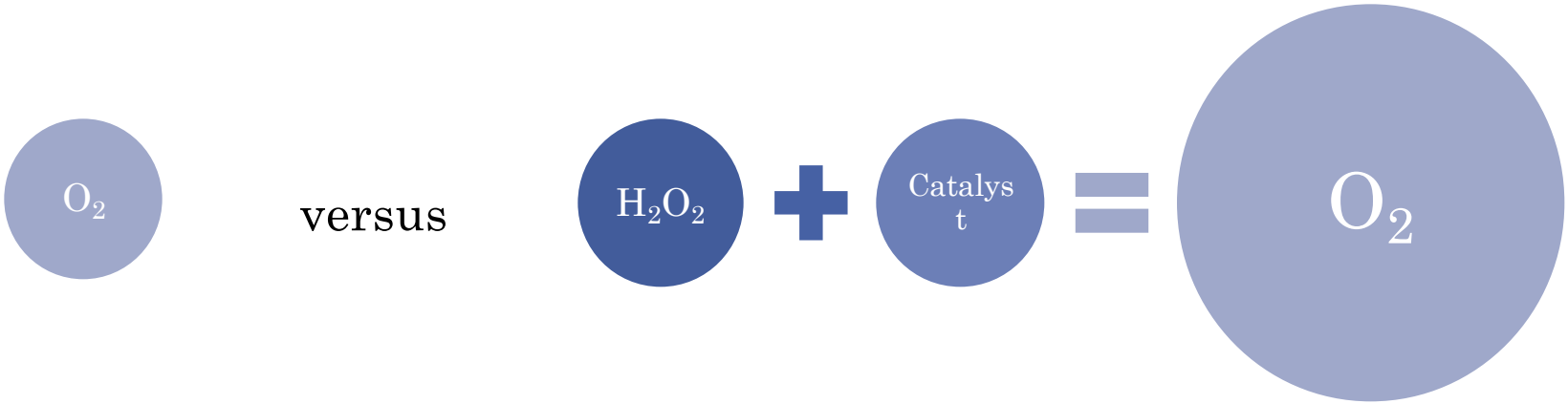
H_2O_2 Decomposition Catalyst

Presentation of Past Research

November 18, 2016

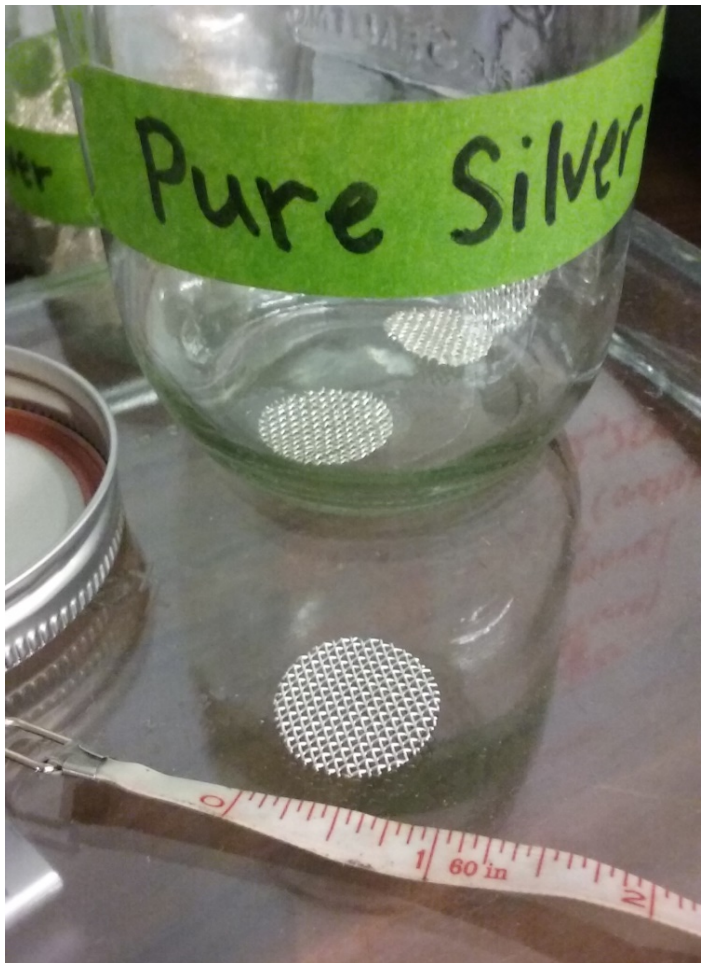
Why Do We Need to Decompose H_2O_2?

- H_2O_2 decomposition yields oxygen (and water, but we don't need that)
- Use ^ oxygen as hybrid motor oxidizer
- Why not just use regular GOX?
  - H_2O_2 is more volumetrically efficient



How Can We Force Decomposition?

- H_2O_2 spontaneously decomposes naturally, but too slowly for our purpose
- Catalysts speed up decomposition
- Different materials work
  - Silver
  - Platinum
  - Palladium
  - And more!

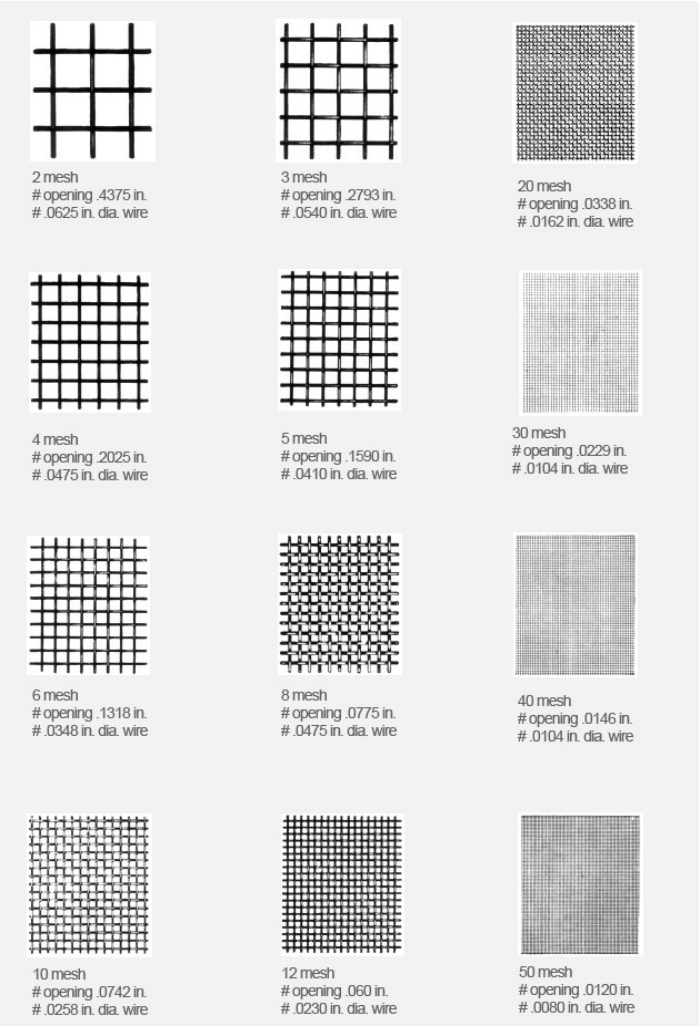


Variables for a "Good" Catalyst

- Catalyst shape and size
- Catalyst base material
- Activation method
- Bed packing pattern
- Bed packing process

Bottom line: finding a good recipe is an art form

Sizing



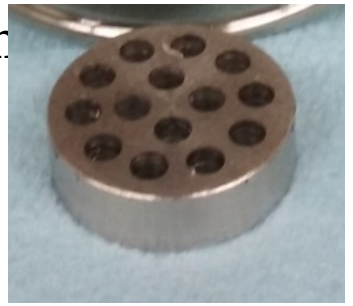
- Wire mesh provides large surface area for decomposition reaction
  - Some sources suggest varying the mesh size along catbed length
- Catbed diameter
  - $D = \sqrt{\frac{4*\dot{m}}{\pi*P_{LF}}}$
  - P_{LF} is the liquid feed load
    - Typically = 0.014 kg/(min*mm^2)

Silver Catalyst

- Tried and true
- Usually activated with some treatment
  - Goal is to increase surface area microscopically
- Typically treated with samarium nitrate
  - Between 2% and 10% solution
    - Runkel reports no discernable advantage from treatment concentrations above 2%
  - Hazardous to work with
- Other sources reported successes with nitric acid solution and heat treating
- Not much documentation on exact methods
  - How long to leave in solution?
  - To bake or not to bake? How long?

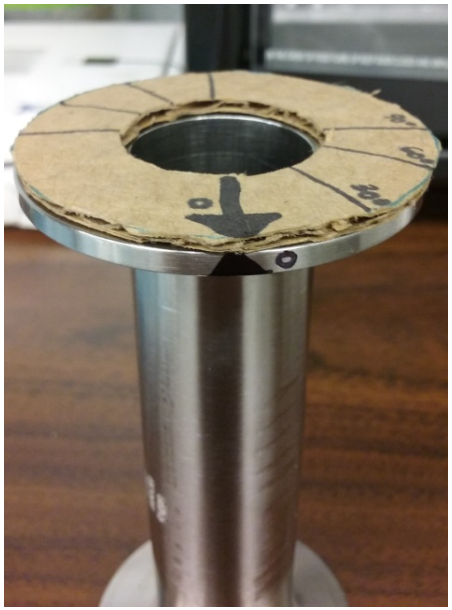
Bed Packing Pattern and Process

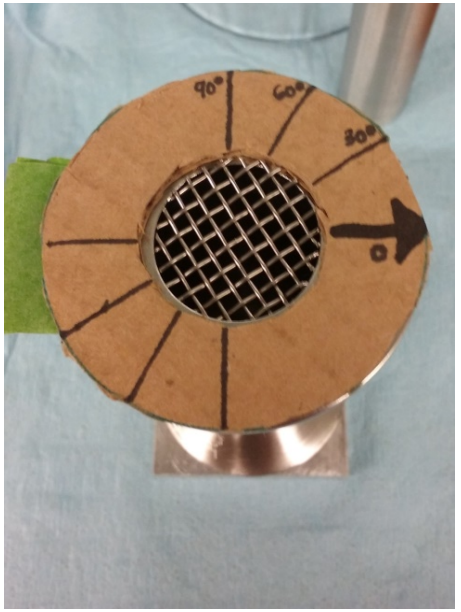
- Inert support structure
  - Pure silver can melt at high decomposition temperatures
  - Stainless steel or monel screens provide inert support
- Inlet/outlet distribution plates recommended
  - 1/8” or 4 mm holes adding to 25% to 33% of total catbed cross sectional area
- Anti-channel baffles recommended
  - Reduce possibility of liquid peroxide streaming along bed walls without passing over silver m



Bed Packing Pattern and Process

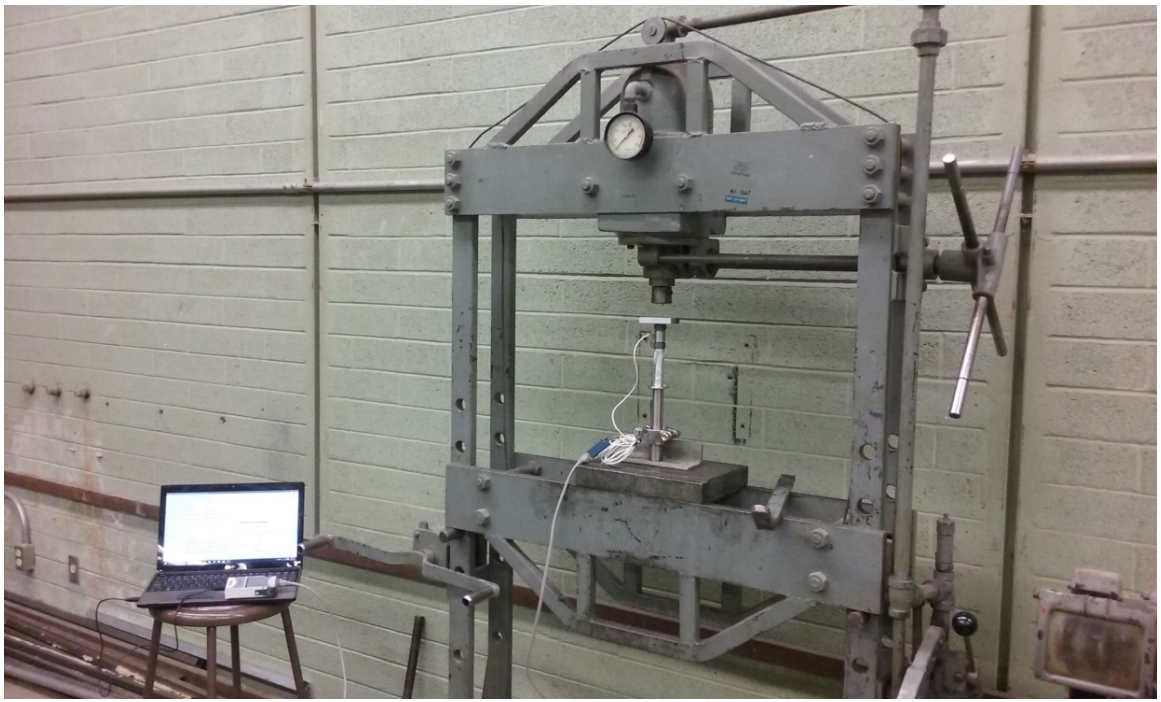
- Number and order of active catalyst and inert support requires trial and error
  - Runckel tested several configurations
- Rotating orientation of mesh during packing is recommended to reduce risk of channeling





Bed Packing Pattern and Process

- Compressing catalyst bed pack
  - Reduce risk of channeling → increase decomposition
  - Can use press in Terry's shop and calibrated load cell (VI in zip file at end)



Tested Configurations

- Runckel configuration 2

Bed	Length, in.	Screen arrangement	Number of screens		Motor	Packing pressure, psi
			Active	Total		
2	1.38	2 pieces 20 mesh, 0.014 stainless-steel screen 1 antichannel baffle 20 pieces 20 mesh, 0.014 silver screen, 10% $Sm(NO_3)_3$ 1 antichannel baffle 40 pieces 20 mesh, 0.014 silver screen 2 pieces 24 mesh, 0.014 monel screen 13 pieces 10 mesh, 0.025 monel screen	60	77	A	2,200

- Distribution plates with 14, 1.8” diameter holes
- Used nitric acid and heat treatment variations in place of samarium nitrate
  - 30% and 70% nitric solution
  - 5 and 60 seconds in solution bath
  - Rinsed and unrinsed
  - 15 and 45 minutes in 450 degree F heat treatment

Results

- Tested with 50% hydrogen peroxide from chem store
- Control test (pure, untreated silver)
- Sample 1
  - Soaked in 30% nitric acid solution for 60 seconds then heat treated at 450 degrees F for 15 minutes
- Very little variation in H_2O_2 decomposition between treatments
  - The control seemed to be the best…
- Unrinsed samples developed a powdery coating after heat treat
  - Un-decomposed H_2O_2 after testing was cloudy and contaminated with pieces of the powder – not good

Results

- Tested full configurations with temperature measurement
  - Again, no difference between control and treatments
- Tests in-line with Motor
  - Pure, untreated silver, otherwise Runckel config. 2
  - DID decompose some H_2O_2
  - Still some liquid water and/or decomposed H_2O_2 present

Suggestions

- Try samarium nitrate treatment
  - May need a safer laboratory setup

Effects of Exposure:

To the best of our knowledge the chemical, physical and toxicological properties of samarium nitrate have not been thoroughly investigated and reported.

Lanthanides can cause delayed blood clotting leading to hemorrhages. Exposure may also lead to sensitivity to heat, itching, increased awareness of odor and taste, and liver damage.

Small doses of nitrates may cause weakness, general depression, headache and mental impairment. Larger doses may cause dizziness, abdominal cramps, vomiting, bloody diarrhea, convulsions and collapse.

Backup Slides

More information!

References and Resources

- USU Interim Report (PDF) → 

  - General info about the project
- http://www.peroxidepropulsion.com/
  - General guide (also referenced as Bengtsson)
- https://catalog.hathitrust.org/Record/011449060
  - Runckel's study – the guide for the experimental work presented here
- http://www.tecaeromex.com/ingles/cata-i.htm
  - Catalyst materials
- Chan et al.
  - Describes catalyst activation using nitric acid (HNO3)

References and Resources

Black Hole of
Catalyst Info

Part Specifications & Ordering

- Silver mesh
  - 0.016” wire diameter
  - 20X20 mesh
  - $488.25/sqft (quoted on 2/4/2016)
  - Contact Belleville Wire Cloth: dan.steele@bwire.com
- Punched silver into 7/8” rounds using punch in aviation side of technology building