# Fuel recycling at copper catalysts

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## Motivation

- Recycle combustion waste products, $CO_2$ and CO.
- Develop the fundamental understanding of how to regenerate fuels from these waste products.
- Turn our everyday linear vicious use of hydrocarbons into a cycle, where the end products, $CO_2$ and CO, are treated chemically and used again as the fuels they once were.

## Project Description

- Synthesize novel metal-based catalysts with potential to enforce the chemical regeneration of fuels starting from $CO_2$/CO.

## Context

- Currently this transformation is known to occur in copper metal surfaces, shown below.[1]
- In copper surfaces, products such as ethanol (the holy grail end product) have been observed.
- There are no homogeneous systems to carry out this transformation. Thus, much of the fundamental steps *en route* to fuels remain unknown.

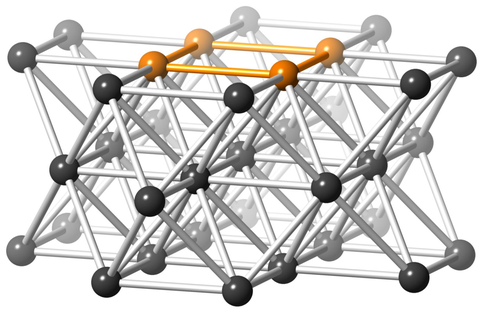

**Figure 1.** Copper (100) crystallographic plane known to effect the $CO_2$/CO transformation into small hydrocarbons, i.e. ethanol. Shown in orange is the proposed catalytic active sites.

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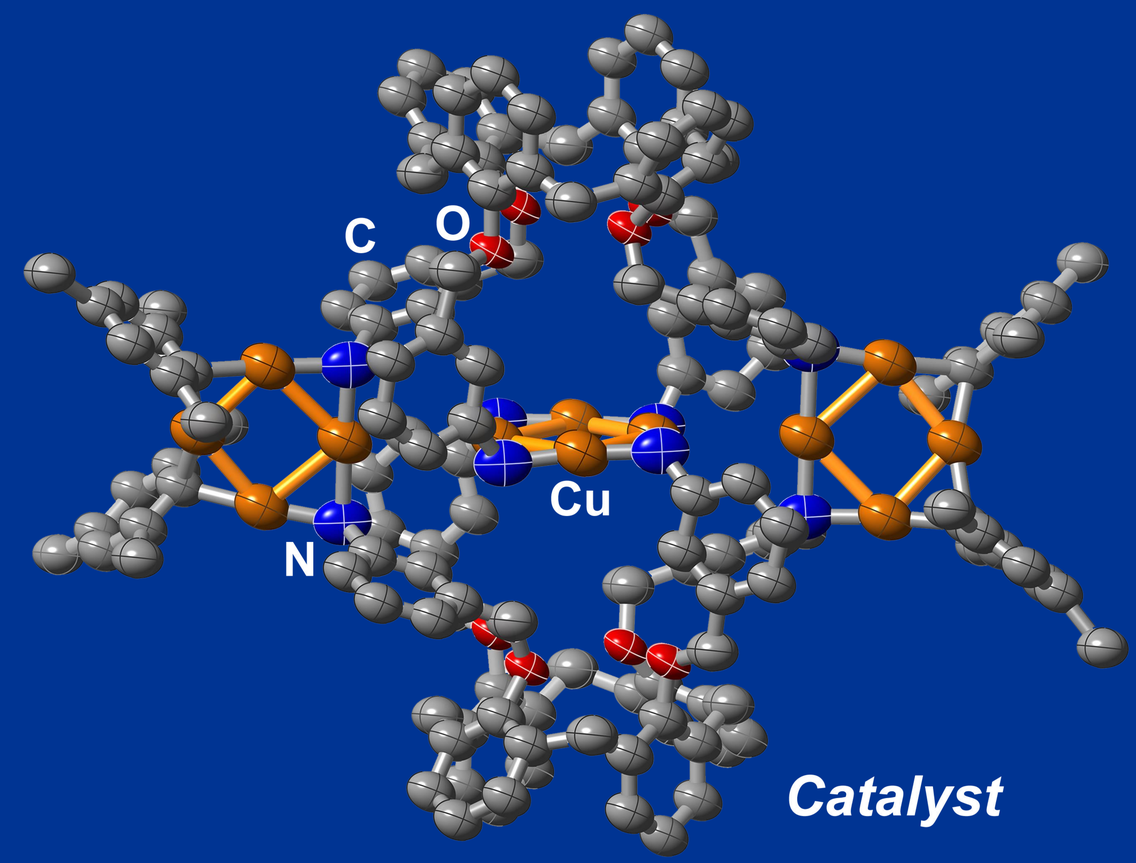
# This research plan will develop metal-based *catalysts* to transform **inert greenhouse gases**, i.e. carbon monoxide and carbon dioxide, into **fuels.**




*Catalyst*

**Greenhouse gases** [catalyst] → **Hydrocarbons (fuels)**

## Project Deliverables

- This research plan will deliver a family of catalysts with the appropriate geometry to test the reduction of $CO_2$/CO into short hydrocarbons.

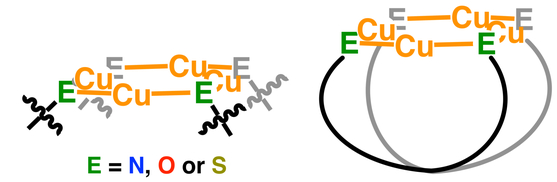



**Figure 2.** Ligand design concept.

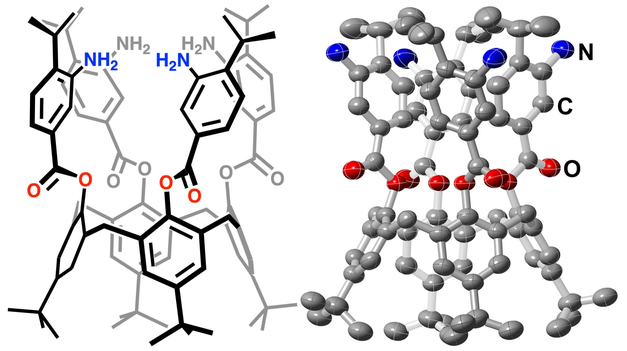



**Figure 3.** Example of ligand synthesized in the HSG. Shown on the right hand side is the crystal structure of this ligand.

- This funding will allow us to investigate an un unexplored landscape of polynuclear copper homogeneous catalysis.
- Data collected throughout the upcoming year will serve as the basis to a major NSF and/or DOE grant application.

## Potential Impact

- Success of this research will provide a guideline to develop catalytic systems to reintroduce carbon-based waste products into our energy-thirsty society.
- These catalysts promise to unveil the chemicals steps to guide society to ***sustainability***.

## References and Acknowledgements

[1](a) K. P. Kuhl; E. R. Cave; D. N. Abram; T. F. Jaramillo. "New Insights into the electrochemical reduction of carbon dioxide on metallic copper surfaces". *Energy Environ. Sci.* **2012**, *5*, 7050; (b) C. W. Li; J. Ciston; M. W. Kanan. "Electroreduction of carbon monoxide to liquid fuel on oxide-derived nanocrystalline copper". *Nature* **2014**, *508*, 504.

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