DEVELOPMENT OF A NOVEL Pd-BASED HETEROGENEOUS CATALYST FOR CO_2 CONVERSION

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Various efforts have been attempted to mitigate global warming by reducing the CO_2 emission

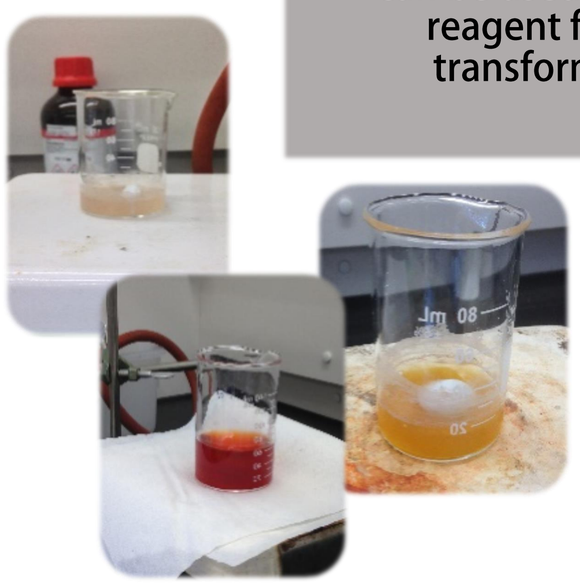
Background

The elevate CO_2 emissions contributes to the increase of the greenhouse effect

Hydrogen is a high energy material which can be used as the reagent for CO_2 transformation

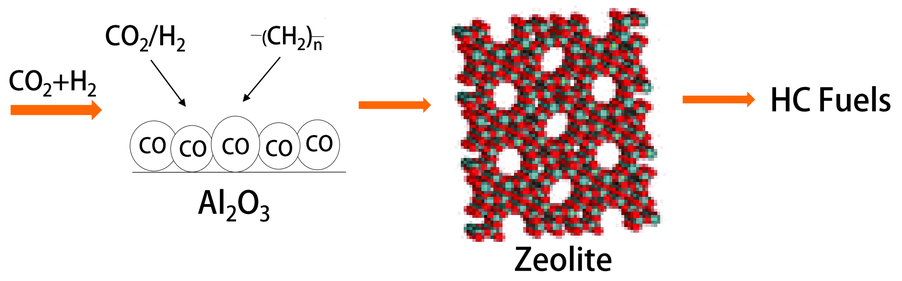
Objective

Developing a novel Pd-based heterogeneous catalyst to enhance the catalytic conversion of CO_2 by H_2 for the synthesis of value-added chemicals such as CO, methanol and fuels



Chemical Reactions

- $CO_2 + H_2 \longleftrightarrow CO + H_2O$
  $\Delta H(573K) = 38$ kJ/mol
- $CO + 2\,H_2 \longrightarrow (CH_2) + H_2O$
  $\Delta H(573K) = -166$ kJ/mol
- $CO_2 + H_2$ → Chemicals → Methanol
  $CO_2 + H_2$ → Fuels → Hydrocarbons



A. Preparation of Pd(II) complex solution

ACIDIC System

- 0.0107 g of Oxalic acid was added to 5 g of acetone
- 0.0858 g of Palladium acetate is added to the solution
- 0. 097 g of Tin oxalate and 0.134 g of Ammonium oxalate is added to 10 ml of Di-water
- The Tin solution is added to the Pd one

BASIC System

- Mix 0.0285 g of Oxalic acid and 0.01055 g of Palladium acetate in 3.5 g of Di-water
- Slowly add ethylene diamine to make the solution clear

Palladium acetate

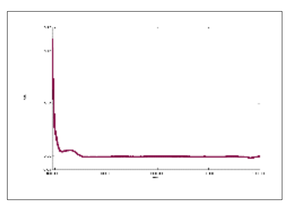
B. Wet Incipient Impregnation

- Add the solution to 5 g of support until the support is damp
- Dry the support in a rotating tumbler with a drying lamp
- When the support has absorbed all the solution, dry in the oven at 120° C overnight

Results

- The Pd solution was tuned to be either acidic or basic to adapt to different catalyst support
- The heterogeneous catalyst was synthesized on alumina support (acidic) and active carbon support (basic)

- The solution was characterized by ultraviolet-visible spectroscopy at the wavelenght of 190 ~ 1000 nm



Two absorption peaks were observed indicating the existance of two Pd species in the solution

Future Studies

1. Test the performance of the synthetized catalysts using a continuous fix-bed reactor
2. Collaborate with Brookhaven National Lab (BNL) and Dalian Institute of Chemical Physics (DICP) on catalyst characterizations: Brunauer Emmett Teller (BET) surface area, pore size and volume, Transmission Electron Microscope (TEM), X-ray photoelectron spectroscopy (XPS), X-ray diffraction (XRD)
3. Establish a relationship between activity and properties
4. Understand the reaction pathway for CO_2 hydrogenation

Challenge

Since CO_2 hydrogenation does not always produce methanol and fuels, we need to develop an efficient catalyst and minimize the formation of by-products

References

Samrand, Nor Aishah, and Mohammad Reza Rahimpour. «Hydrogenation of CO_2 to value-added products-A review and potential future developments.» Journal of CO_2 Utilization 5 (2014): 66-81. Web