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# Supircat™: A high performing internal reforming catalyst technology for SOFC applications

MS&T18, COLUMBUS, OH

# Outline

- Brief Company introduction
- Focus of today's presentation
- Background
- Reactor design and testing system
- Internal reforming results
- Other studies
- Conclusions

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# About Nexceris, LLC

- Founded in 1994, privately held
- Technology Developer
  - advanced ceramics, electrochemical devices
- Product Developer
  - sensors and monitors, solid oxide fuel cells, catalysts
- Manufacturer/Distributor
  - sensors, solid oxide fuel cells and related products
- ISO 9001:2015 certification
  - covers all products and operations

www.nexceris.com

# Our Brands

FCM

fuelcellmaterials.com

PERFORMANCE AND QUALITY DELIVERED

**fuelcell**materials.com is our sales division to supplying high quality fuel cell and battery materials, coatings, and related materials for R&D and OEM markets.

NTM Sensors

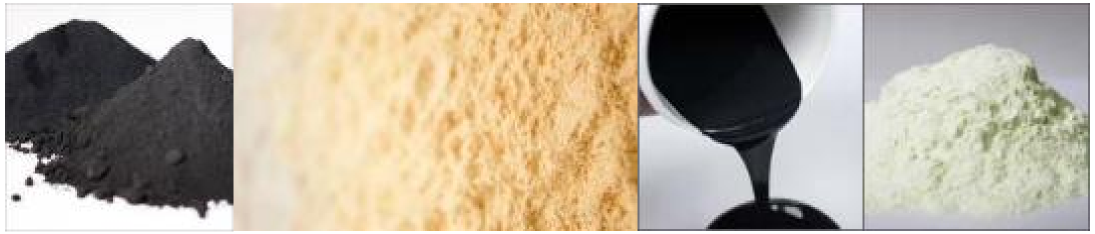
we sense a green future

LI-ION TAMER®

# FCM PRODUCTS

## Powders & Pastes

- Standard and custom powders for SOFC researchers

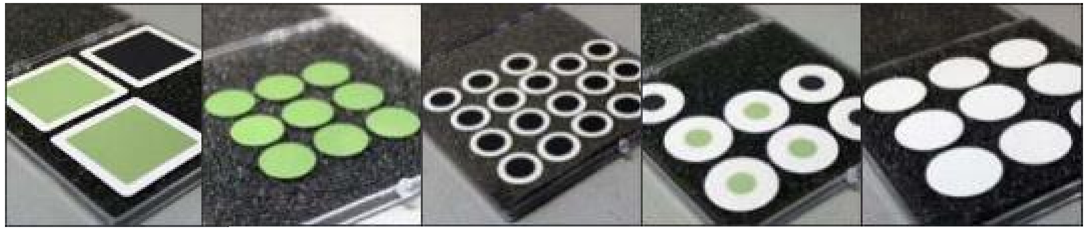


## Test Fixtures and Systems

- For researchers needing credible data

## Cells and Substrates

- Many sizes, formulations and geometries for reproducible results



## Components and Other

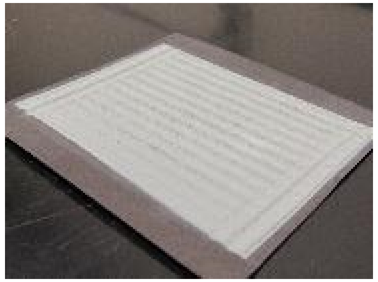
- Seals, process materials, current collecting meshes, etc.

# SOFC Catalyst Technology

## Focus of today's talk

Powder

Suspension



Coated on High κ Part

Cell Fuel System

$$CH_{4(g)} + H_2O_{(g)} \longrightarrow 3H_{2(g)} + CO_{(g)} \quad \Delta H_{r298} = 206 kJ/mol$$

$$CO_{(g)} + H_2O_{(g)} \longrightarrow H_{2(g)} + CO_{2(g)} \quad \Delta H_{r298} = -41 kJ/mol$$

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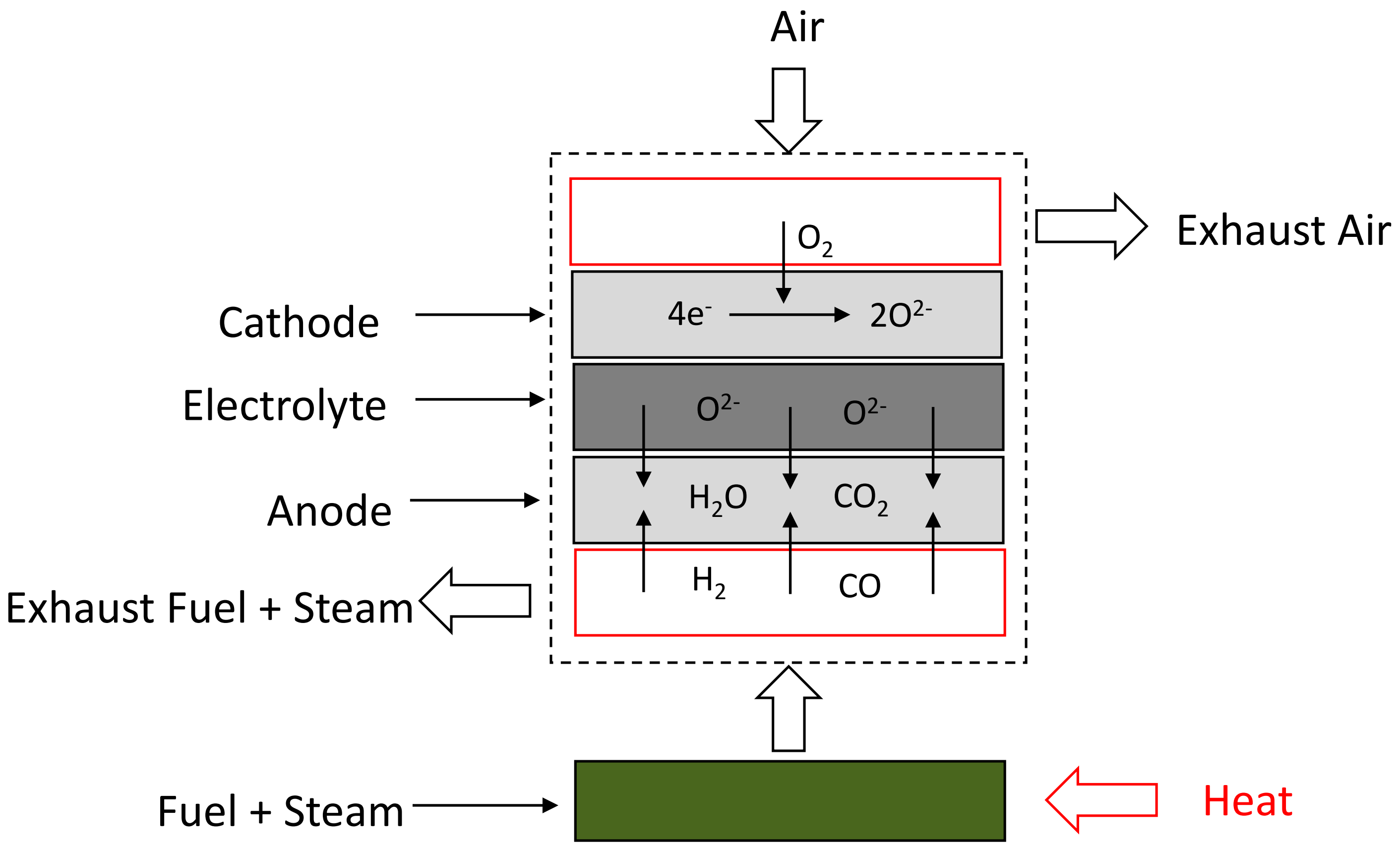
# External Reforming SOFC

## Principles of ER SOFC




- Endothermic reforming reaction takes place outside the cell
- Heat for reforming is provided from an external source
- Complex cell design

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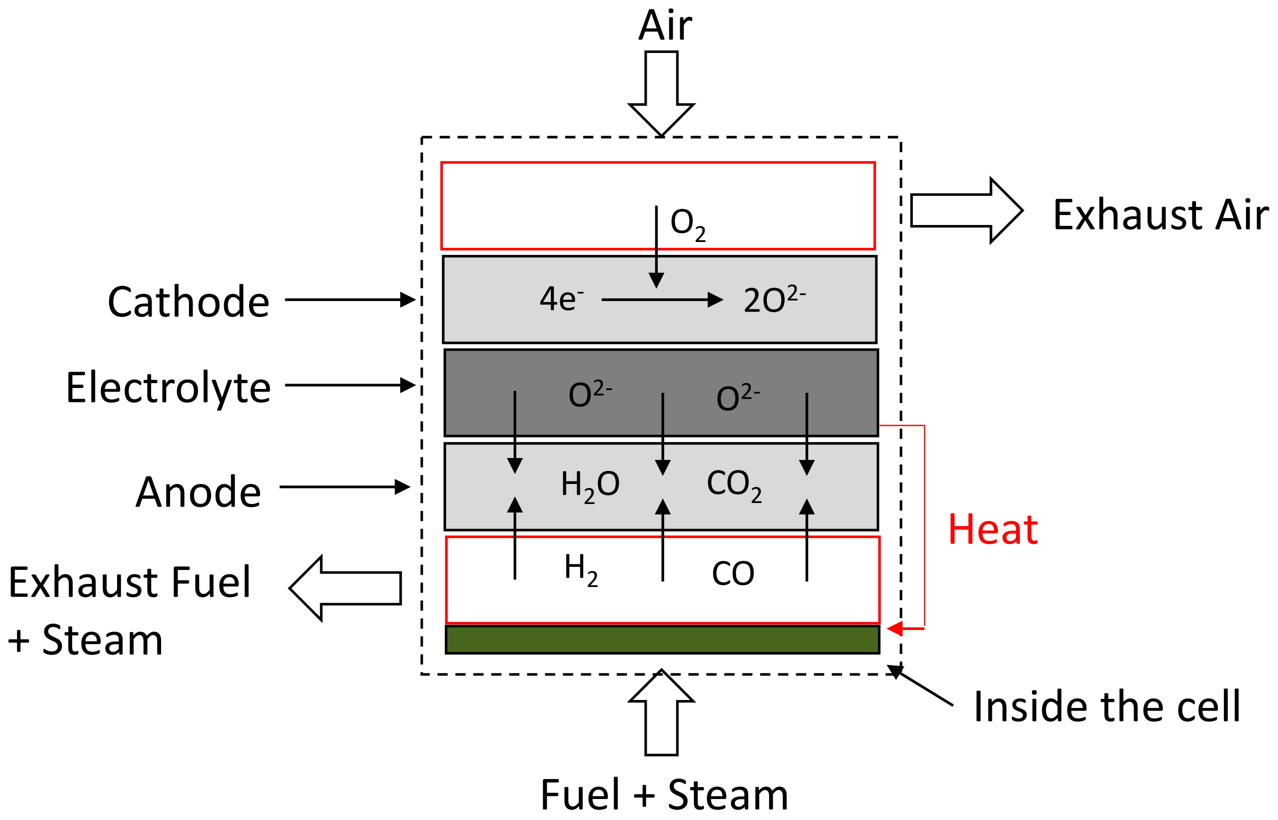
# Indirect Internal Reforming SOFC

## Principles of IIR SOFC




- Endothermic fuel reforming reaction takes place inside the cell (close to anode)
- Heat for reforming is harnessed from exothermic electrochemical reaction
- Simplified cell design (more attractive)

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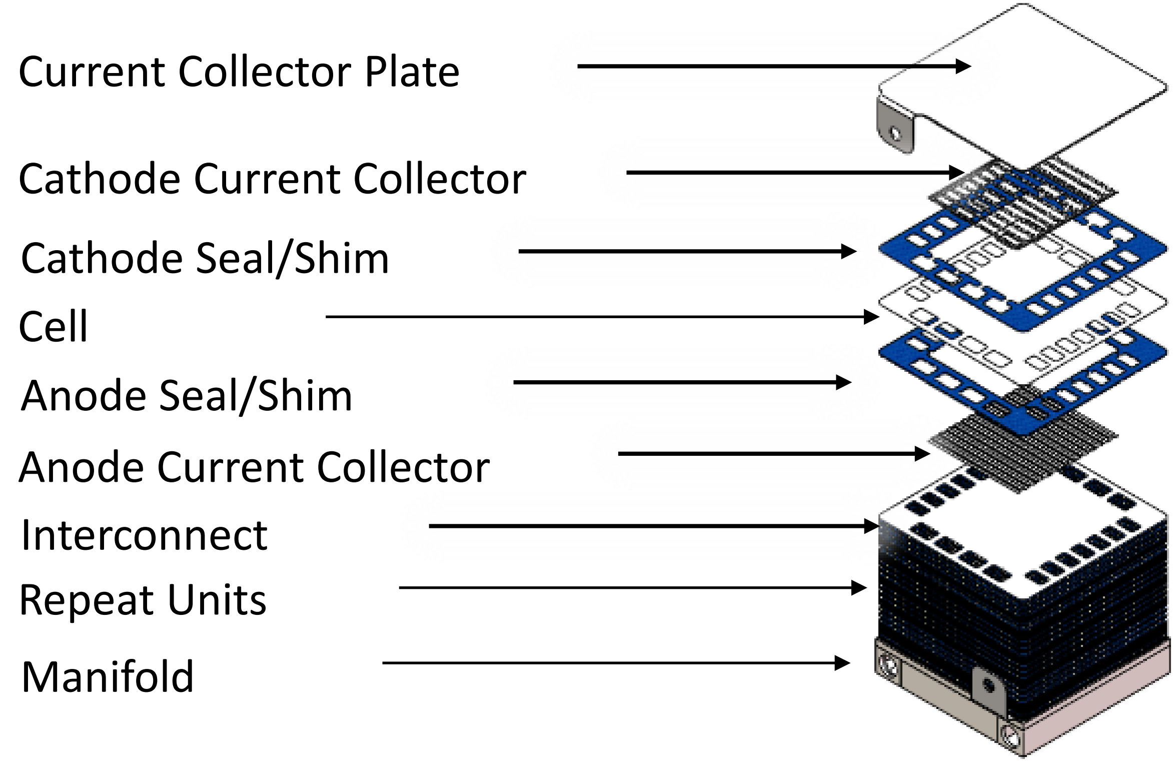
# Nexceris' SOFC stack design

## SOFC Stack Repeat Unit




U.S. Patent No. 8,968,956

- FlexCells: ScSZ electrolyte material
- Thin-foil interconnects: Crofer 22 APU with cathode-face coatings
- Seals: Glass ink and ceramic/glass composites
- Shims: Alloys or inorganic materials
- Cathode current collectors: Coated metal alloy meshes
- Anode current collectors: Nickel foam, coatings to preserve sulfur tolerance

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# IIR Integration

## Where to integrate reformer

Current Collector Plate

Cathode Current Collector

Cathode Seal/Shim

Cell

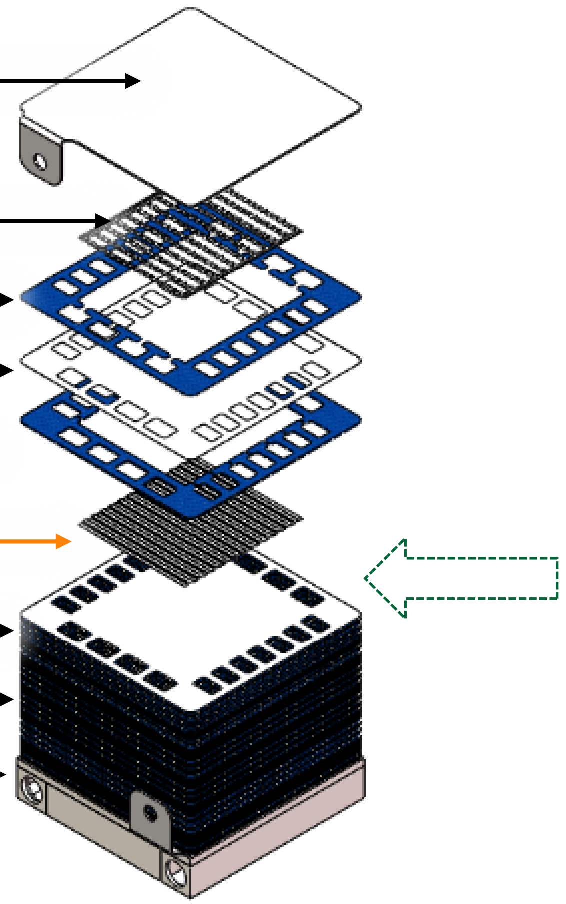
Anode Seal/Shim

Anode Current Collector

Interconnect

Repeat Units

Manifold

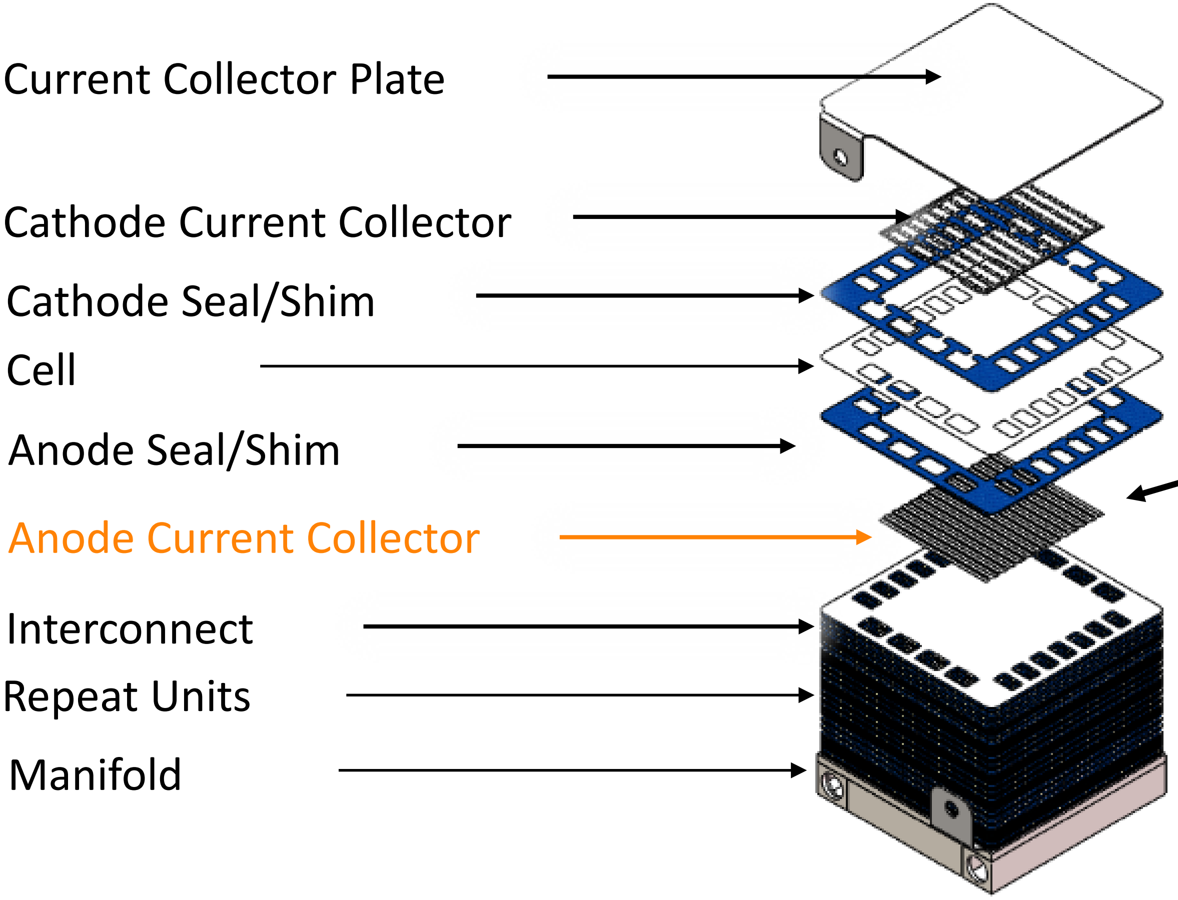


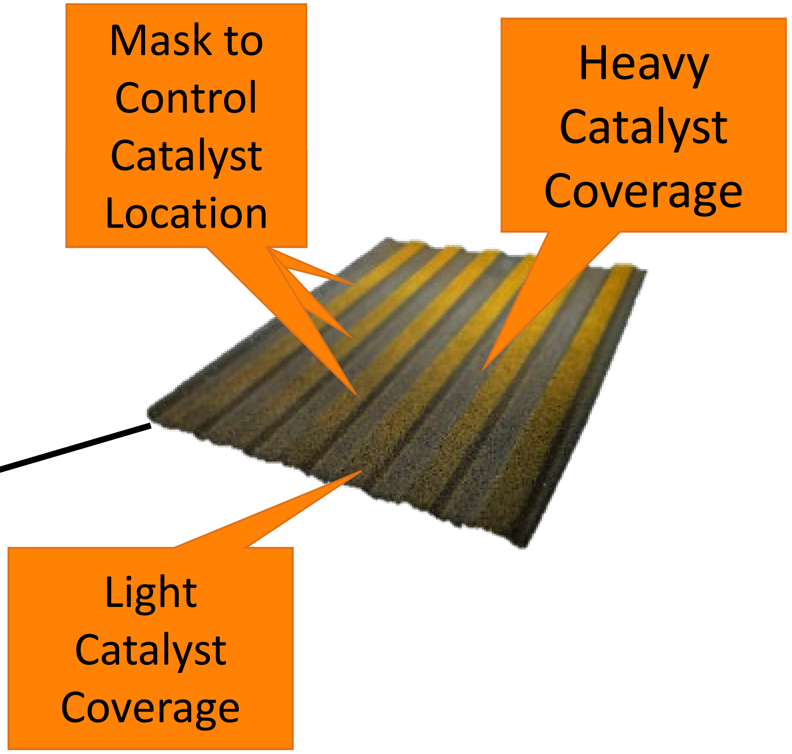
Reformer

- Possible integration locations
  - Anode current collector
  - Separate metallic plate (slight cell redesign)

# IIR Integration

## Use of Ni foam current collector

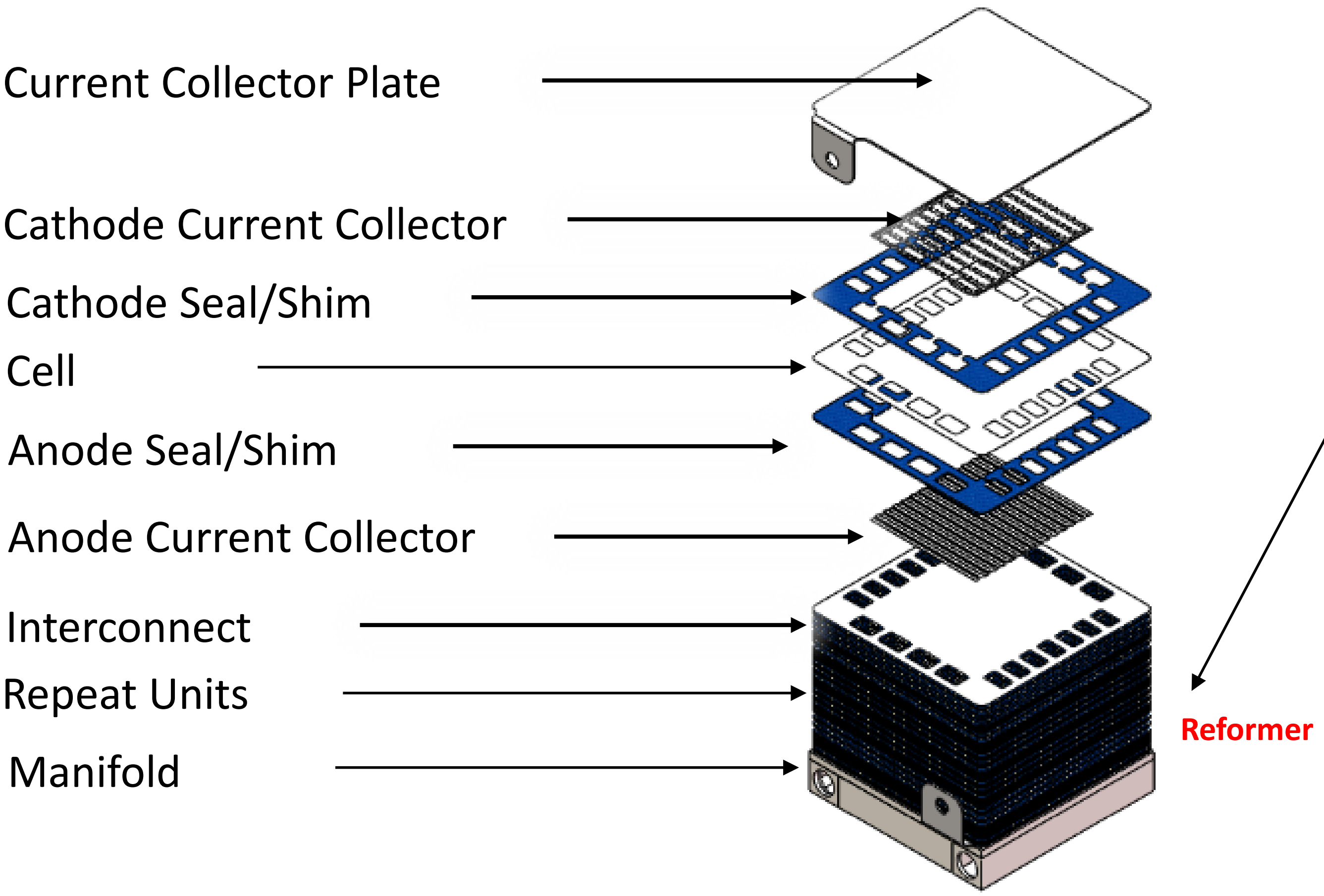


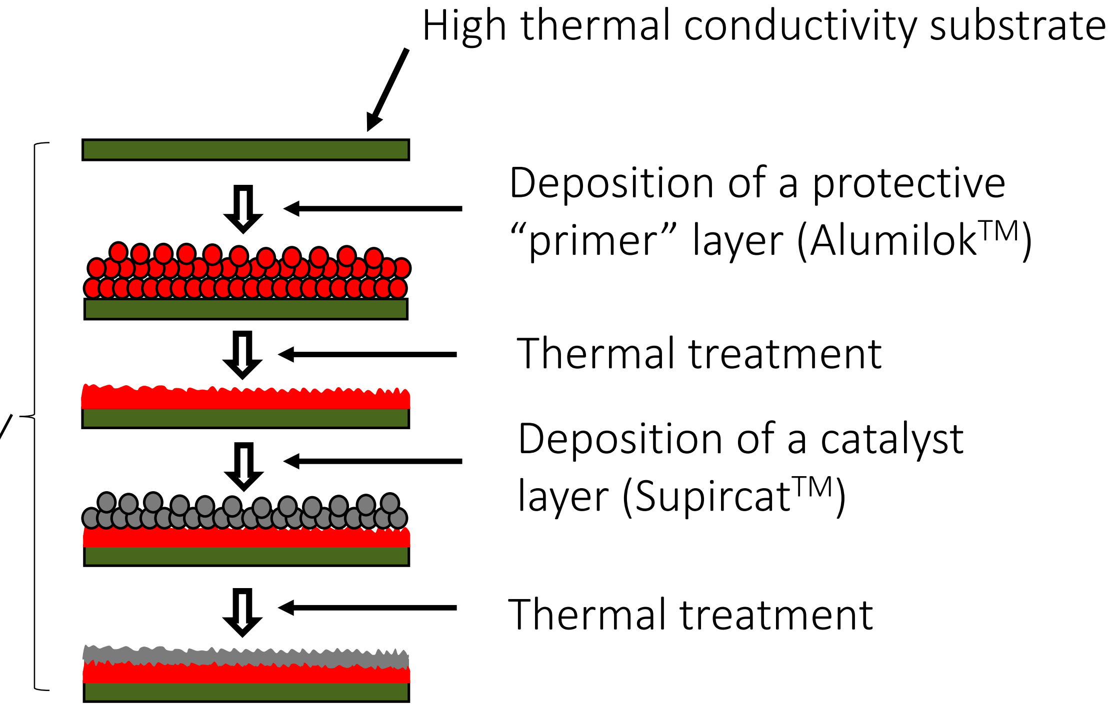




Conceptual 7 cm x 4 cm Supircat$^{TM}$ Support with Patterned and Graded Catalyst Deposition

# IIR Integration

## Use of high thermal conductivity substrate



# Design Principles

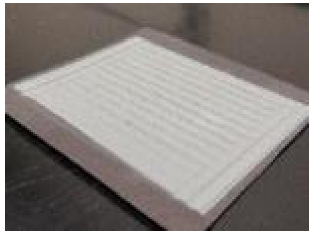
### Catalyst Powder

- Cost
- Immediate activation (no reduction needed)
- Equilibrium activity
- Sulfur tolerant
- Resistant to coking
- Performance stability

### Slurry Suspension

- Optimized flow characteristics (rheological properties)
- Optimized solids loading
- Spray-ability

### Coating

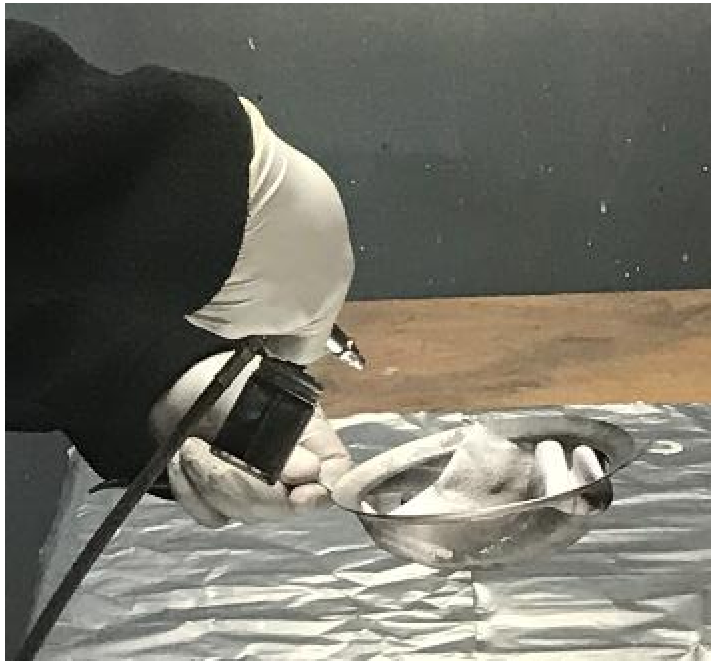


- Controlled layer thickness
- Layer adhesion

# Layer Application

**Spraying Capabilities**

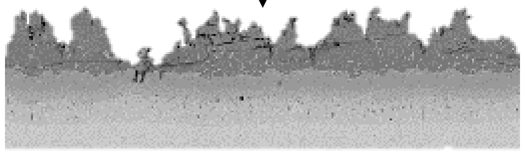
Manual spraying



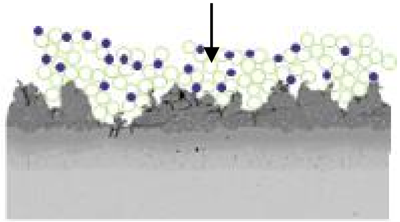
Automated spraying

## Compact manifold

*AlumiLok*™ coating



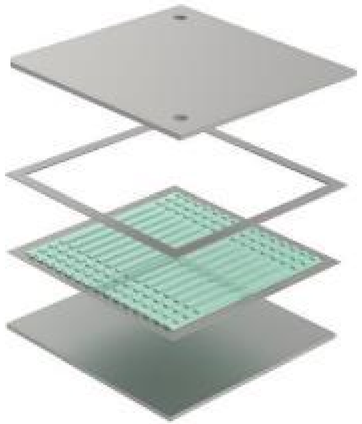
*Supircat*™ coating



Catalyst layer deposited on top of an AlumiloK™ layer

Manifold top cover

Supircat™ coated plate



Rendered manifold design

Crofer 22 APU

# Internal Reforming Testing

## Testing & Analysis System and Conditions

Test rig

Analysis system

| Table 1. Testing Conditions | | |
|---|---|---|
| Parameter | Min. | Max. |
| Temperature (°C) | 500 | 850 |
| Pressure (bara) | 1 | 1.5 |
| GHSV ($h^{-1}$) | 3,000 | 35,000 |
| S:C ratio | 2.5 | 4.0 |

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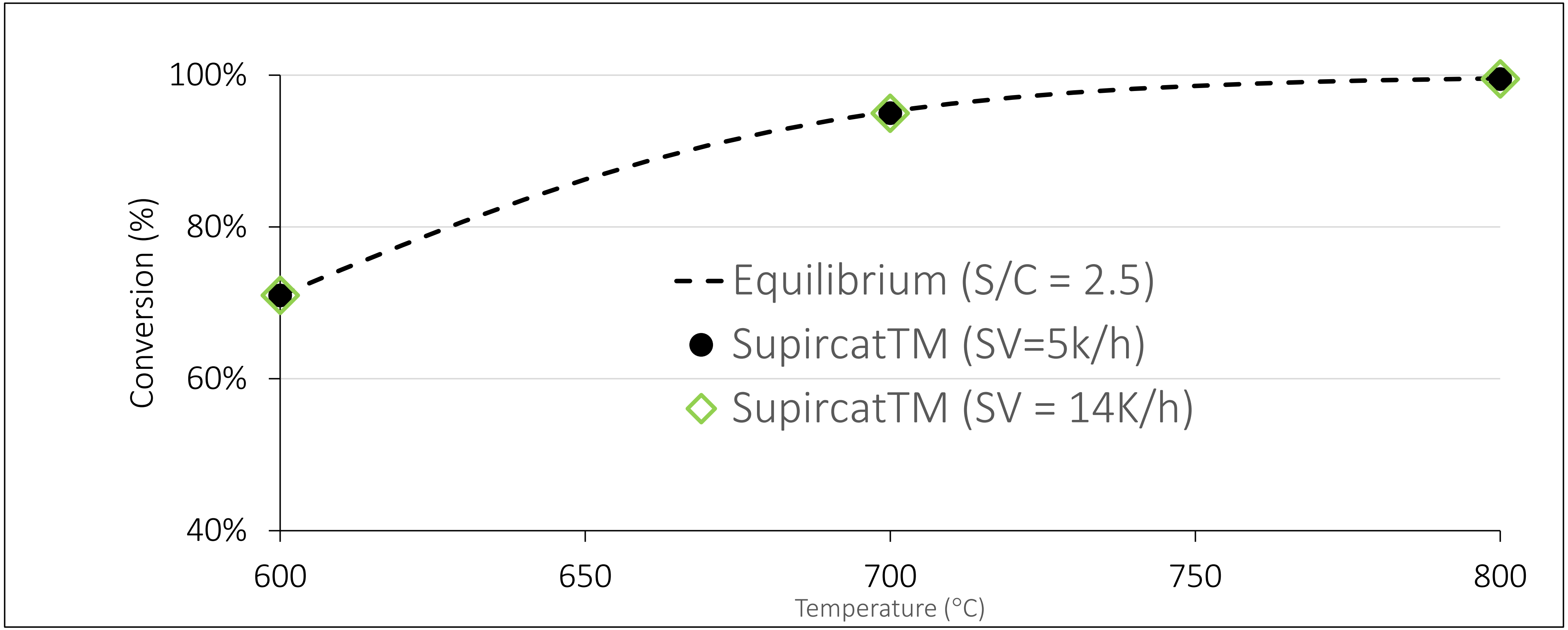
# Temperature and Space Velocity Study

Conditions: Temp: 600 – 800 °C, Pres: 1 bara, GHSV: 5 & 14K, S/C: 2.5

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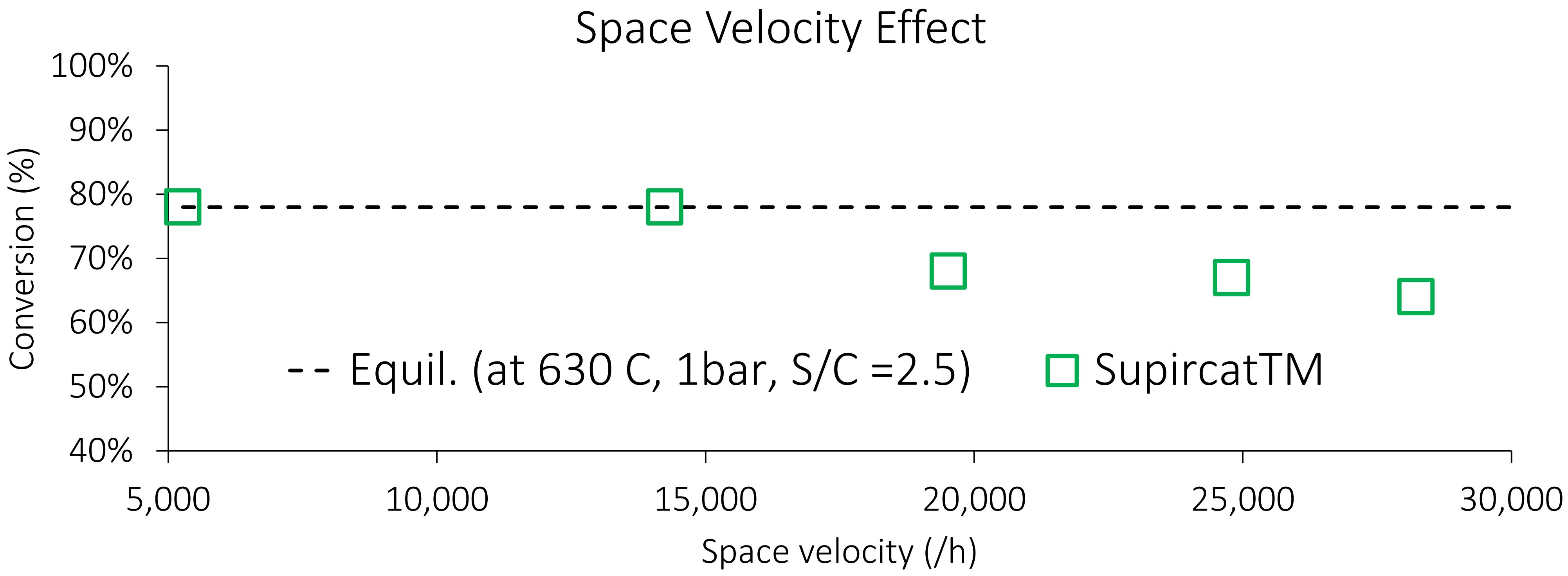
# Space Velocity Effect

## At isothermal conditions

Conditions: Temp: **630 °C**, Pres: 1 bara, S/C: 2.5

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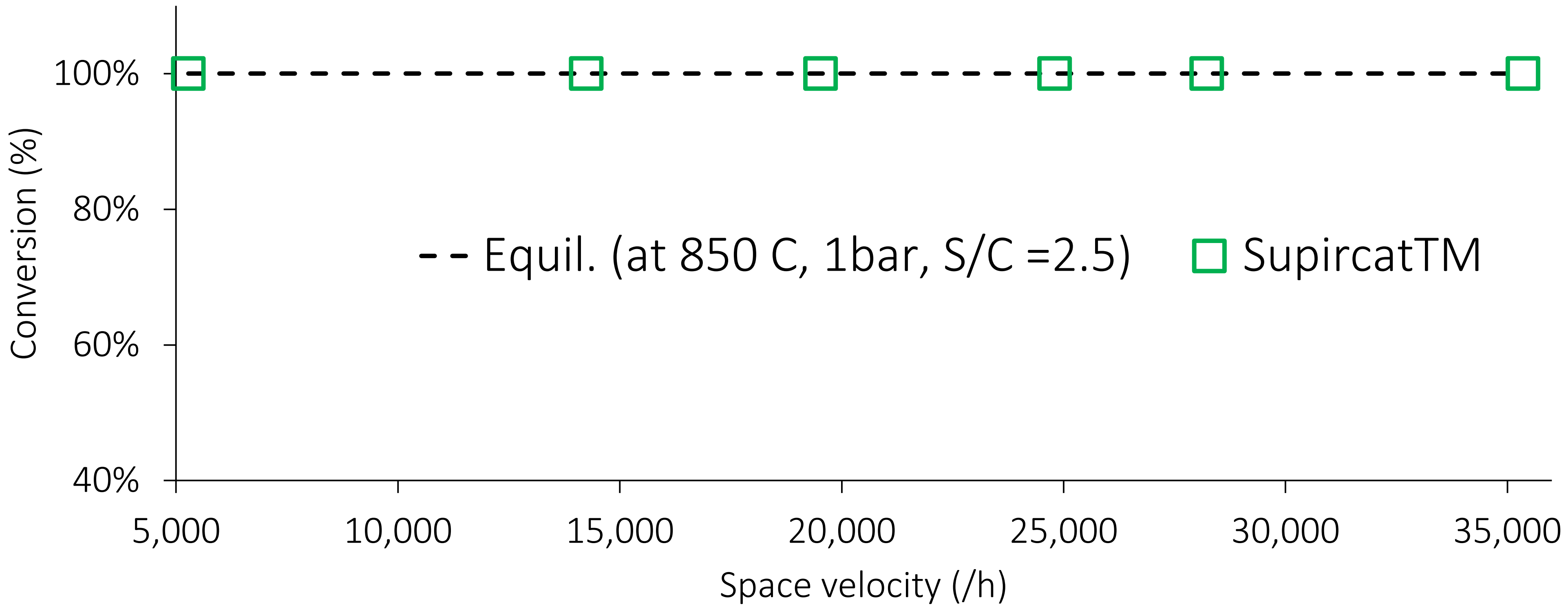
# Space Velocity Effect

## Isothermal Conditions

Conditions: Temp: 850 °C, Pres: 1 bara, S/C: 2.5

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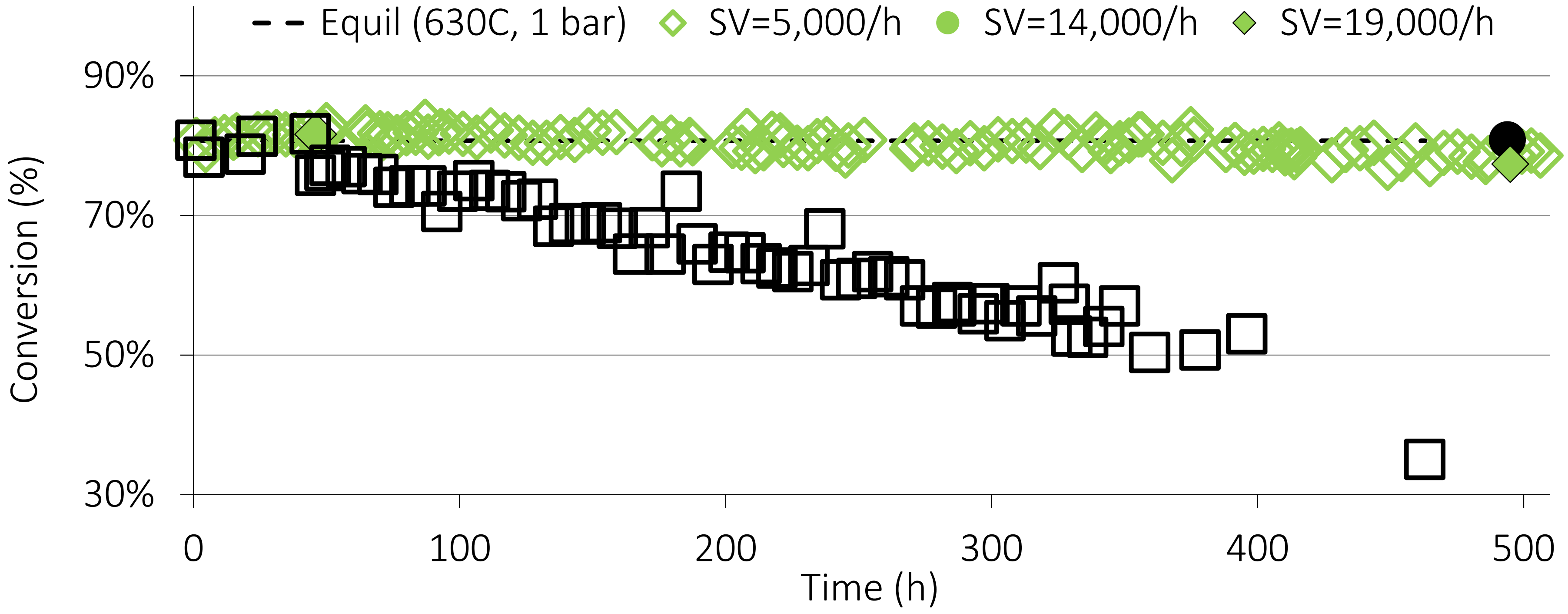
## Effect of Poison

Conditions: Temp: **850 °C**, Pres: 1 bara, S/C: 2.5

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# Conclusion

- Alumilok™ and Supircat™ catalyst technologies proven active
  - Baseline performance
  - Life-time stability
- Good tolerance to poisons e.g. Cr and S

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