Microchannel Reaction Technology

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Battelle Institute for Interfacial Catalysis
Control of Chemical Transformations for a Secure Energy Future

Office of Science
U.S. DEPARTMENT OF ENERGY

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

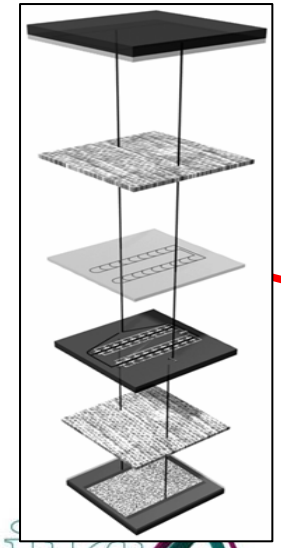
Background

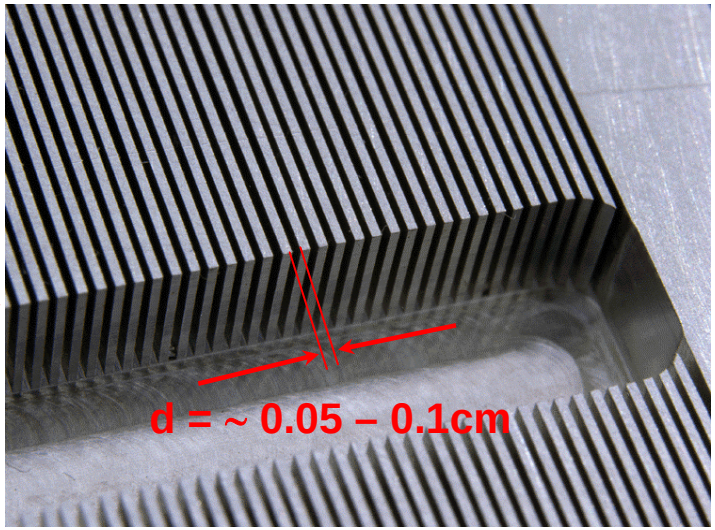
- Simultaneously improve catalysis and reaction engineering
  - Exploit heat and mass transfer advantages in engineered microstructures
  - Maximize catalyst performances

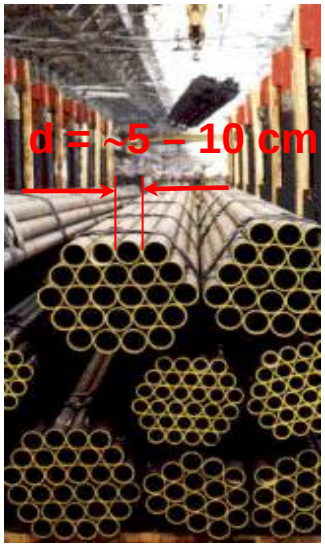
- What's unique?
  - Increase space time yields
  - Explore unique chemistry
  - Reduce size, footprint, and weight; increase efficiency

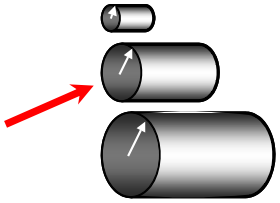
Characteristics of Microchannel Reactor

- Faster heat transfer rate
  - Shorter distances between heat source and heat sink
  - Higher surface to volume ratio
- Higher mass transfer rate
- Low pressure drop
- Internal channel dimensions same as commercial reactor
- Dependent on economy of mass production, not economy of scale









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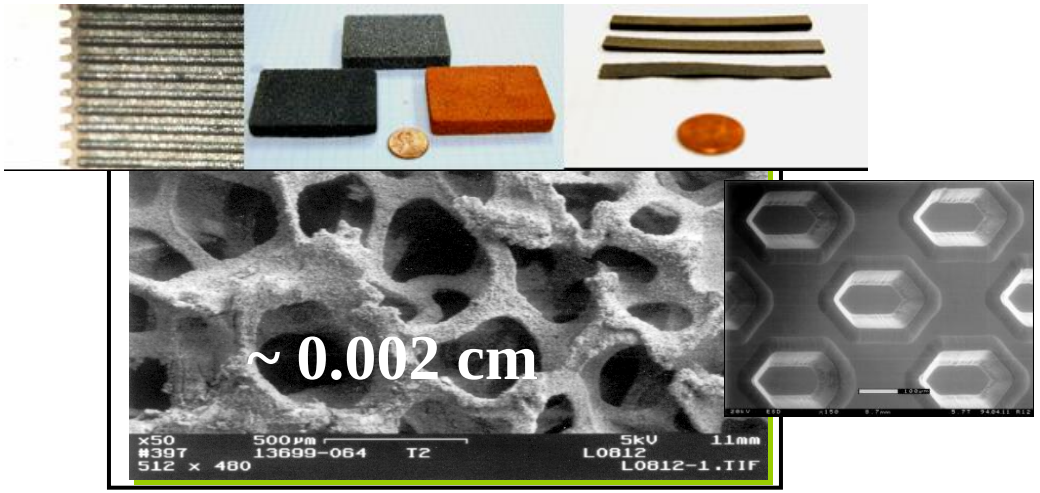
Engineered Catalysts for Microchannel Reactors

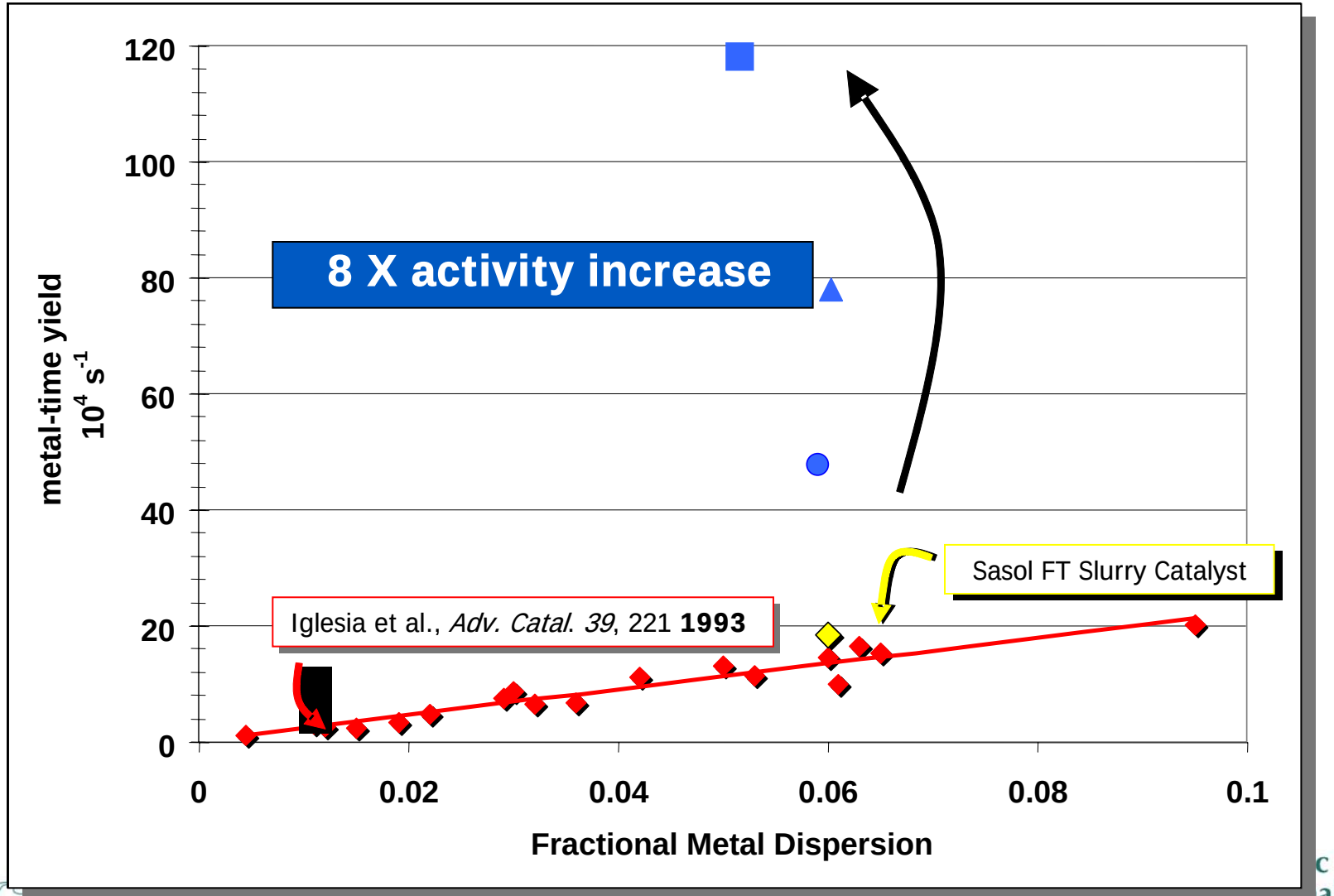
Microchannel



Conventional

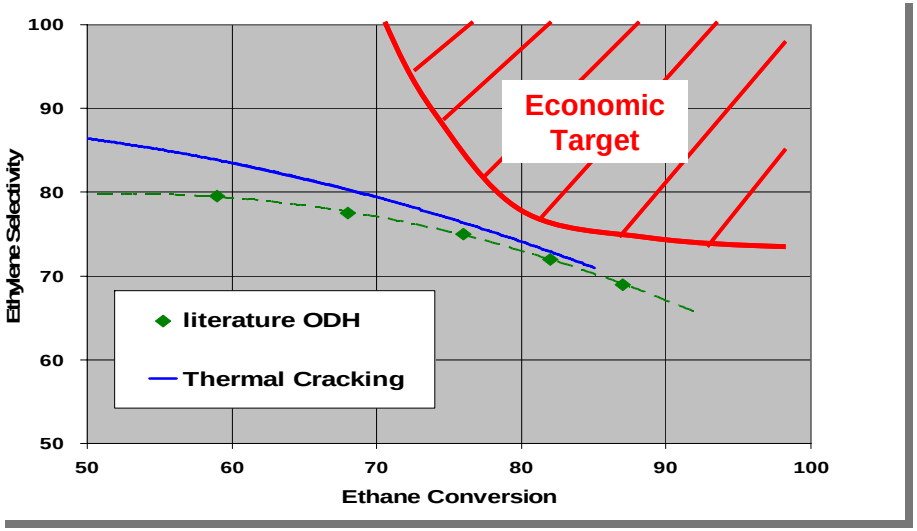
Porous Metal	Support	Porous Ceramic
High	Heat Flux	Low
High	Mass Transport	Low
High	Activity	Limited
Reactor Tailored for Catalyst	Design Philosophy	Catalyst Tailored for Reactor

Space time improve in GTL Applications: Fischer-Trospch Synthesis

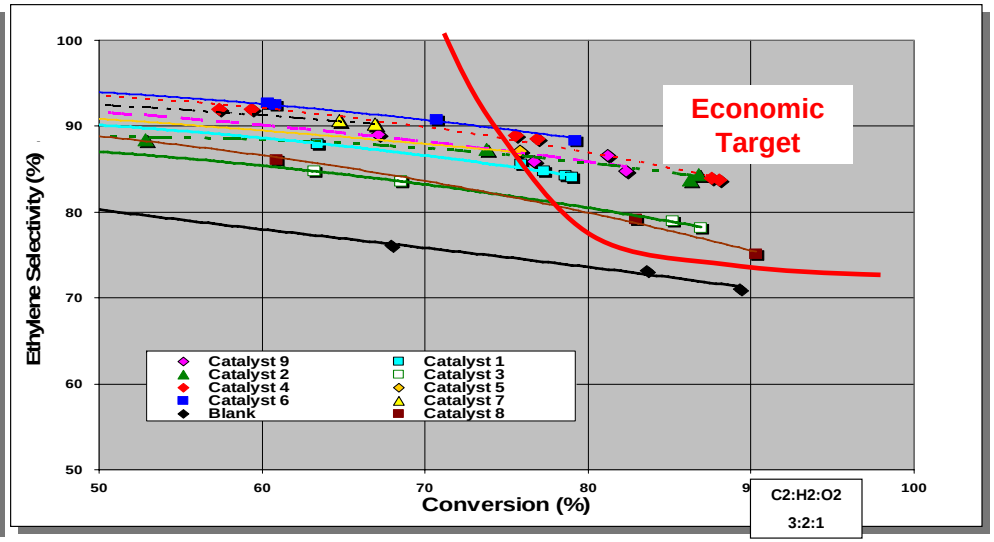


Oxidative Dehydrogenation of Ethane to Produce Ethylene

Yield Challenge



Catalyst Optimization in Microchannel



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Hydrogen Production for Fuel Cells: A Compact mW Reformer

Air Products 35 million standard-cubic-feet-per-day hydrogen plant at Tosco Corporation's Avon refinery near Martinez, Calif.

World's smallest mW reformer system

Key Features

- Fuel Processor Vol: < 0.25cm³
- Fuel Processor Wt: <1 gm
- Operating T: 250-300°C
- Catalytic combustion
- Catalytic methanol reforming
- 3 vaporizer/ heat exchangers
- Self-sustaining

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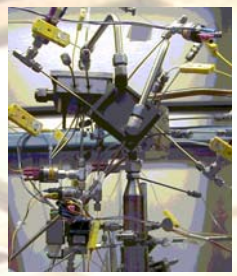
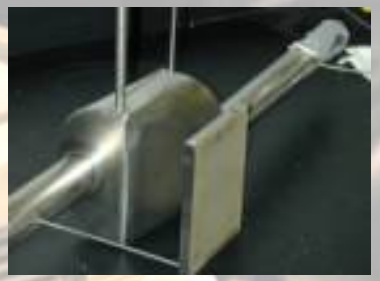
Fuel Processor Development

FY 1998
Full-size gasoline vaporizer/combustor
R&D100 Award

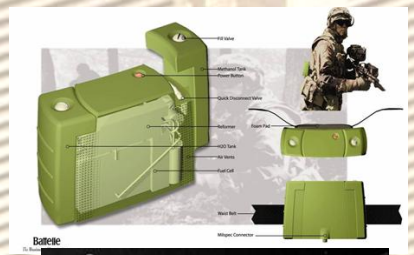


FY 1999
Fast SR kinetics demonstrated in a microchannel reactor

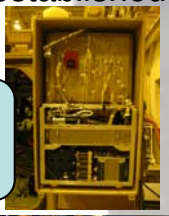
FY 2000
Designed and built
25 kWe SR with integrated HX network

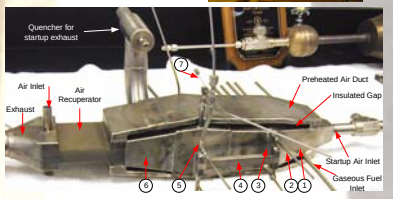


FY2001
10 kWe reactor testing
First "low dP" vaporizers
Modular test stand established

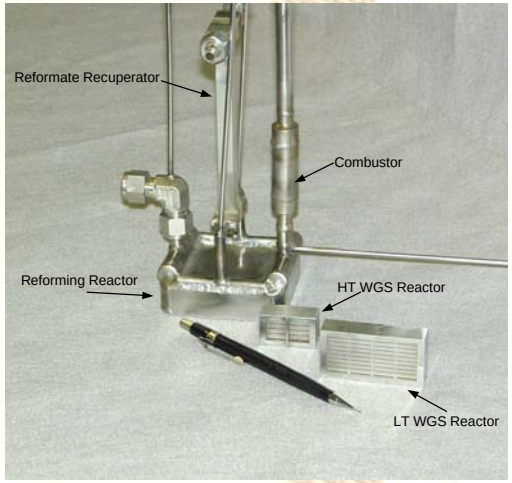


Bradley Pre-Prototype



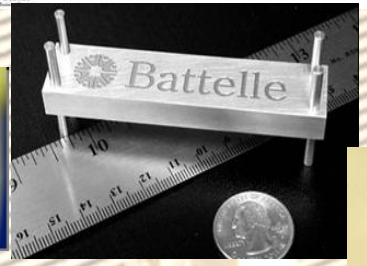


FY2004
2 kWe "fast start" processor
12 second start demonstrated



FY 2002
SR fuel flexibility, durability testing
WGS/PROX catalyst studies
Differential temperature reactor
SR/WGS/PROX integration
Full-scale low dP vaporizers

FY2003
100 mW processor demonstrated



FY2004
25W processor demonstrated

VELOCYS