Recent Research in Chen Group

**Development of novel catalysts in heterogeneous catalysis and electrocatalysis**

**Single crystal surfaces:**
- Fundamental atomic-level understanding through experiments and theory

**Supported catalysts:**
- More relevant to industrial catalysts and commercial processes

**Research approach:**
Combining model surfaces with supported catalysts

**Example 1:** Heterogeneous catalysis for CO₂ activation

**Key reaction pathways:**
- CO₂ reduction by light alkanes

**Tuning selectivity with non-precious metal catalysts**
- Fe modification of Ni catalysts improves CO selectivity while maintaining high catalytic activity
- In-situ X-ray spectroscopy probes the phase and function of bimetallic catalysts

**Example 2:** Conversion of inexpensive molecules into valuable chemicals

**Key reaction steps:**
- Selective scission of C-O bonds in the HDO reaction of glycerol

**Example 3:** Electrocatalysis of CO₂ to value-added products

**Key reaction processes:**
- Electrocatalytic (EC), thermocatalytic (TC), and combined hybrid (HB) processes for CO₂ reduction to methanol

**Enhancing Activity and Reducing Cost for CO₂ Electrochemical Reduction**
- Pd supported on transition metal carbides (TMCs) show high activity for the CO₂ reduction reaction to produce syngas (CO/H₂ mixture)
- By supporting Pd on TMCs, the cost of the catalyst can be reduced

**Bimetallic and carbide catalysts offer the advantages of reduced cost and enhanced activity, selectivity and stability.**

**Example 3 (continued):**
- Phosphorus (P)- and gallium (Ga)-modified ZSM-5 catalyzes a one-step reaction from CO₂ and ethane to aromatics
- DFT calculations provide insight into the effect of Ga- and P-modification, and the role of CO₂.

**Tandem reactions of CO₂ reduction and ethane aromatization**


**Enhancing Activity and Reducing Cost for CO₂ Electrochemical Reduction**


**L.R. Winter, E. Gomez, B. Yan, S. Yao, J.G. Chen, Applied Catalysis B: Environmental (2018).**

**E. Gomez, S. Kattel, B. Yan, S. Yao, J.G. Chen, Nature Communications (2018).**
