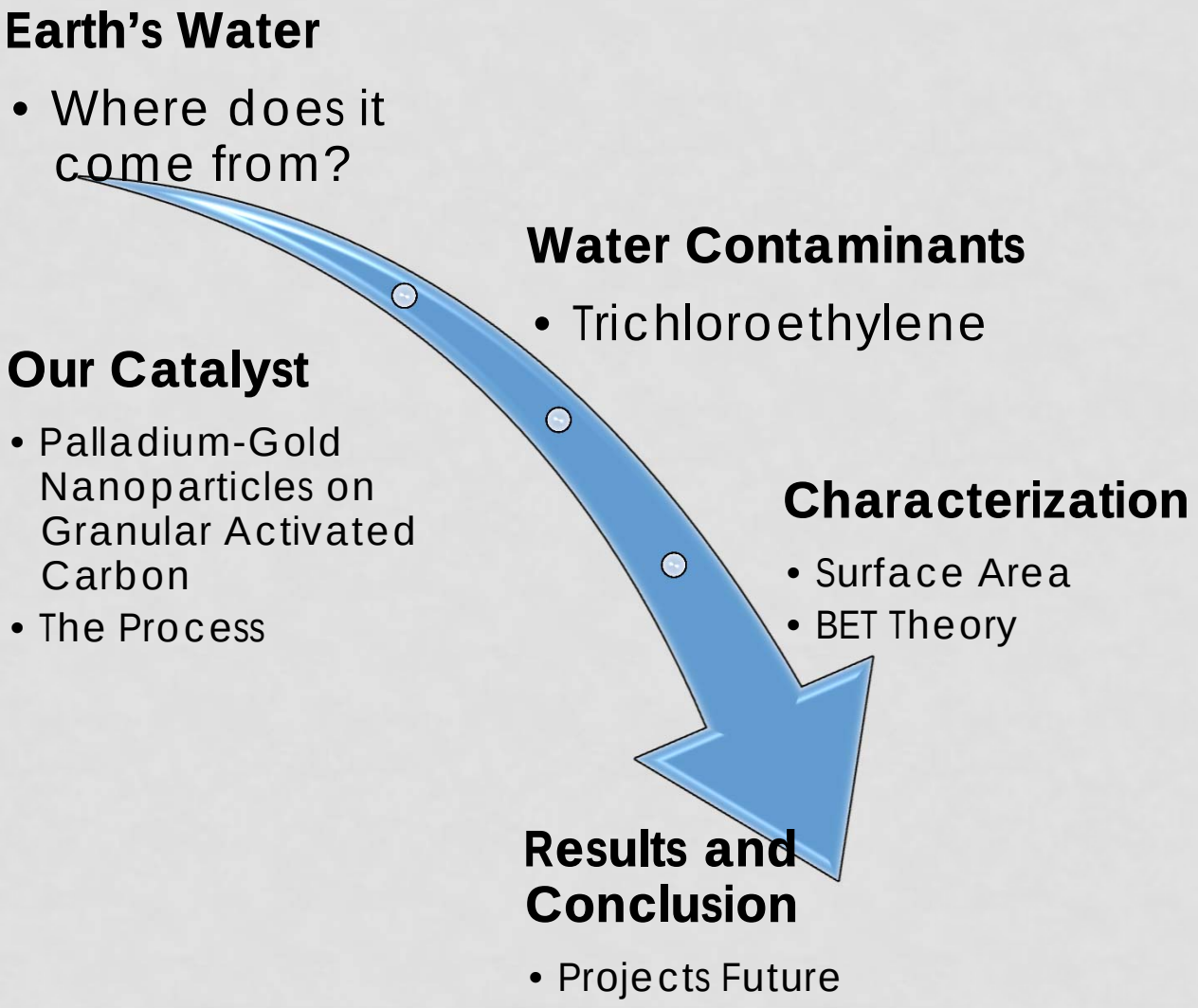
WATER TREATMENT USING PALLADIUM-GOLD NANOPARTICLES ON GRANULAR ACTIVATED CARBON: THE CATALYTIC EFFECTS OF SURFACE AREA USING BET THEORY

Dr. Jun Jiao (P.I.)
Kavita Meduri (Mentor)
August 12, 2016
REU-Portland State University

LEXI CROWELL
WORCESTER POLYTECHNIC INSTITUTE

PRESENTATION MAP



WHAT I DID OVER 7 WEEKS…

The purpose of our research is to find the most effective catalyst that will decrease the amount of Trichloroethylene in water over a specified amount of time.

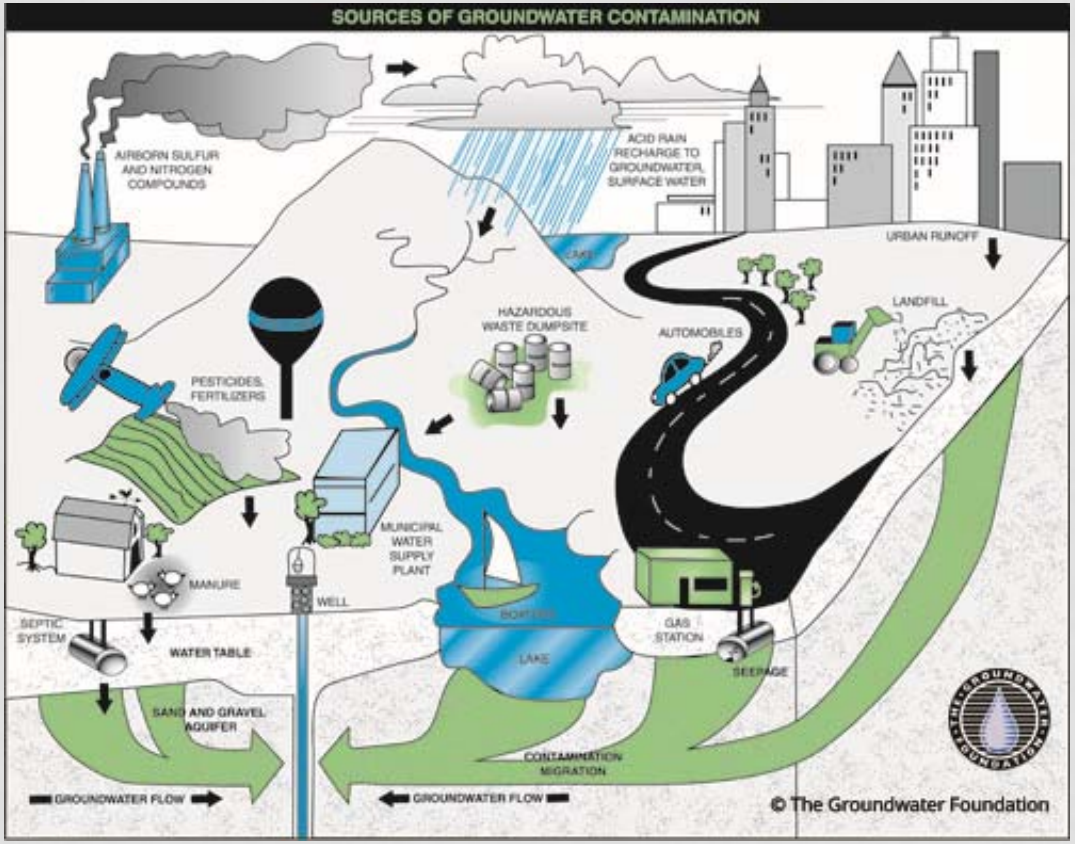
My research over the past 7 weeks has been to investigate the characteristics of our catalyst, in which I focused on a method called BET Theory.

Earths Water

71% of the Earth is made of water	There is only 2.5% of freshwater on Earth	30.1% of freshwater comes from the ground	Over 50% of the U.S. relies on groundwater for drinking water

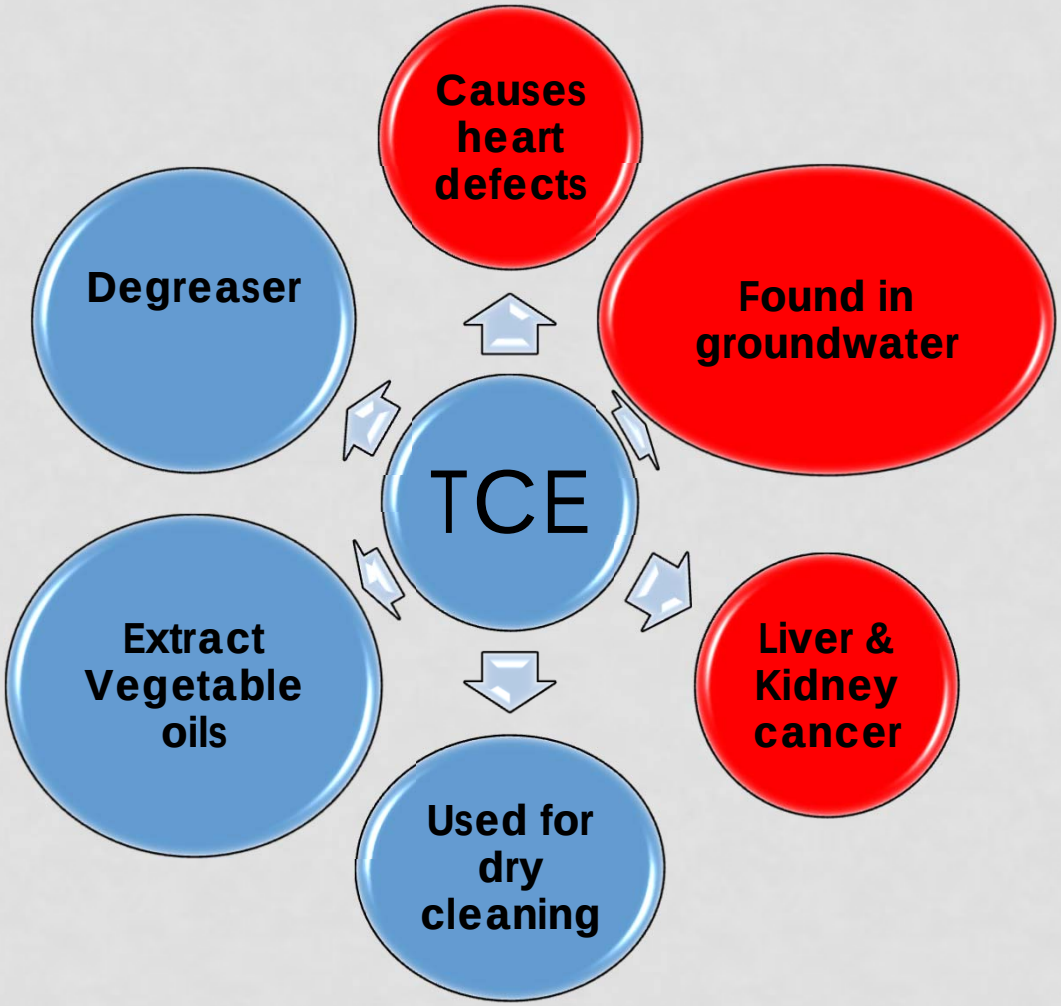
GROUNDWATER CONTAMINANTS

- Ground water contamination occurs when man-made products get into the groundwater and cause the water to become toxic
- Drinking contaminated groundwater can have serious health effects such as cancer and hepatitis

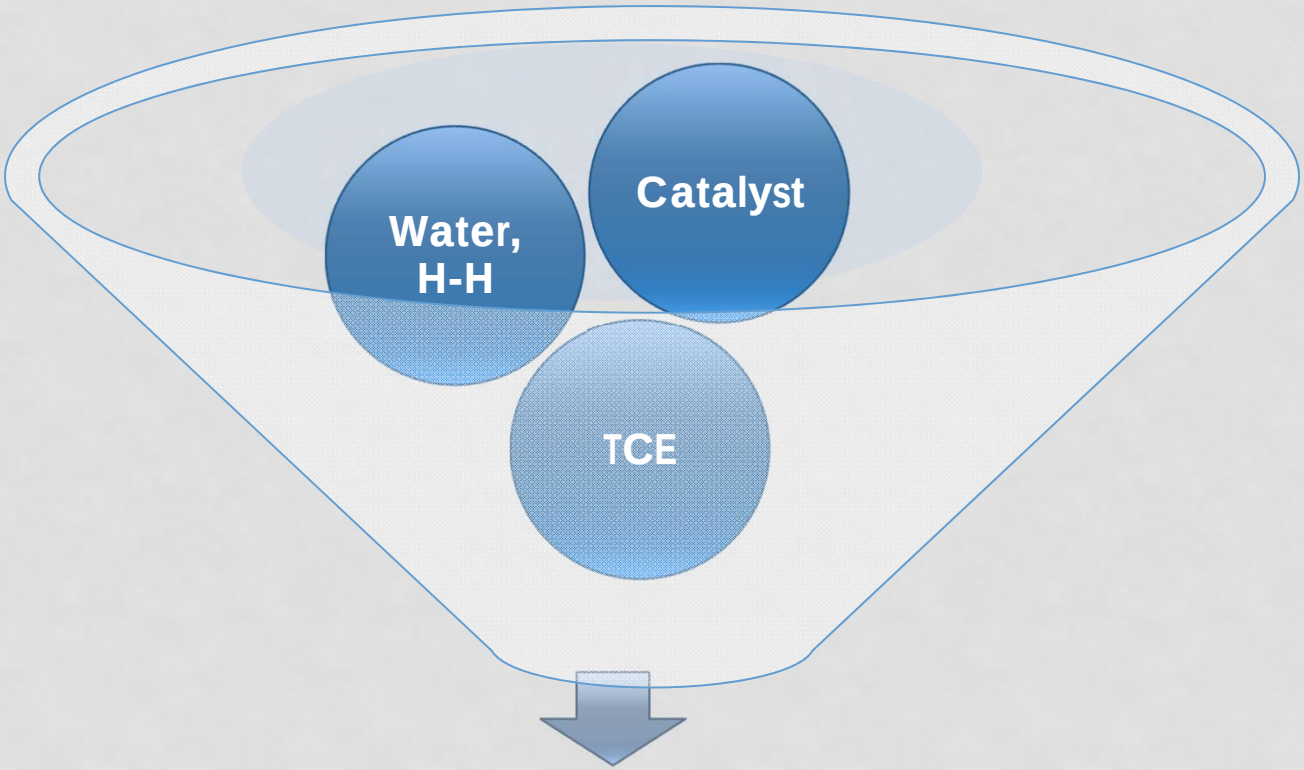


Source: http://cdn.firespring.com/images/af24b3fc-c41e-435f-b0e4-0b2dba3e8ffa.jpg

TRICHLOROETHYLENE (TCE)

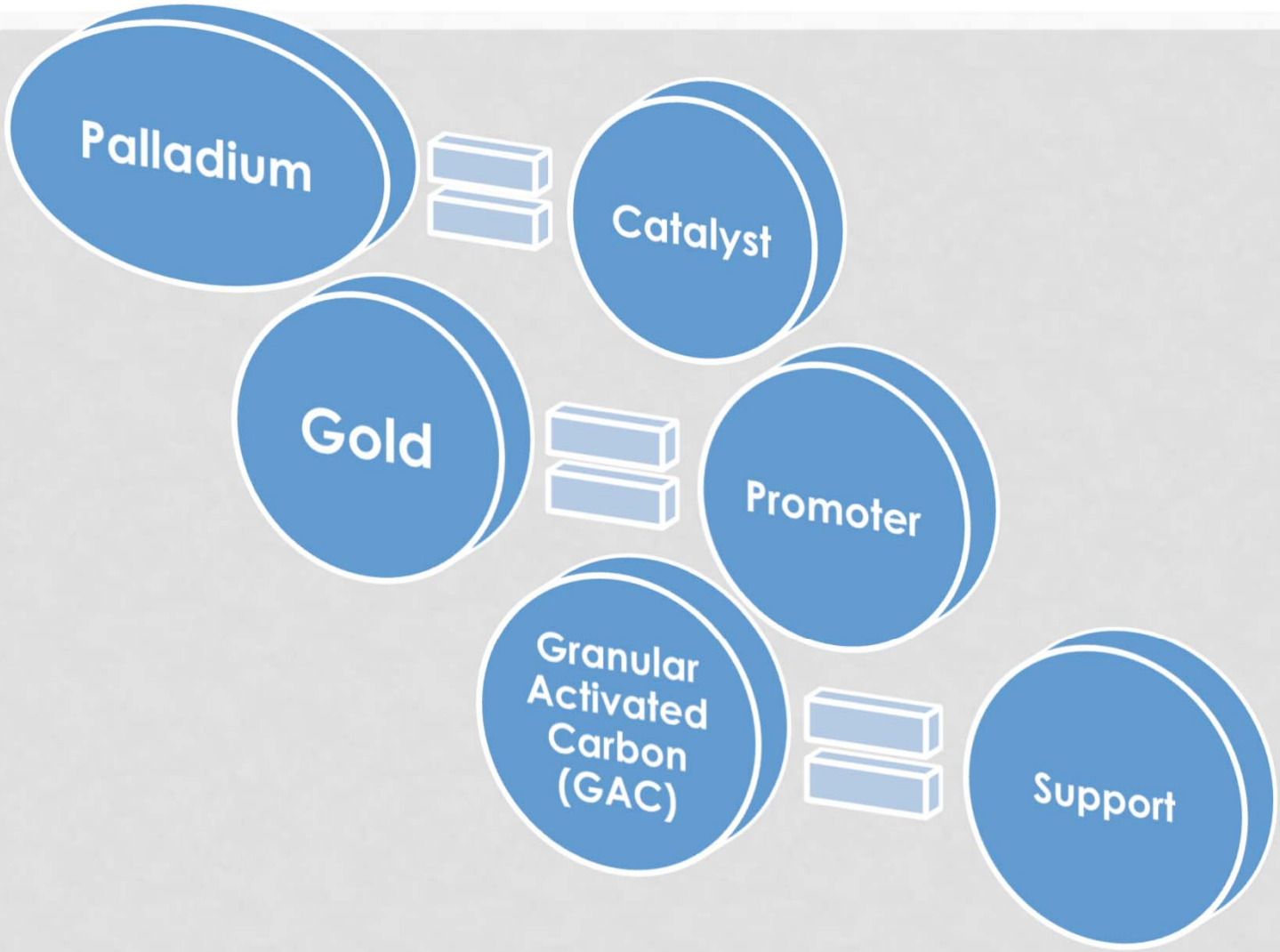


HOW TO REMEDIATE GROUNDWATER

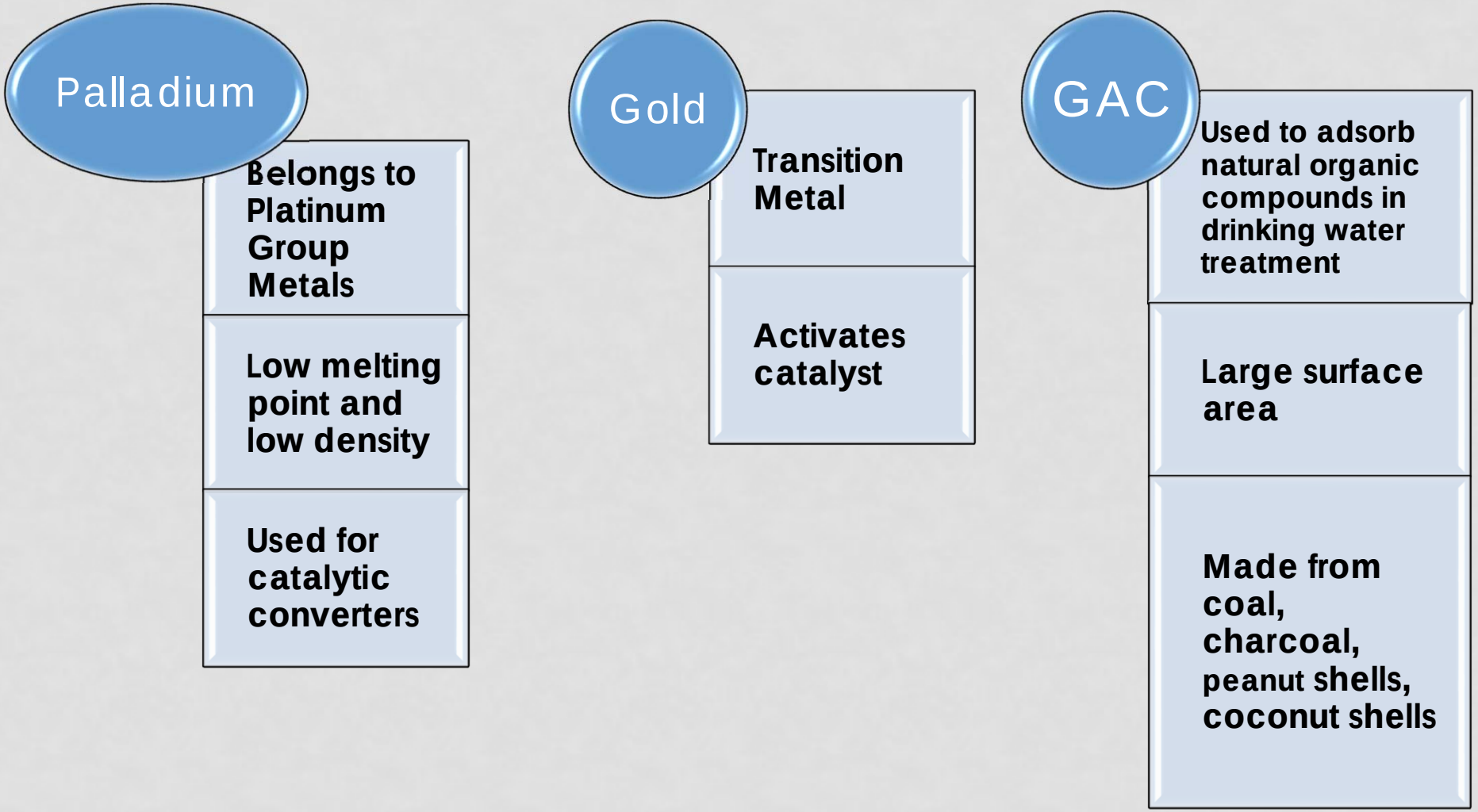


Decrease Amount of TCE

WHY OUR CATALYST IS EFFECTIVE

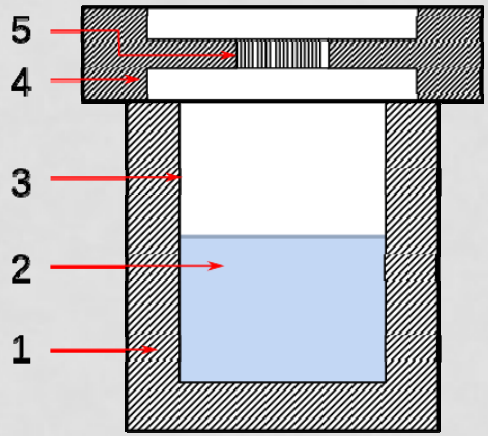


CHARACTERISTICS OF PRECURSORS



THE PROCESS

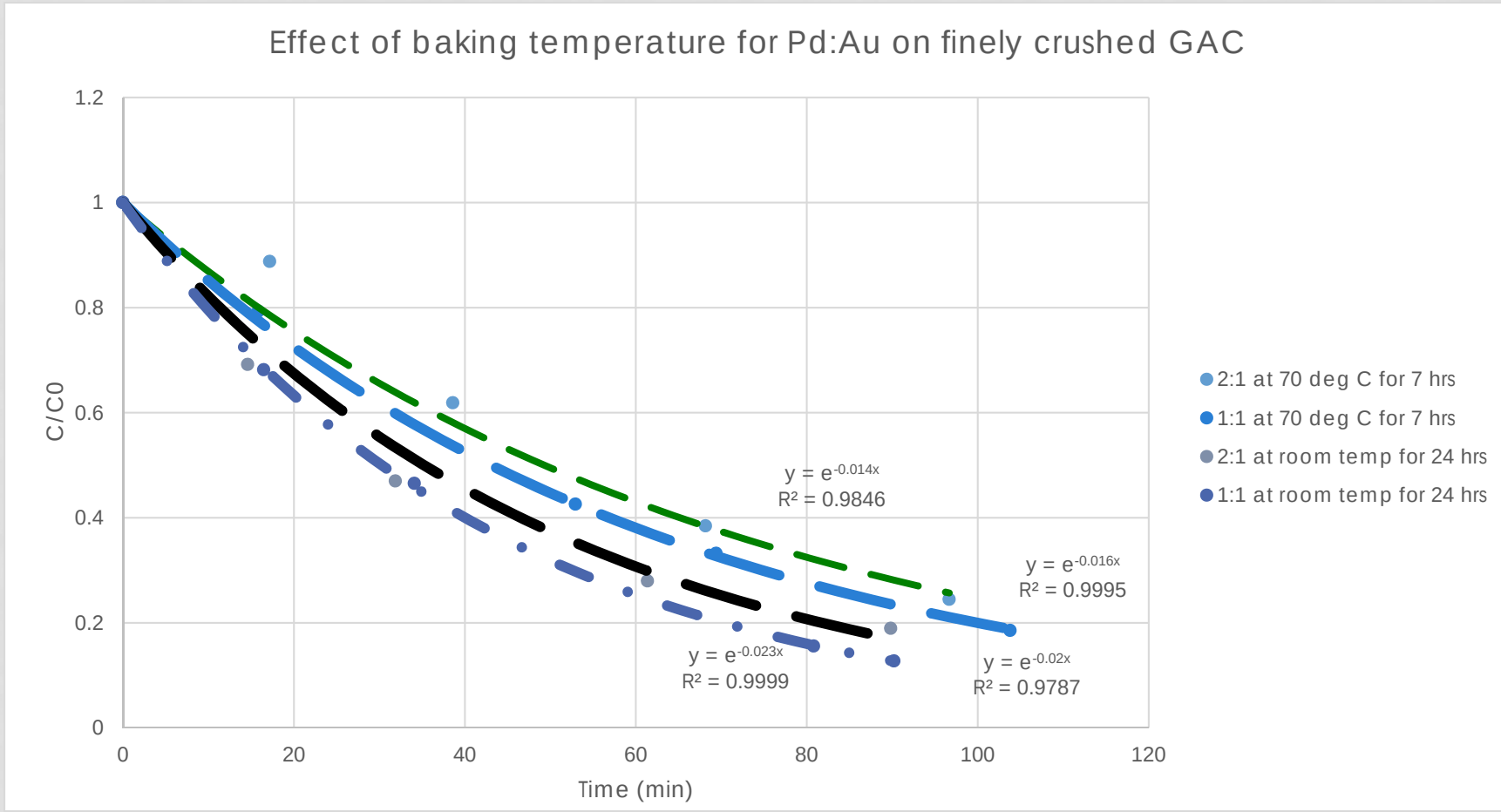
- Solvothermal Method: A transformation of precursors in the presence of a solvent under moderate to high pressure and temperature



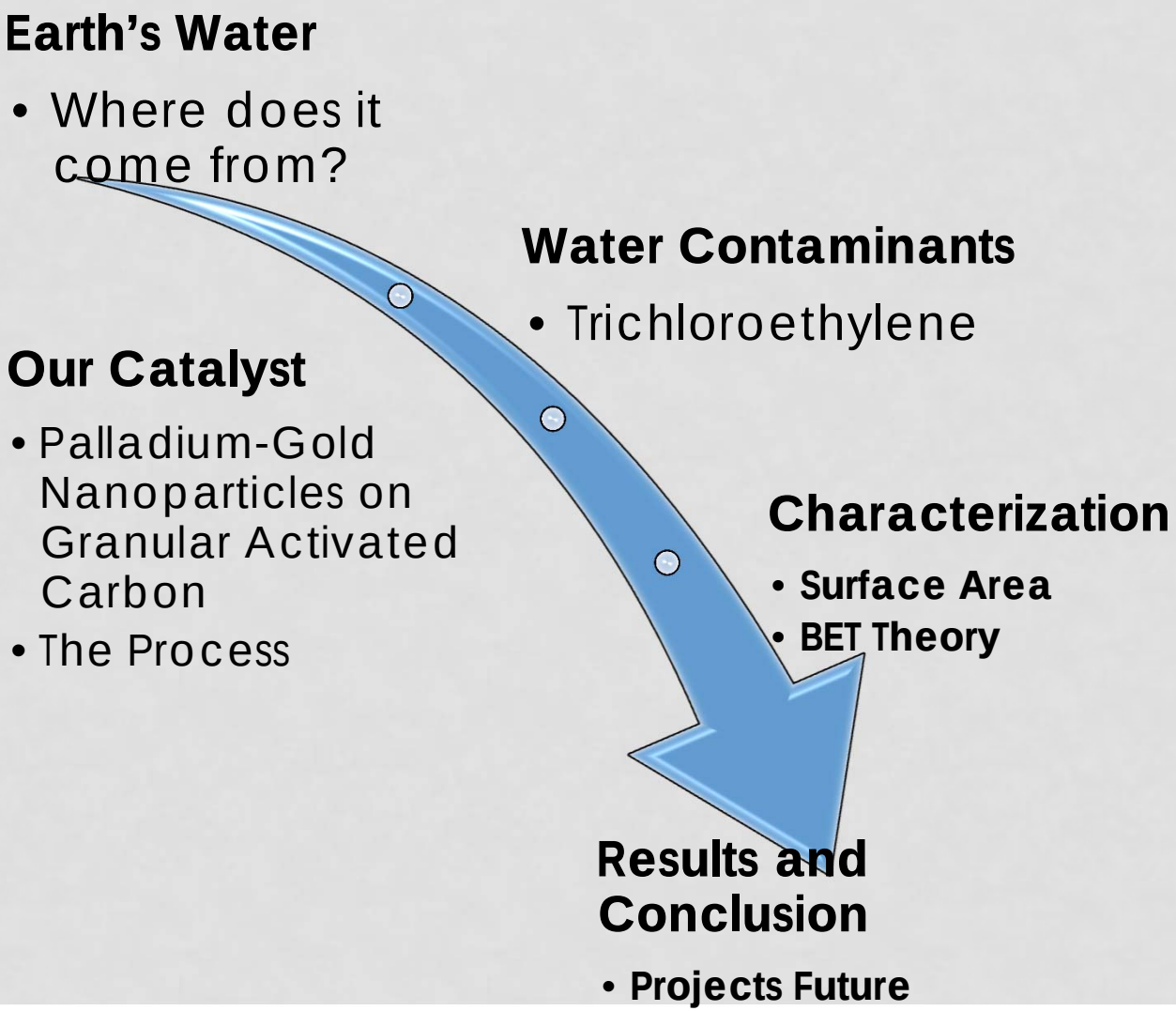
http://adsabs.harvard.edu/abs/2007JMatS..42.6583X

1. stainless steel autoclave
2. Solution
3. Teflon liner
4. stainless steel lid
5. Spring

RESULTS


Effect of baking temperature for Pd:Au on finely crushed GAC
C/C0
Time (min)
1.2
1
0.8
0.6
0.4
0.2
0
0
20
40
60
80
100
120
y = e-0.014x
R² = 0.9846
y = e-0.016x
R² = 0.9995
y = e-0.023x
R² = 0.9999
y = e-0.02x
R² = 0.9787
2:1 at 70 deg C for 7 hrs
1:1 at 70 deg C for 7 hrs
2:1 at room temp for 24 hrs
1:1 at room temp for 24 hrs

PRESENTATION MAP

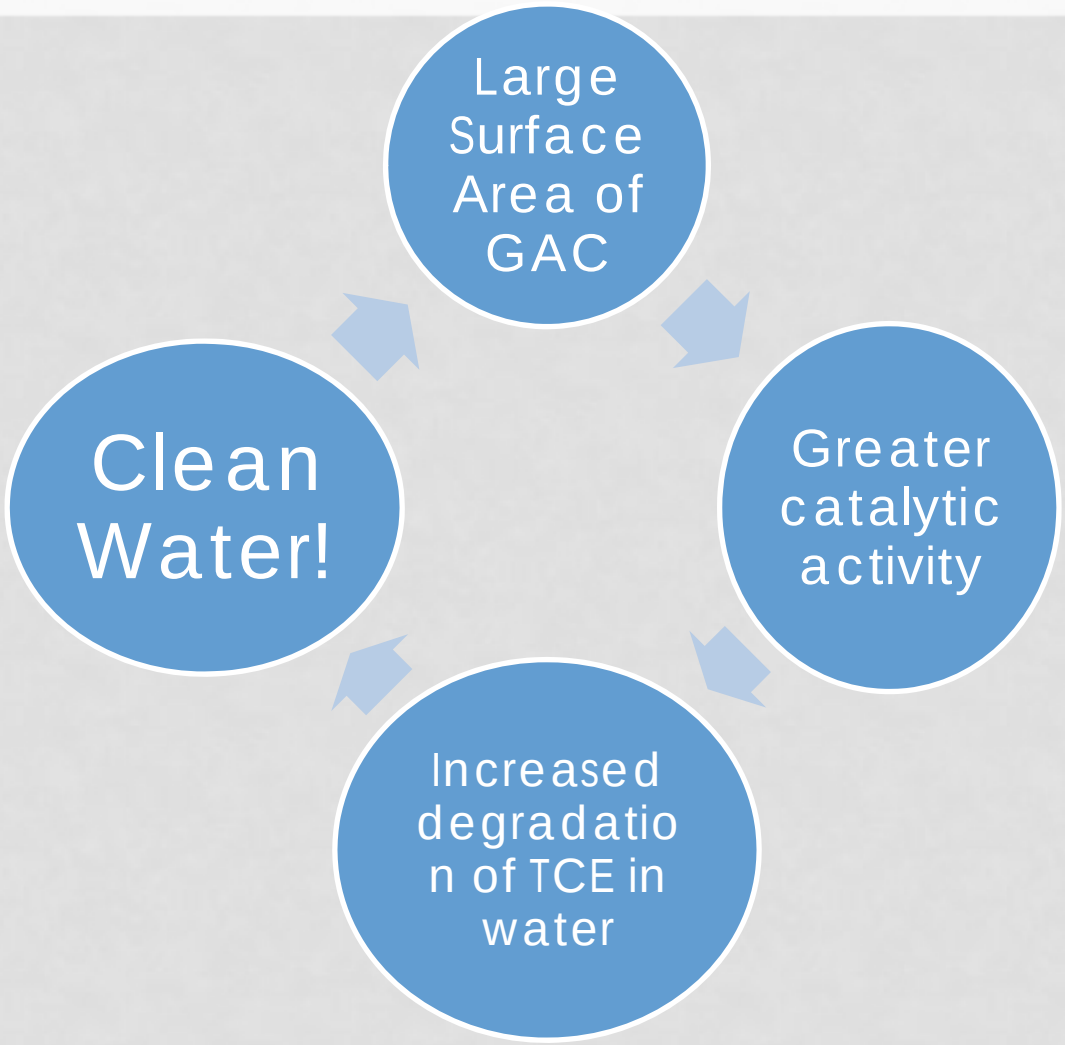


WHY IS SURFACE AREA IMPORTANT?

The surface area of the Granular Activated Carbon (GAC) is extremely large

This indicates that there is more reaction area for the catalyst

RESEARCH PURPOSE

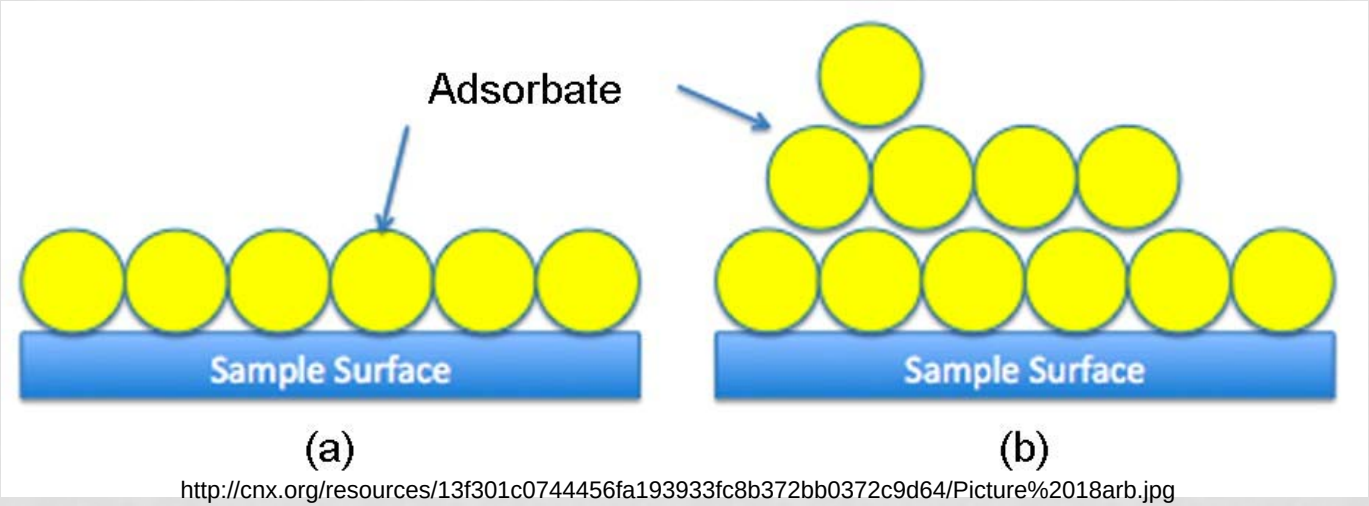


BRUNAUER-EMMETT-TELLER

- Brunauer-Emmett-Teller Theory was developed in 1938 by 3 physicists
- The theory explains the physical adsorption of gas molecules

BET THEORY

The theory aims to explain the physical adsorption of gas molecules on a solid surface and serves as the basis for an important analysis technique for the measurement of the specific surface area of a material



http://cnx.org/resources/13f301c0744456fa193933fc8b372bb0372c9d64/Picture%2018arb.jpg

IMPORTANT FACTORS

- BET Equation
- Pressure
- Adsorbate
- The 5 assumptions made when using theory

$$\frac{1}{\left[V_a\left(\frac{P_0}{P}-1\right)\right]} = \frac{C-1}{V_m C} \times \frac{P}{P_0} + \frac{1}{V_m C}$$

5 ASSUMPTIONS MADE

Adsorptions only occur on well defined sites

A molecule can act as a single adsorption site for a molecule of the upper layer

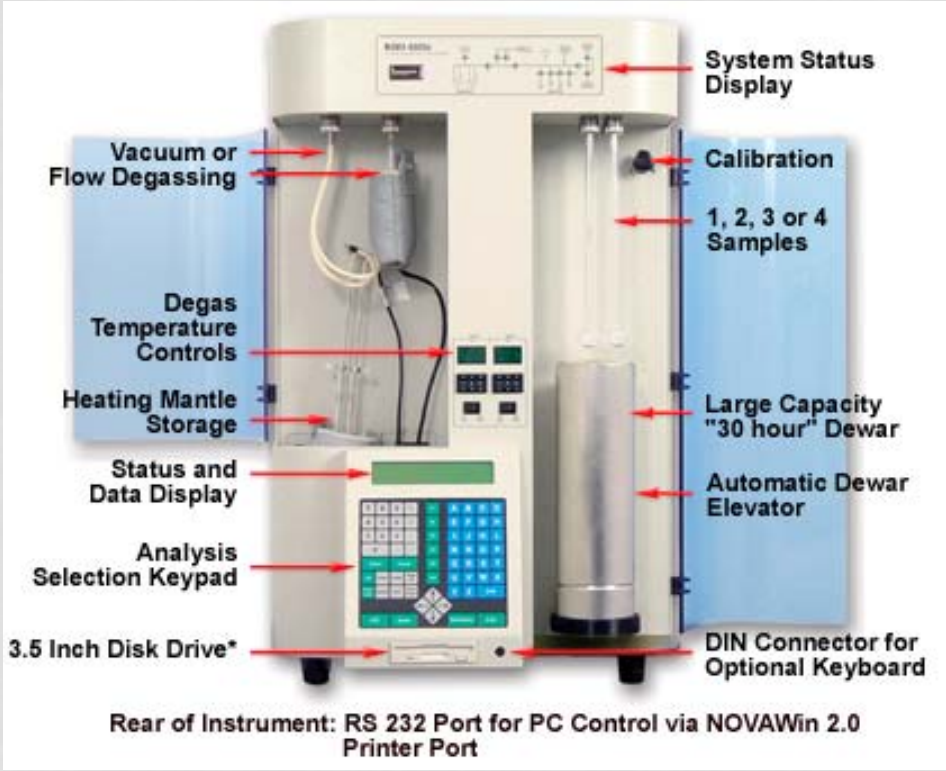
The desorption is a kinetically limited process

The uppermost molecule layer is in equilibrium with the gas layer

At saturation pressure, the molecule number tends to infinity

QUANTACHROME NOVA 2200E SERIES

- Analyzes pore size and surface area
- Affordable
- Small and compact
- Can use any gas as adsorbate
- Calculates BET and Langmuir surface area



http://www.giangarloscientific.com/graphics/quantachrome/Nova-e-Series.jpg

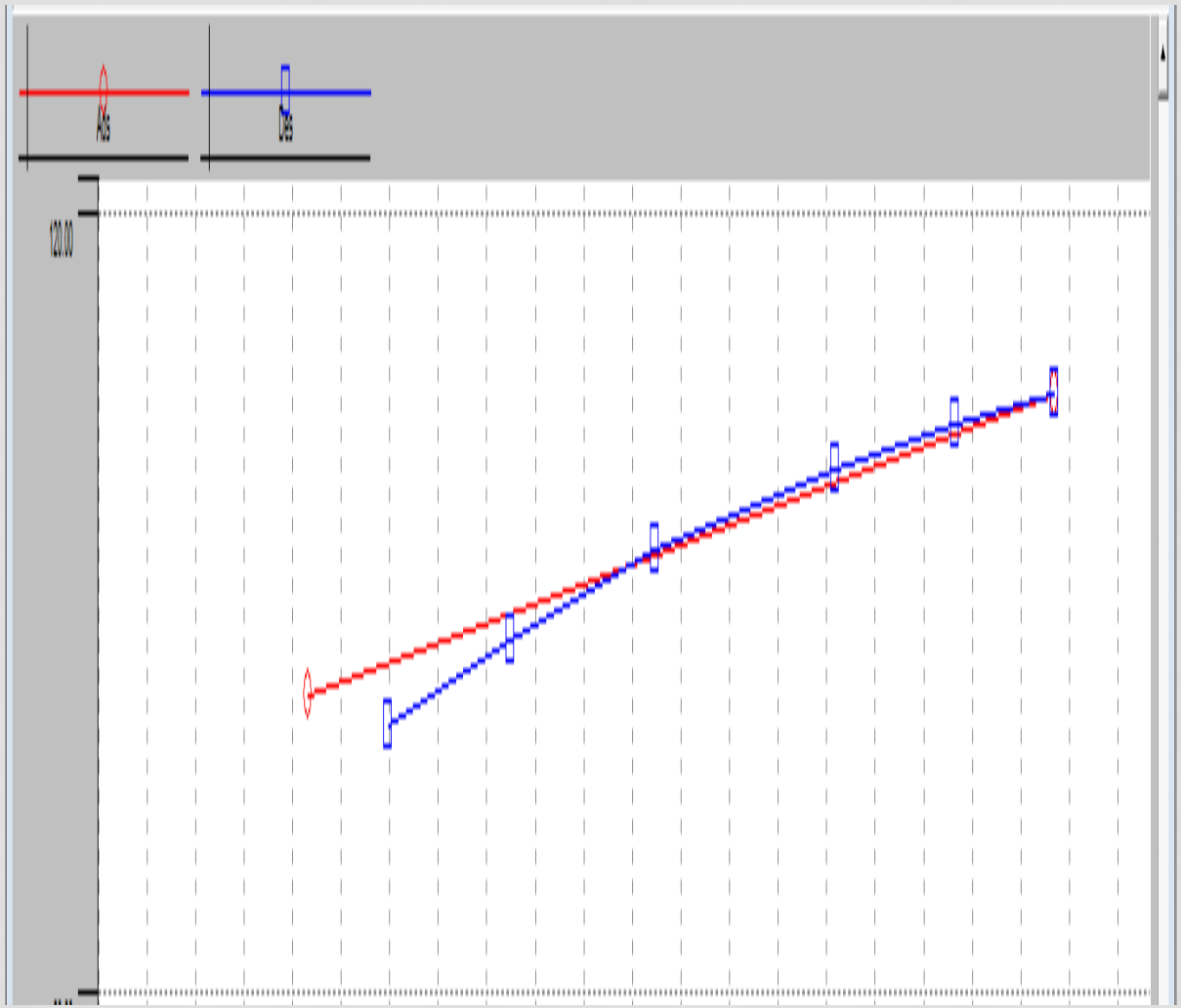
SURFACE AREA RESULTS

Parameters

- Pressure
- Mass of GAC
- Operating time

Results

- Surface Area: 459.989 m^2/g



PROJECT FUTURE

- Continue measuring surface area of catalyst using BET Method
- Characterization using SEM and TEM
- Other synthesis techniques

WORKS CITED

1. Carole, W.; Colacot, T. Understanding Palladium Acetate from a User Perspective. Chemistry: A European Journal Mini review, [Online], April 29, 2016. http://onlinelibrary.wiley.com.ezproxy.wpi.edu/doi/10.1002/chem.201601450/epdf (accessed July 20, 2016).

2. Tsuji, Y.; Fujihara, T. Homogeneous Nanosize Palladium Catalysts. Inorganic Chemistry Article, [Online], September 29, 2006. http://pubs.acs.org.ezproxy.wpi.edu/doi/pdf/10.1021/ic061872q (accessed July 20, 2016).

3. Vile, G.; Albani, D. A Stable Single-Site Palladium Catalyst for Hydrogenations. Angewandte Chemie, [Online], July 31, 2015.http://onlinelibrary.wiley.com.ezproxy.wpi.edu/doi/10.1002/anie.201505073/epdf (accessed July 20, 2016).

4. Pagliaro, M.; Pandarus, V. Heterogeneous versus Homogeneous Palladium Catalysts for Cross-Coupling Reactions. ChemPubSoc Europe, [Online], July 27, 2012. http://onlinelibrary.wiley.com.ezproxy.wpi.edu/doi/10.1002/cctc.201100422/full (accessed July 20, 2016).

5. Toebes, M.; van Dillen, J.; de Jong, K. Synthesis of supported palladium catalysts. Journal of Molecular Catalysis, [Online] 2001, 173, 75-98.

6. Bonarowksa, M.; Kaszkur, Z.; Lomot, D.; Rawski, M.; Karpinski, Z. Effect of gold on catalytic behavior of palladium catalysts in hydrodechlorination of tetrachloromethane. Applied Catalysis B: Environmental, [Online] 2015, 162, 45-56.

7. Baeza, J.; Calvo, L.; Gilarranz, M.; Mohedano, A.; Casas, J.; Rodriguez, J. Catalytic behavior of size controlled palladium nanoparticles in the hydrodechlorination of 4-chlorophenol in aqueous phase. Journal of Catalysis, [Online] 2012, 293, 85-93.

8. Stakheev, A.; Mashkovskii, I.; Baeva, G.; Telegina, N. Specific features of the catalytic behavior of supported palladium nanoparticles in heterogeneous catalytic reactions. Russian Journal of General Chemistry, [Online], May 7, 2010. http://au4sb9ax7m.search.serialssolutions.com/ (accessed July 20, 2016).

9. Matsumoto, H. Catalytic Behavior of Palladium-Zeolite in Oxidation of Methane to Carbon Monoxide and Hydrogen. Journal of Physical Chemistry, [Online] 1994, 98, 5180-5182.

10. Silva, A.; Robles-Dutenhefner, P.; Dias, A.; Fajardo, H.; Lovon, A.; Lovon-Quintana, J.; Valenca, G. Gold, palladium and gold-palladium supported on silica catalysts prepared by sol-gel method: synthesis, characterization and catalytic behavior in the ethanol steam reforming. Journal of Sol-Gel Science and Technology, [Online] 2013, 67, 273-281.

11. Tesfamichael, A.; Suggs, K.; Felfli, Z.; Wang, X.; Msezane, A. Atomic gold and palladium negative ion-catalysis of water to peroxide: fundamental mechanism. Journal of Nanoparticle Research, [Online] 2013, 15.

12. Pura, J.; Kwasniak, P.; Jakubowska, D. Investigation of degradation mechanism of palladium-nickel wires during oxidation of ammonia. Catalysis Today, [Online] 2013, 208, 48-55.

13. Liu, R.; Crozier, P.; Smith, C.; Hucul, D.; Blackson, J.; Salaita, G. Metal sintering mechanisms and generation of palladium/alumina hydrogenation catalysts. Applied Catalysis A: General, [Online] 2005, 282, 11-121.

14. Mitchell, M.; Vannice, M. Adsorption and Catalytic Behavior of Palladium Dispersed on Rare Earth Oxides. Industrial Engineers Chemical Fundamentals, [Online] 1984, 23, 88-96.

ACKNOWLEDGEMENTS

Au-Pd on GAC Research Group

- Dr. Jun Jiao
- Kavita Meduri

REU Program

- Dr. Jun Jiao
- Dr. Erik Sanchez
- Audrey Siefert

WATER TREATMENT USING PALLADIUM-GOLD NANOPARTICLES ON GRANULAR ACTIVATED CARBON: THE CATALYTIC EFFECTS OF SURFACE AREA USING BET THEORY

Dr. Jun Jiao (P.I.)
Kavita Meduri (Mentor)
August 12, 2016
REU-Portland State University

LEXI CROWELL
WORCESTER POLYTECHNIC INSTITUTE