Synthesis and Characterization of Pd/Au Carbon Supported Catalysts

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Overview

Current Issue and Solutions
- Trichloroethylene leached into groundwater
- GAC and Air stripping

Palladium Catalysts
- Gold as a promoter metal
- Carbon Supports

Synthesis Process
- Sonochemical
- Solvothermal

TEM Analysis

Reaction Rates

Purification of Groundwater

Issue

Trichloroethylene (TCE)

Commonly used as a solvent in the electronics industry [1]

- Leached into water sources after disposal

Health Hazards [2]

- Carcinogenic
- Kidney and liver damage
- Reproductive issues

Current Solutions

Granular Activated Carbon (GAC)

- Adsorbs contaminants onto surface
- Saturates quickly
- Does not destroy TCE

Air Stripping

- Removes headspace continuously from above a liquid
- Requires GAC to purify resulting air
- Does not destroy TCE

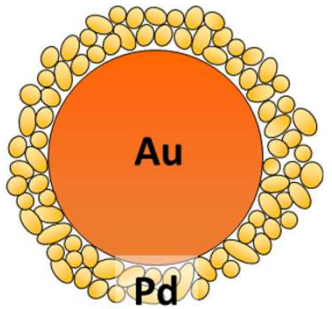
Palladium Bi-Metallic Catalysts

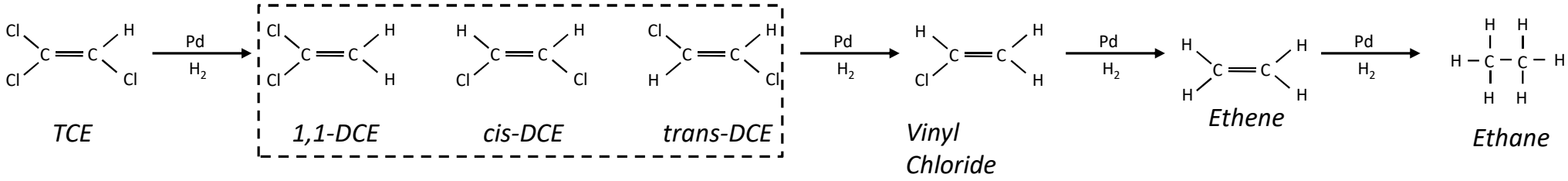
Chosen for its reactivity and selectivity [3]

- Low susceptibility to degradation
- High reduction activity

Pd reactivity boosted when supported by a second metal

- Gold, platinum, and alumina have been looked at
- Gold used for this study





Pd/Au Carbon Supported Catalysts

Carbon Supports

GAC

- A form of carbon with small pores

Graphite

- A many layered crystalline carbon structure

Graphene

- A single layer sheet of graphite

Carbon Black

- A sponge-like carbon powder

Benefits

Prevent Contamination of Treated Water

- Unsupported NPs difficult to retrieve from water.
- Supports
  - anchor NPs
  - control aggregation
  - offer practicality

Adsorption

- Carbon GAC has the ability to adsorb particles
- Synergistic interaction between support and catalyst

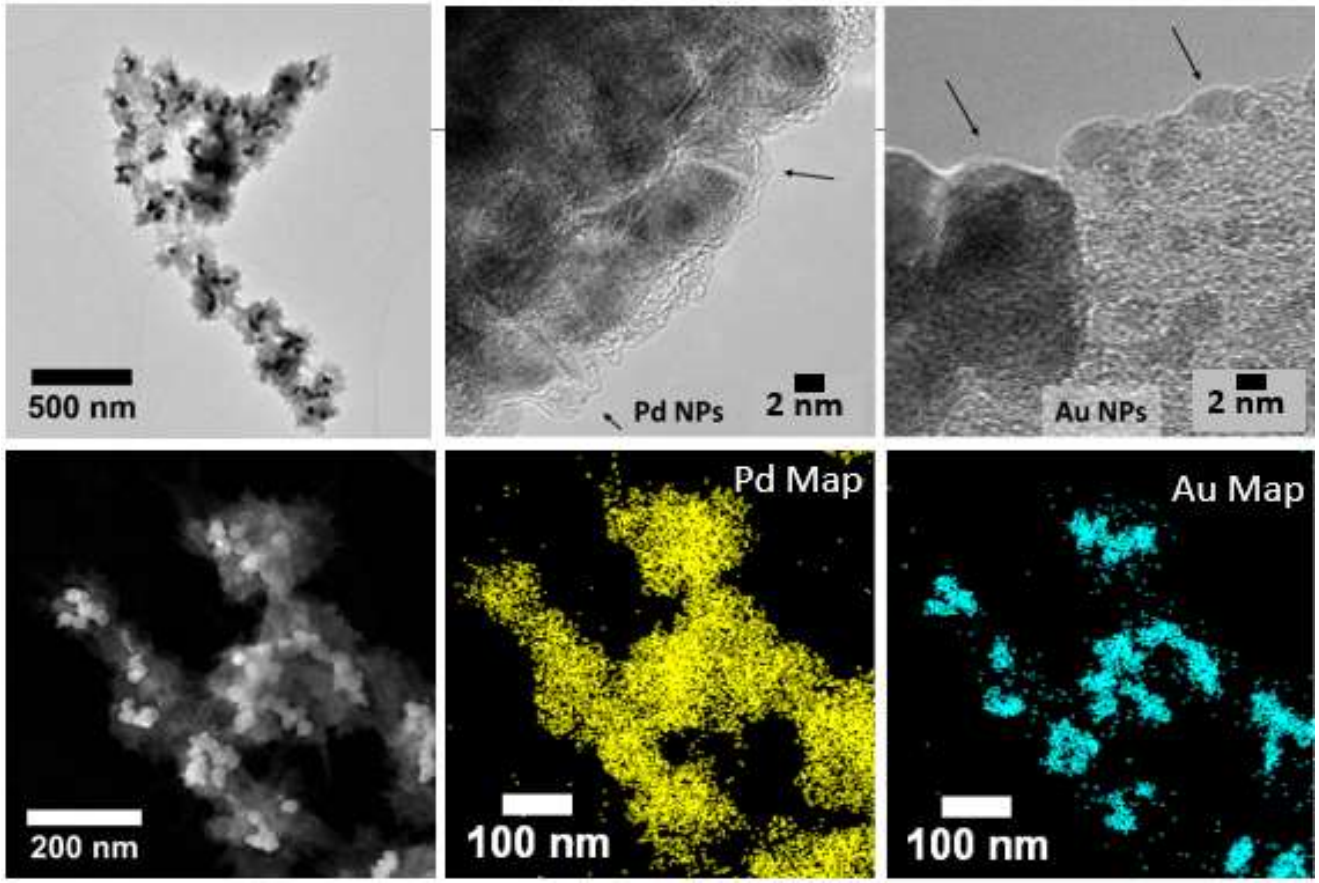
Synthesis

Sonochemical

- Precursors of Palladium (III) Acetate (Sigma Aldrich) and Tetrachloroauric Acid Trihydrate (Sigma Aldrich)
- Sonicated in acetone (ACS Grade)

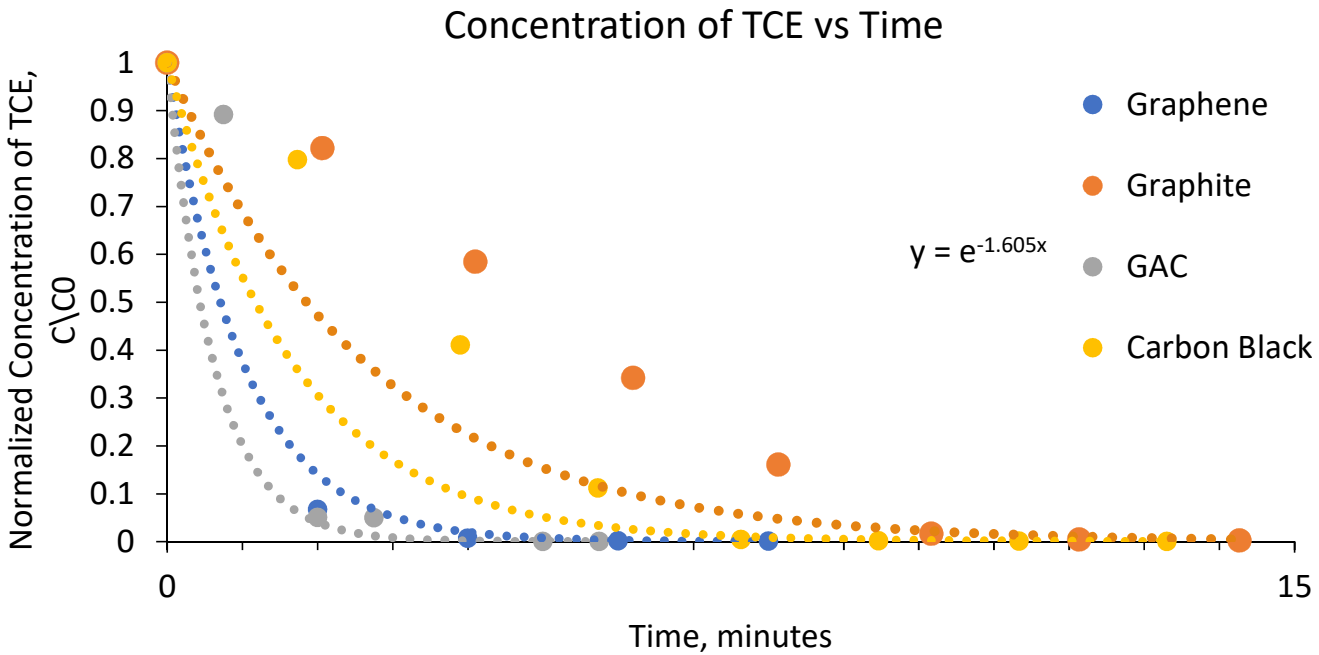
Solvothermal

- Carbon support is added to the sonicated solution
- Solution is put in autoclave for 24 hours at room temperature



TEM Analysis of Pd/Au Nanoparticles on Graphene

Rate of Reaction



- GAC has a reaction rate almost double that of graphene
- High GAC and graphene rates likely due to high surface area

- K Values
  - GAC: 0.027
  - Graphene: 0.016
  - Carbon Black: 0.01
  - Graphite: 0.006

Conclusion

Current Solutions

- Granular Activated Carbon
  - Saturates quickly
  - Does not destroy TCE
- Air Stripping
  - Requires use of GAC
  - Not 100% effective
  - Does not destroy TCE

Our Solution

- Pd/Au Carbon Supported Catalyst
  - Synergistic effect between catalyst and carbon supports
  - Quick reaction time
  - Reduces TCE down to ethane

Summary of Results

Nanoparticles

Size
- Pd: 2-3 nm
- Au: 10-15 nm

Morphology
- Irregular shape
- Crystal structure
- Pd aggregate shell around Au center

Carbon Supports

GAC
- High surface area
- Able to adsorb
- K: 0.027

Graphene
- High surface area
- Flat plane
- No adsorption abilities
- K: 0.016

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References

[1] H. H. Russell, J. E. Matthews, G. W. Sewell, R. S. Kerr Environmental, and W. W. Kovalick, “Ground Water Issue EPA TCE Removal from Contaminated Soil and Ground Water Superfund Technology Support Center for Ground Water,” 1992.

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[3] M. S. Wong, M. O. Nutt, K. N. Kowalski, and J. B. Hughes, “Designing Pd-on-Au bimetallic nanoparticle catalysts for trichloroethene hydrodechlorination,” *AIChE Annu. Meet. Conf. Proc.*, vol. 39, no. 5, p. 9795, 2005.

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