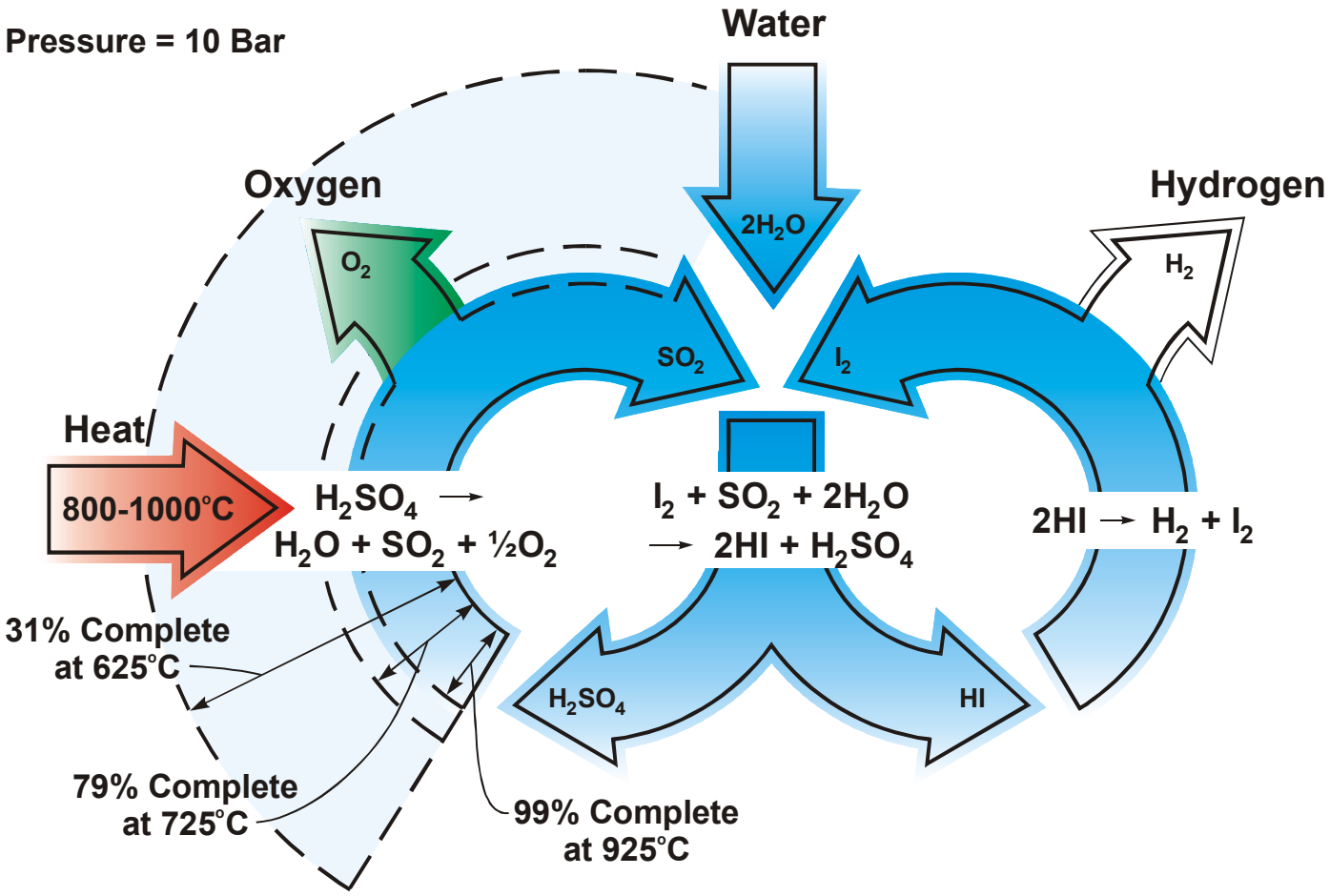


High Temperature Sulfur-Iodine Process Limitation

($H_2SO_4 \Leftrightarrow H_2O + SO_3 \Leftrightarrow SO_2 + H_2O + ½O_2$)

- **High-temperature steps are equilibrium steps: conversion is a function of temperature**
  - **31% at 625°C**
  - **79% at 725 °C**
  - **99% at 925°C**
- **The process can operate efficiently at lower temperatures if the reaction goes to completion at lower temperatures**

Incomplete High-Temperature Reactions Lead To Massive Recycle Streams Within the Process and Low Efficiencies



ORNL LDRD Proposed Solution

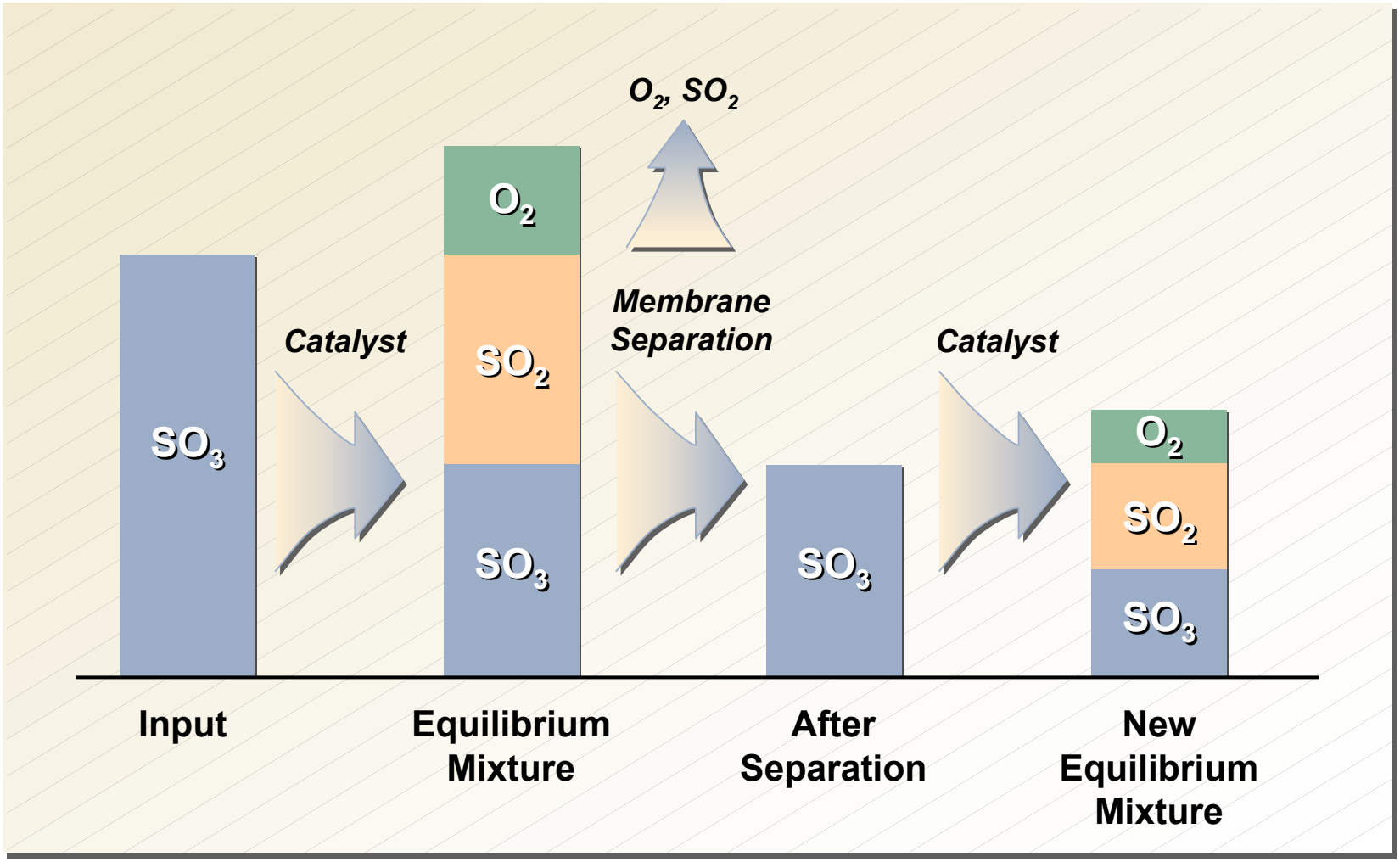
- Push equilibrium high-temperature reaction to completion at lower temperatures by removing reaction products

$$H_2SO_4 \Leftrightarrow SO_3 + H_2O \Leftrightarrow SO_2 + H_2O + 1/2\ O_2$$

- Membrane separation of O_2, H_2O, and SO_2 from SO_3 drives reaction to the right allowing high conversion at lower reaction temperatures

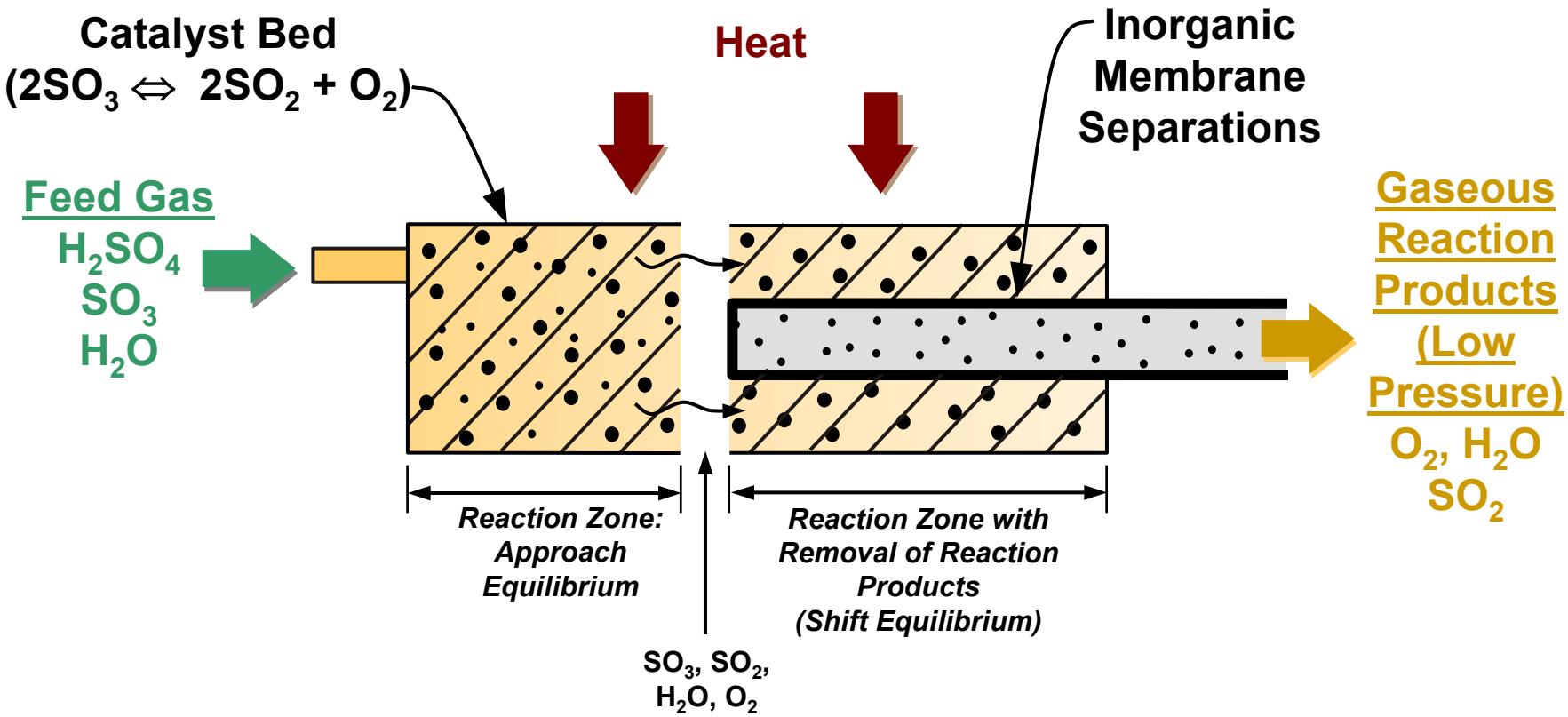
- Potential to reduce peak temperature to between 650 and 750°C

Separation of the Sulfur Dioxide and Oxygen Drives the Reaction to Completion



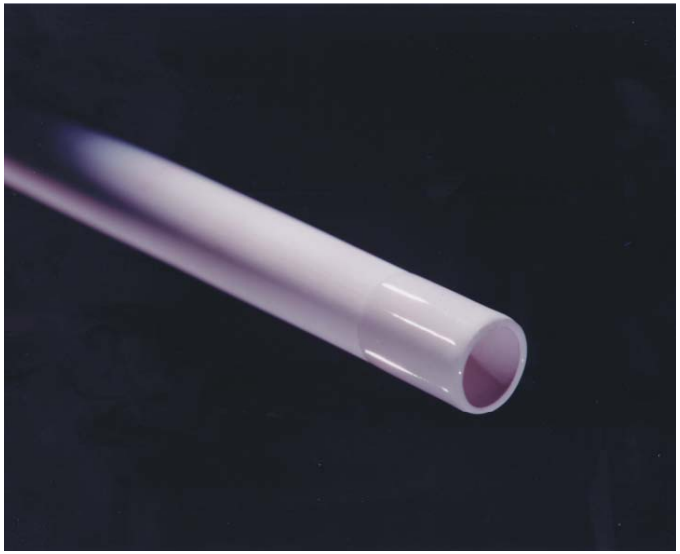
Idealized Iodine-Sulfur Inorganic-Membrane Chemical Reactor

(Operating Temperature 650 to 750°)



Inorganic Membranes

- Base technology developed for separation of uranium isotopes by gaseous diffusion
  - ORNL maintains technology for DOE/NE
  - Variants are sold commercially
- Choice of pore diameters
- Separative layer is applied to metal or ceramic support tube
- Layer thickness is 2µm or less yielding a high permeance at low pressure drop
- Support structure and layer made of variety of metals and ceramics



Portsmouth Gaseous Diffusion Plant:
An Early Application of Inorganic Membrane Technology

Inorganic Membranes Are Applicable to Multiple Thermochemical Cycles

- Brown, Funk, and Showalter evaluated over 100 cycles
- Three of the top four cycles share the same sulfuric acid decomposition step
  - Westinghouse
  - Ispra Mark 13
  - GA Sulfur-Iodine
- Technology covers multiple options

Conclusions

- Inorganic membranes are potentially an attractive option for lower-temperature, efficient thermchemical cycles
- Many technical questions and issues that must be addressed
  - Analysis underway
  - Initial experimental data later this year