What does this group do?

- **What is synthesis gas?** A mixture of CO and H\textsubscript{2}, syngas can be derived from both renewable and fossil resources, making it a highly flexible building block.

- **Why is syngas important?** Fuel flexibility. Syngas can be used to make ultra-clean transportation fuels (diesel, jet fuel, hydrogen for fuel cells) and chemicals (lubricants, waxes, oxygenates).

- **Why are syngas-derived fuels important?**
  - Fuels have *ultra-low sulfur content* and low aromatics.
  - Drop-in premium fuels have *high cetane number* (*superior combustion quality*), excellent performance.
  - Hydrogen fuel cells are the ultimate *zero emission* power device.
Ongoing projects: Fischer-Tropsch synthesis

- **Feedstock**
  - Natural Gas
  - Coal
  - Biomass

- **Syngas Generation**
  - Gasification
  - Steam Reforming

- **Fischer-Tropsch process**

- **Hydrocarbon Chains**

- **Upgrading to Fuels / Chemicals**

Diagram showing the process flow from feedstock to syngas generation, Fischer-Tropsch process, hydrocarbon chains, and upgrading to fuels/chemicals.
• **What is a CHER?** Compact Heat Exchange Reactor

• **What are the advantages of a CHER?** FTS is a very exothermic reaction (generates heat). A conventional slurry reactor (e.g., slurry bubble column reactor) offers excellent heat and mass transfer management, facile catalyst replacement, but relatively lower productivity due to back mixing.

A microchannel reactor offers good thermal management and offers the high throughput of a fixed bed reactor, but catalyst replacement is very difficult (e.g., washcoats are often used).

The new CHER combines the high productivity of a fixed bed reactor with internal heat transfer (via a heat exchanger). Catalyst particles, between heat transfer plates, may be easily replaced. Co and Fe catalysts must be developed (pore-mod).

<table>
<thead>
<tr>
<th>Catalyst</th>
<th>CO conversion (%)</th>
<th>Space velocity (slph/gcat)</th>
<th>Selectivity (C%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25%Co/Al2O3 (T1)</td>
<td>23.3</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>16.3%Co/PF#1 (T1)</td>
<td>25.6</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>6.3%Co/PF#2 (T1)</td>
<td>26.6</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>25%Co/Al2O3 (T1)</td>
<td>51.0</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>16.3%Co/PF#1 (T1)</td>
<td>52.9</td>
<td>1.5</td>
<td></td>
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<tr>
<td>6.3%Co/PF#2 (T1)</td>
<td>54.8</td>
<td>1.25</td>
<td></td>
</tr>
</tbody>
</table>
Ongoing projects: Dehydrocyclization Catalysts

Pt/KL zeolite mechanism for n-hexane aromatization: Isotopic tracer studies - direct 1,6 ring closure.

Pt Ensemble Size
Hydrogenolysis > Dehydrocyclization > Dehydrogenation

CVD of Ag (inert)

Ag atoms

Pt
Additional info

• Where does the CFC group get funding from?

  Industrial Collaborations  U.S. Department of Energy  NASA
  State Governments (Kentucky, Wyoming)  International Collaborations (QNRF)

• Where does the CFC group publish?

  Chemical Engineering Journal  Industrial & Engineering Chemistry Research  Fuel
  Catalysis Today  Energy & Fuels  Catalysis Letters  Topics in Catalysis  Science

• Where does the CFC group present its results?

  North American Catalysis Society Meeting  American Chemical Society National Meeting
  Natural Gas Conversion Symposium  American Institute of Chemical Engineers

• Where do students that work in the CFC group go afterwards?

  Industry (e.g. Chevron, Imperial Oil)  Government (e.g. National Labs)
  Graduate or Medical School  Academia (e.g. Colorado School of Mines, UNISA, EKU)
What skills and expertise can you acquire?

- **Chemical Engineering**
  - CHER
    - Reactor design
    - Reactor operation
    - Heat / mass transfer optimization
  - Catalysis

- **Materials Engineering**
  - CHER
    - Reactor cost reduction
    - Materials optimization
    - Materials interactions
  - Catalysis

- **Physics**
  - Synchrotron
    - XANES (electronic structure)
    - EXAFS (local atomic structure)
    - Modeling / Nonlinear Fitting
  - Catalysis

- **Computational Analysis**
  - Synchrotron
    - Structural Modeling
    - Nonlinear Fitting
    - Statistical Analysis
  - Catalysis

- **Catalysis**
  - Experimental design
  - Reactor operation
  - Database
  - Catalyst synthesis
  - Catalyst characterization
  - Materials development
  - Fuels synthesis
  - Product workup / analysis
  - Fuels upgrading
  - Equipment design
  - Equipment modifications
  - Equipment maintenance