Biodiesel:
Basics, Benefits, and Brewing

Indiana Energy Conference

January 21, 2006

General Outline of Discussion

- Biodiesel 101
- Home Brewing Biodiesel in the Midwest
  - Cory Scanlan and Tim Richmond
    - Appleseed Reactor
  - Wabash Valley Biodiesel Project
    - Fuel Meister
  - The Rookie sets up a reactor!
- Closing and Q&A

What is Biodiesel?

- Fuel made from Veggie Oil
  - Virgin oils: soy, rape seed, sunflower, etc
  - Recycled Cooking Oil (WVO)
- Can also be made from animal fats
  - Beef tallow, fish oil, slaughter house waste
- ***Runs in any UNMODIFIED diesel engine!***

Origins of Diesel

- Dr. Rudolf Diesel – The Visionary
  - His engine experiments lead him to veggie-oil
  - 1900 World Exhibition – 100% Peanut Oil

" The use of vegetable oils for engines may seem insignificant today. But such oils may become, in course of time, as important as petroleum and the coal tar products of the present time." - Rudolf Diesel, 1912

Benefits of Biodiesel

- Small, local and decentralized way to fuel your vehicle
  - Silver BB, not a Silver Bullet
- More lubricating than petroleum diesel (PD)
  - Increased engine life
  - No need for sulfur additives
- Safe to handle and transport
  - As biodegradable as sugar and less toxic than salt
  - Flash point of 300°F compared to 125°F for PD
- That lovely “French fry” aroma

Emissions of Biodiesel When Compared to Petroleum Diesel

- Reduction of CO_2 emissions by 100%
- Reduction of SO_2 emissions by 100%
- Reduction of soot emissions by 40-60%
- Reduction of CO emissions by 10-50%
- Reduction of hydrocarbon emissions by 10-50%
- Reduction of carcinogenic polycylic aromatic hydrocarbons
  - Phenanthren by 97%
  - Benzofloroanthen by 56%
  - Benzapyren by 71%
- Increase or Reduction in nitrous oxide emissions by 5-10%
  - Depending on the age and type of engine

Commercial Use of Biodiesel Blends

- B5 (5% BD, 95% PD)
  - The BD replaces the use of sulfur as lubricating agent
  - All diesel in France is B5 to eliminate SO_2 emissions
- B20 (20% BD, 80% PD)
- And so on……B100 is 100% BD

- More companies are starting up to produce blended fuels for commercial use
  - Mean Green Biofuels Corp. – 30 million gal/yr near Ft.Wayne

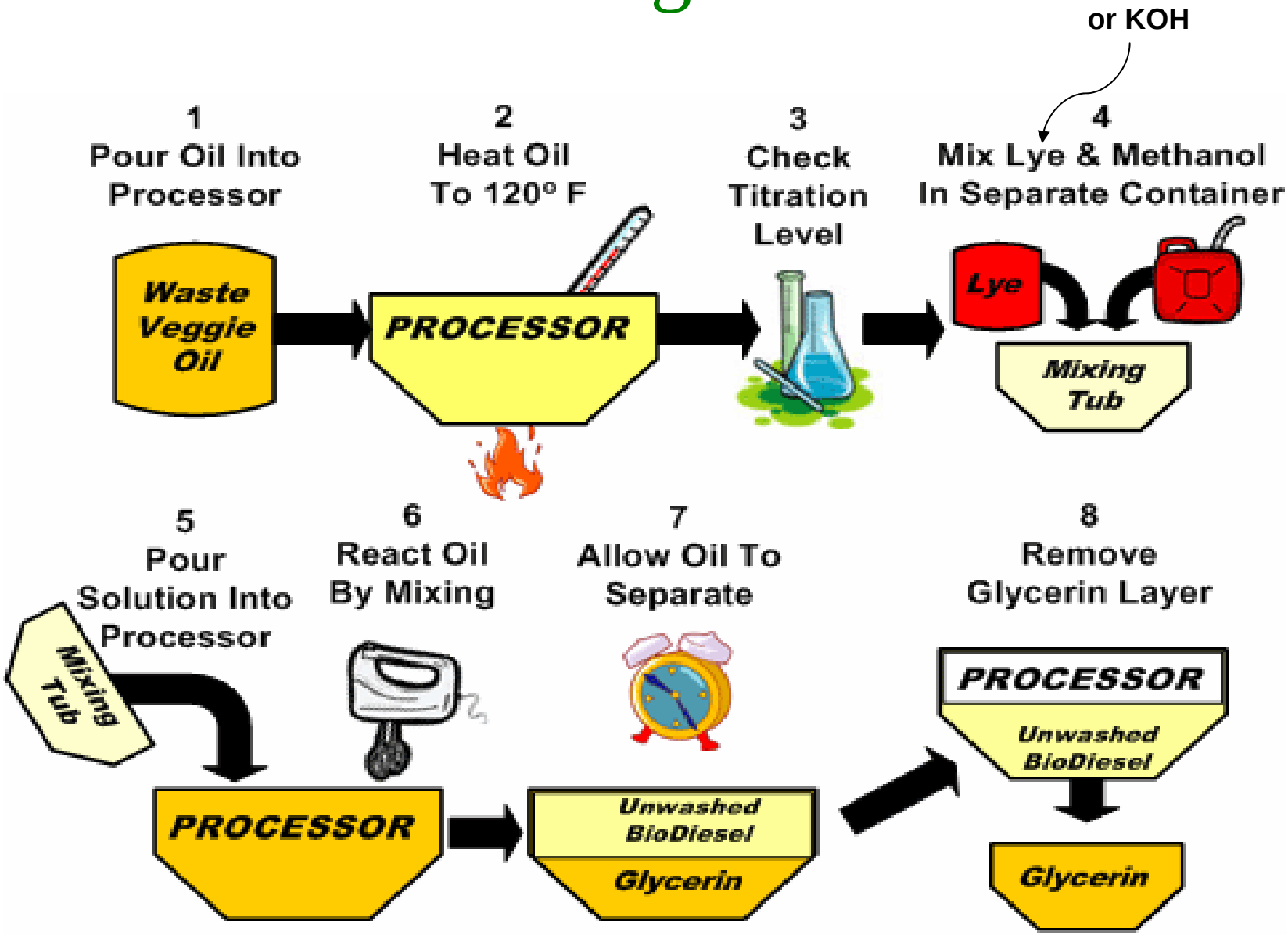
Home Brewing Biodiesel in the Midwest

Processing 101
Chemical Analysis
Titration
Our Appleseed Processor

Cory Scanlan and Tim Richmond

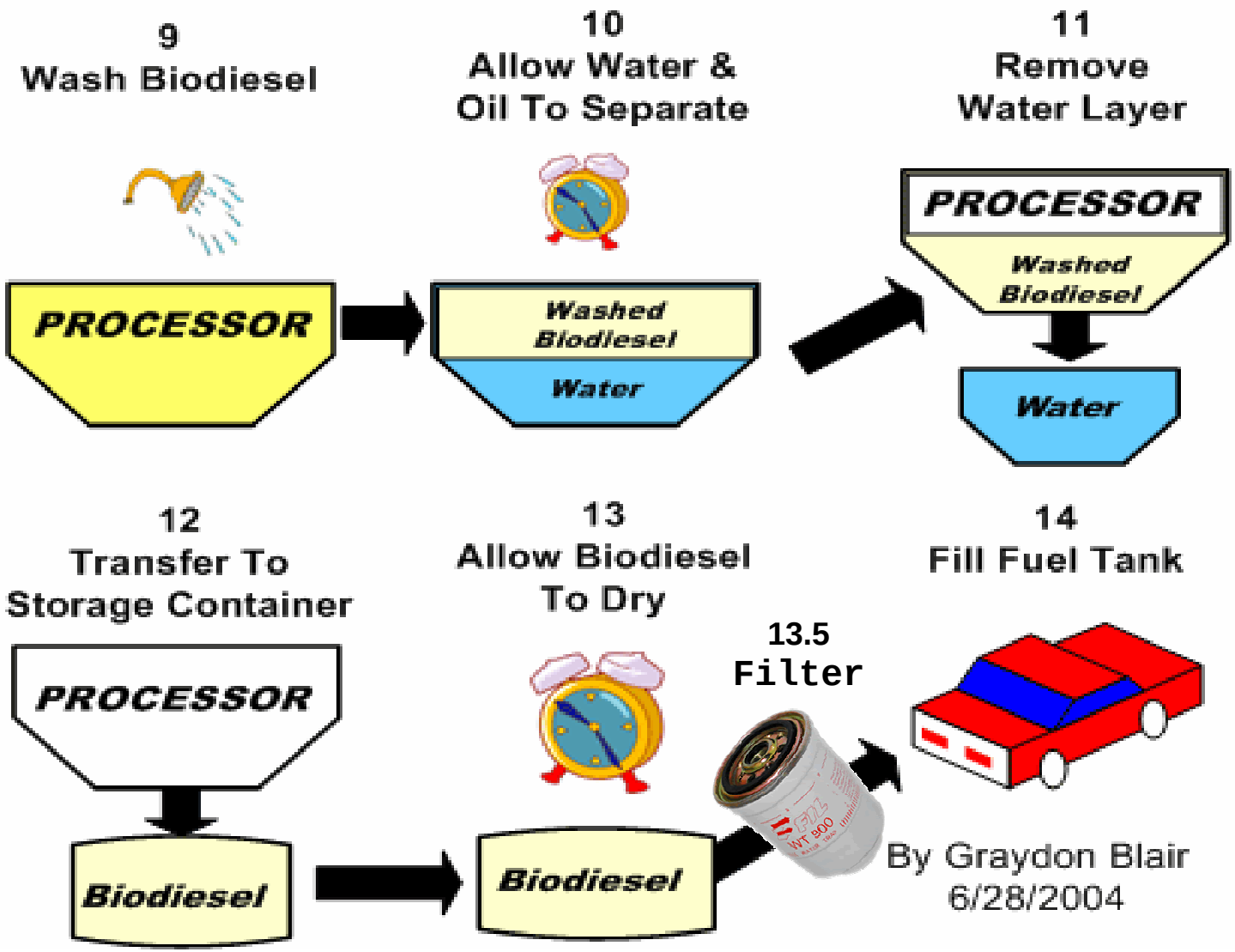
Champaign, IL

Processing Biodiesel



http://www.biodieselcommunity.org/howitsmade/

Washing Biodiesel



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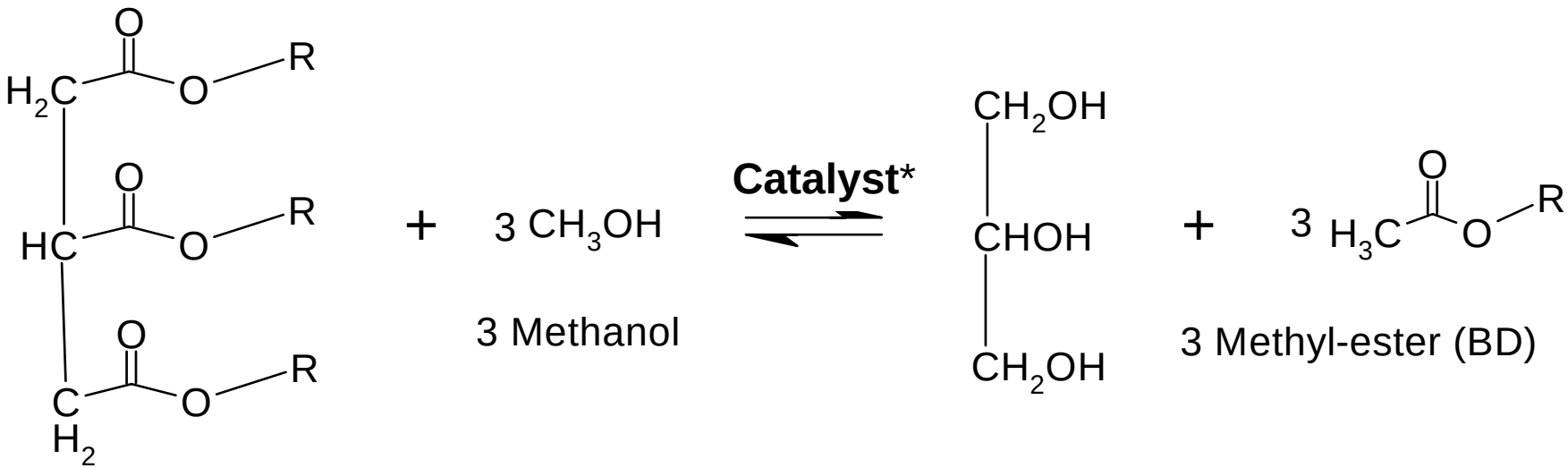
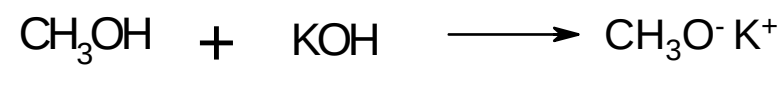
Chemistry of Biodiesel from WVO

- The process of turning a triglyceride (VO) into a methyl ester (BD) is known as a transesterification reaction.



R= —C—C—C—C—C—C—C—C—C—CH3 (H2 H2 H2 H2 H2 H2 H2 H2 H2)

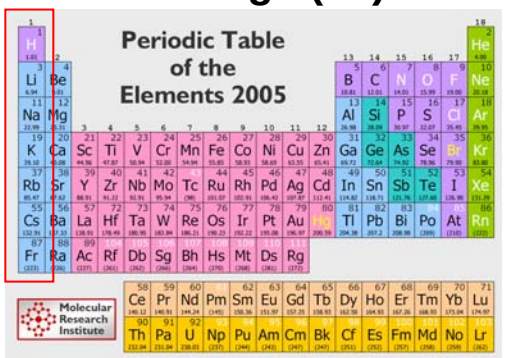


*Catalyst: NaOH or KOH?

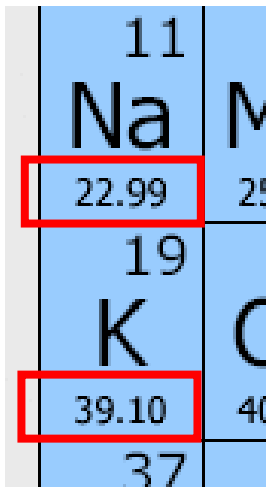
- **NaOH is also known as lye -** common soap making
  - The attractive forces of the Na^+ particles result in the extremely viscous nature of the resultant glycerin.

- **KOH reacts identically as NaOH**, but has a larger outer shell surrounding the positively charged nucleus.

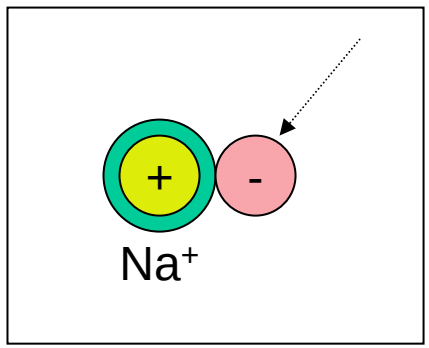
Same Charge (+1)

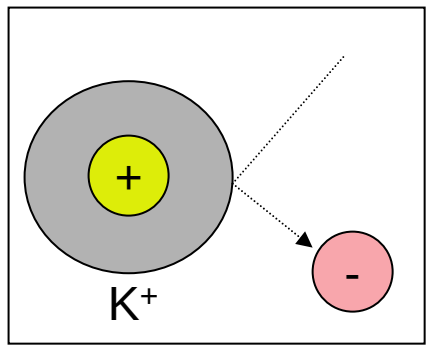


Different Masses



The larger outer shell of the K^+ ion gives it a weaker "pull" on negative ions than Na^+, allowing for a less viscous glycerin solution.





K^+ Pros and Cons

- **Pros**
  - Flows more easily than glycerin containing Na^+
  - Does not “salt” compost piles or soil as much as Na^+
    - **Not as “toxic” to surrounding plant life in larger doses**
- **Cons**
  - KOH has higher mass (56) compared to NaOH (40)
    - Uses 1.4x more KOH (by mass) than NaOH
  - KOH is typically less pure than NaOH
    - Necessary to use more “KOH” by mass
      - **100 lb ~90% KOH pellets = ~$92 (Ulrich Chemical Indy, IN)**
      - **100 lb ~98% NaOH pellets = ~$71**

Performing the titration

What you need…

- Digital gram scale
- Phenol Red or phenolpthalein
- Isopropyl alcohol
- Distilled water
- 0.1% KOH (or NaOH) solution
- Oral syringes graduated in mL
- 3-4 glass jars
- Accurate way to measure 1 liter

Also available from localb100 store……

http://www.localb100.com/testbatch/titration/

Titration

- Mix 1 mL of the WVO with 10 mL of Isopropyl alcohol (Iso-HEET)
- Add 2-3 drops of Phenolphthalein indicator
- Add 0.1% KOH solution in 0.5 mL increments
- Mix well between each addition, when solution turns pink stop and add up the number of mL of KOH you added.
- Each mL added = 1 extra gram of KOH / liter of oil.

- Base amounts (per liter of oil) for KOH is 5 grams, for NaOH its 3.5 grams.

Titration Example Calculation

After titrating 1 mL of a batch of 50 liters of some *nasty* oil from Joe's Pub, you find it requires 3.8 mL of the 0.1% (1ppm) KOH solution to turn the indicator pink.

(alkaline = neutralized the free fatty acids)

Qty Catalyst Needed =Qty WVO x [base grams + mL added in Titration]

Therefore……

[50 liters] x [5 grams KOH + 3.8 mL KOH solution]

= **440 grams KOH**

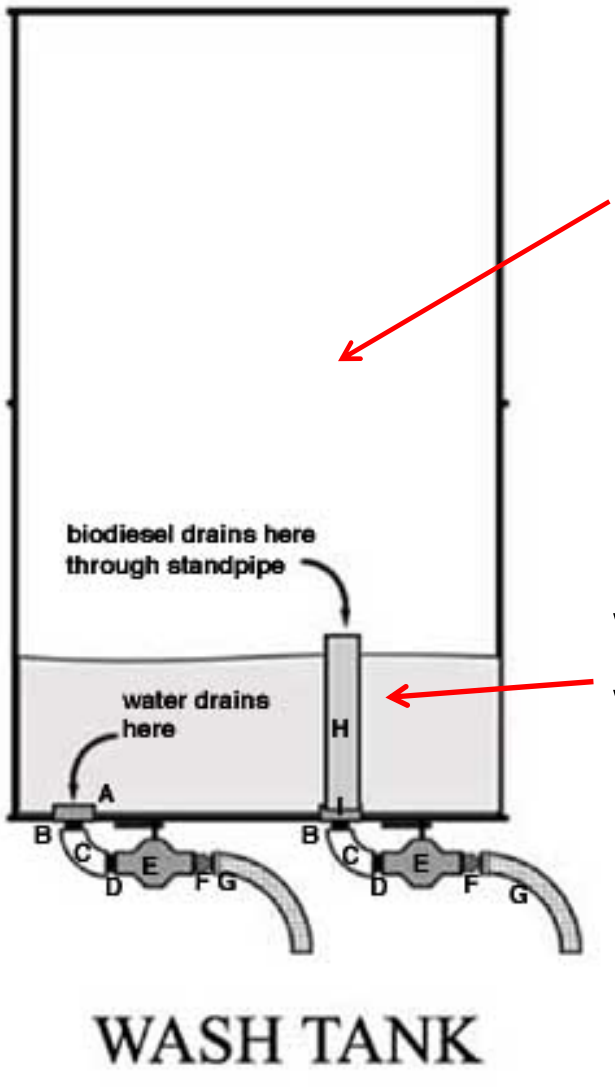
Biodiesel in Champaign, IL

- **We have constructed an "Appleseed" reactor**
  - **Open-source design by Maria Alovert (Girl Mark).**
  - **Main reaction chamber is a donated 80-gallon water heater**
  - **Small ~$35 liquid pump operates flow and mixing**

- **Average ~50 gallons every two weeks in the summer**

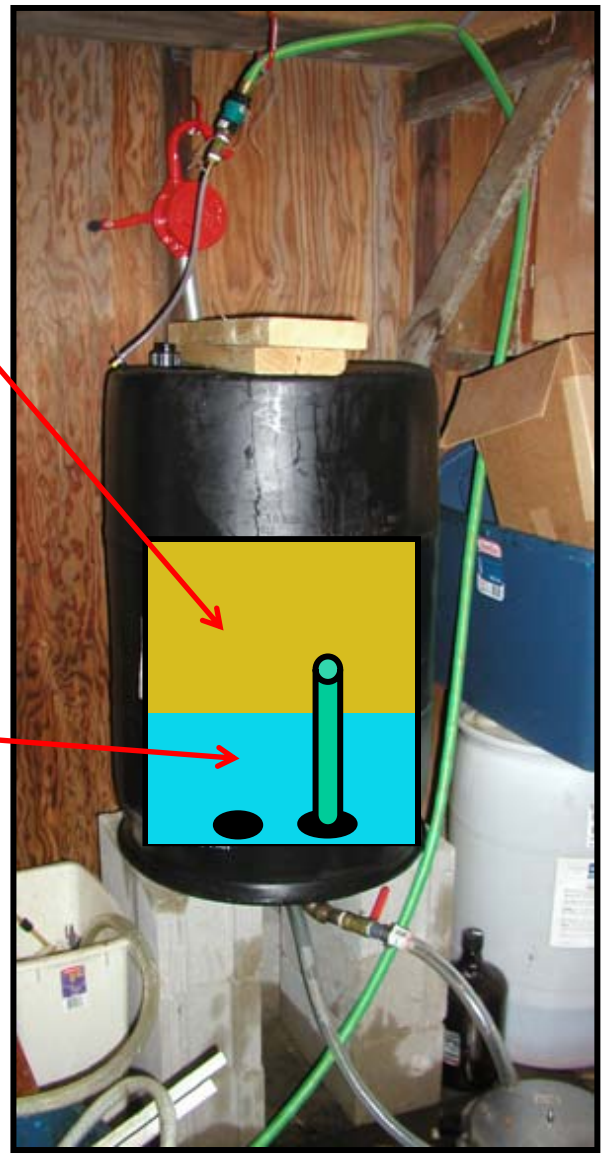
- ***Capacity for 150 gal/wk***

The Standpipe “Wash” Tank



Washed Biodiesel

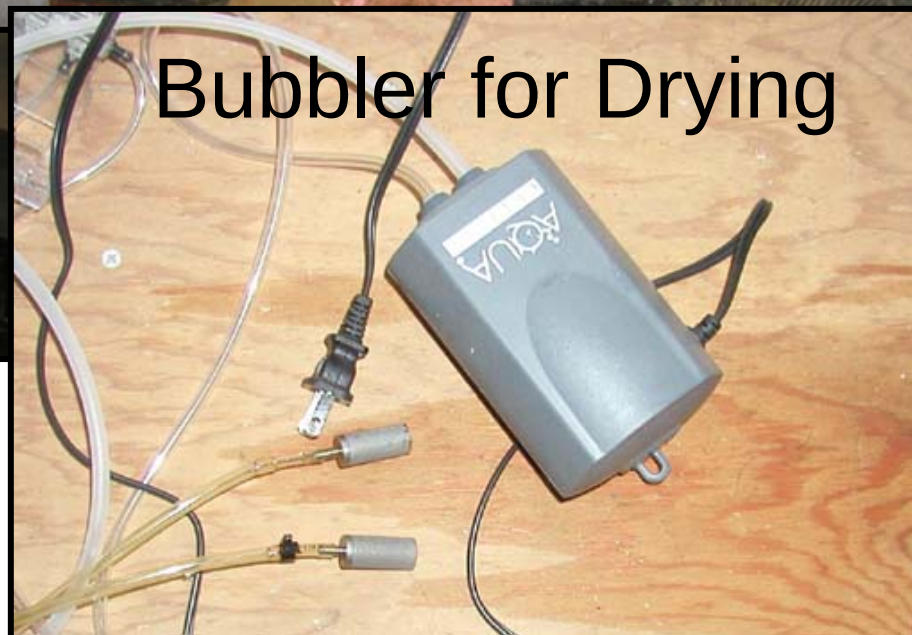
Wash Water



Drying Tank

Filter Assembly

Bubbler for Drying



Useful Trinkets

- Moving grease?
  - Drill Pumps!
  - You can get these little wonders ranging from $2-7 dollars.

- Drying and Bubble Washing?
  - Aquarium pumps!
  - Costs ~$10. Versatile for drying washed BD, or for bubble washing BD.

What can you do with Glycerin?
THE BROWN STUFF!

- Compost it
  - Glycerin is non-toxic and biodegrades quickly as part of a healthy compost environment.

- Sawdust “Logs”
  - Pack paper milk cartons with a paste of mixed glycerin and sawdust – makes a good heating log

- Other possibilities
  - Make it into soap
  - Preserve plants for display
  - Use it as heating oil for your processor
  - Paint Stripper

http://journeytoforever.org/biodiesel_glycerin.html

Cost Breakdown of Our Setup

Hot Water Heater	Free
Black Iron Pipe and Fittings	$85
Brass valves, hose clamps, and thermometer	$35
Clear vinyl tubing and PVC fittings	$40
1” Clear Water Pump	$30
55 and 35 gallon drums	Free
4 Drill pumps	$15
Garden hose and mister	$20
Filter unit (10 micron)	$22
Titration items	$15
100lb drum KOH	$92
50 gallons methanol (MeOH)	$90
5-gallon diesel cans	$6/ea
Two 7-gallon carboys for methoxide	$13
Cordless drill with high speed (1200 rpm)	$60

Total Start-up Cost = $540

Lessons learned

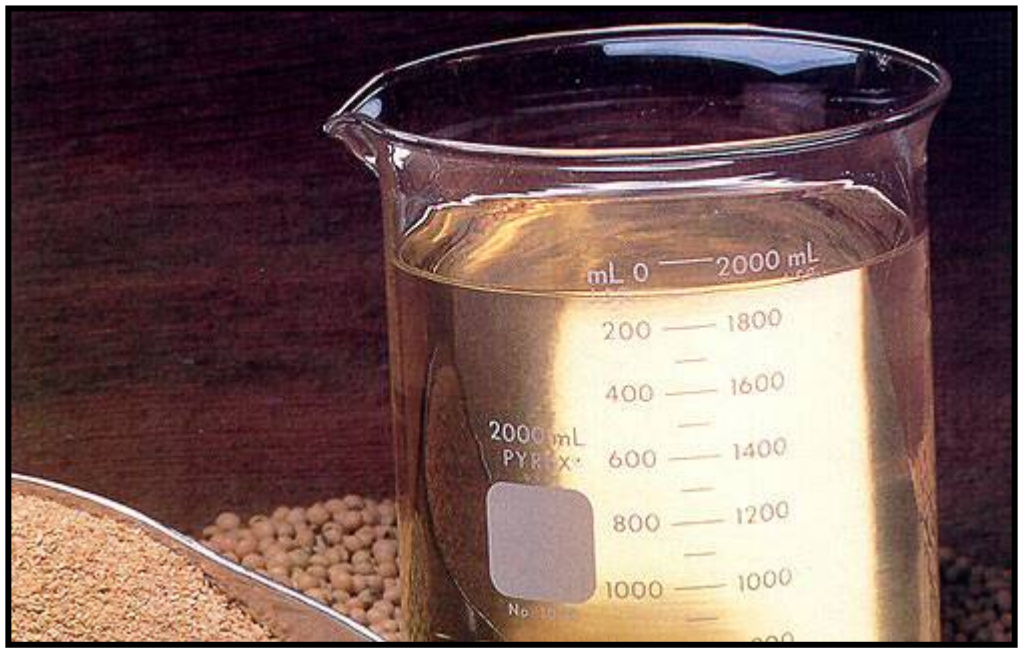
- Don’t be afraid to ask local mom-and-pop restaurants for their grease!
- Titrate where you collect your grease
  - make a portable titration kit
- Watch your fuel filter, it may need a change!
- Winter in the Midwest!
  - Switch to running B20 or less (dependent on weather)

Even though we are Chemists,
you don’t need to be.

Just take your time, be careful, and double-check everything!

Make small batches and slowly increase,
till you feel comfortable with lots of sticky grease!

Thank you for your attention and Good Luck!



Wabash Valley Biodiesel Project

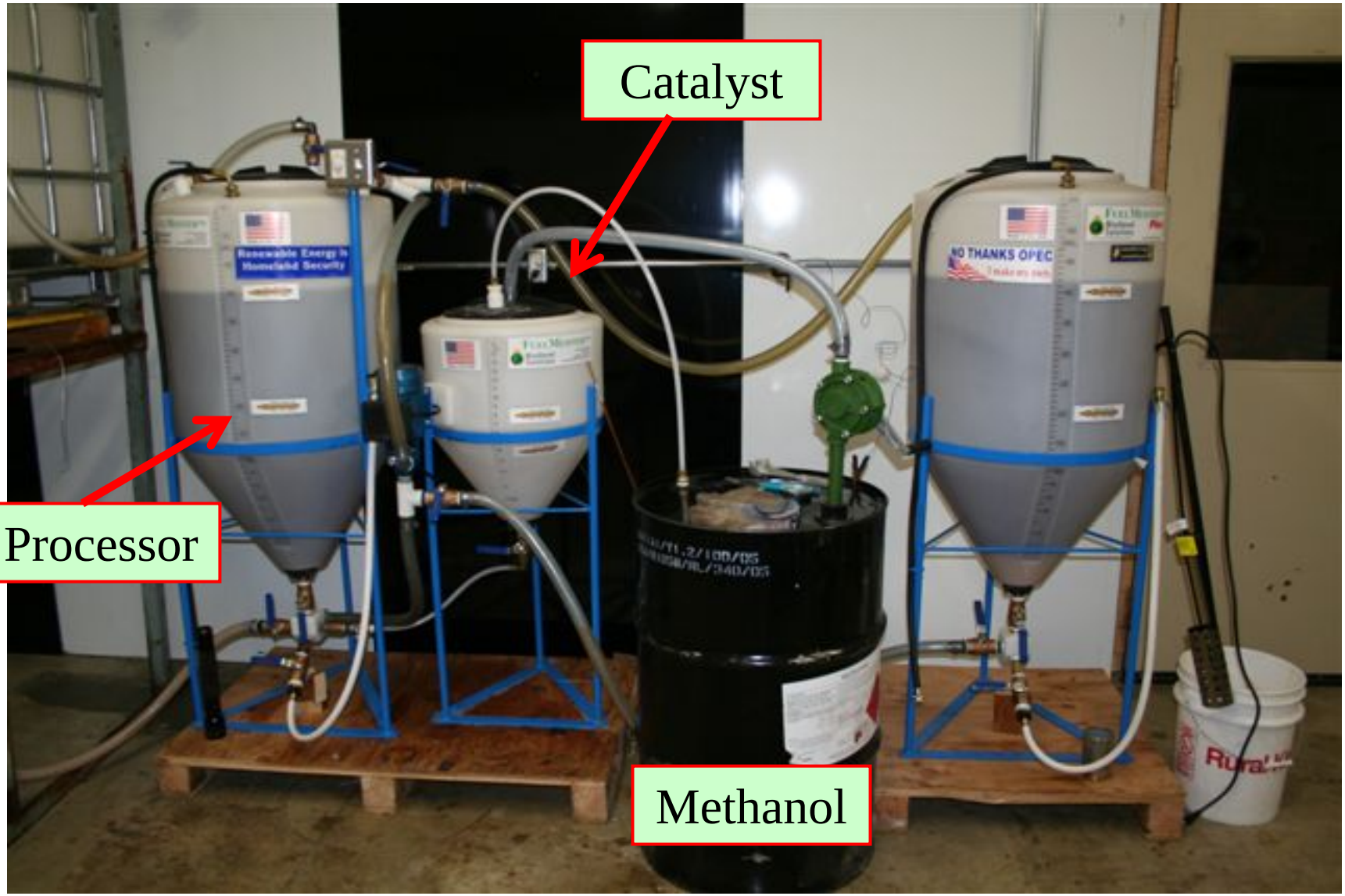
Cooperative project west of Lafayette

What is the Wabash Valley Biodiesel Project?

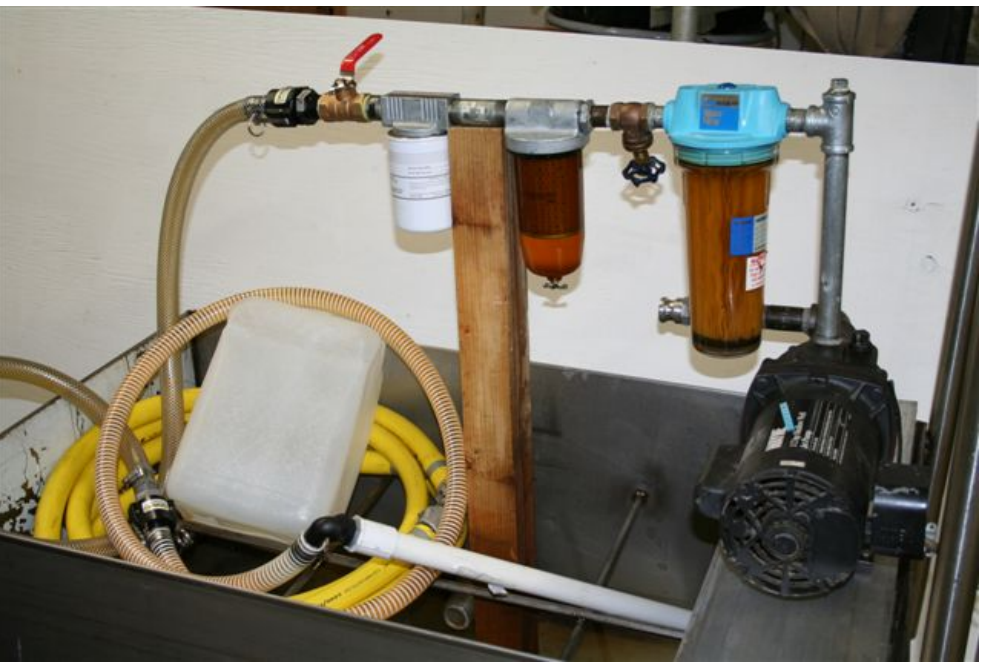
- 6 families who pooled resources
- Purchased a Fuel Meister BD processor
- Shared the cost of $6000

Goal of demonstrating sustainable commuting

Process and Equipment



Process and Equipment



Triple Filter Set-up

Production Facts

- Two 40 gallon processors
- Capacity for 80 gallons per day!
- Currently collection 120 gal/week of WVO
- Produced roughly 480 gallons to date

- 5 vehicles currently running B20 up to B50
- Predicting usage of 250 gal/week in summer
  - When all vehicles using B100
  - Supporting landscaping business with equipment

Cost Analysis

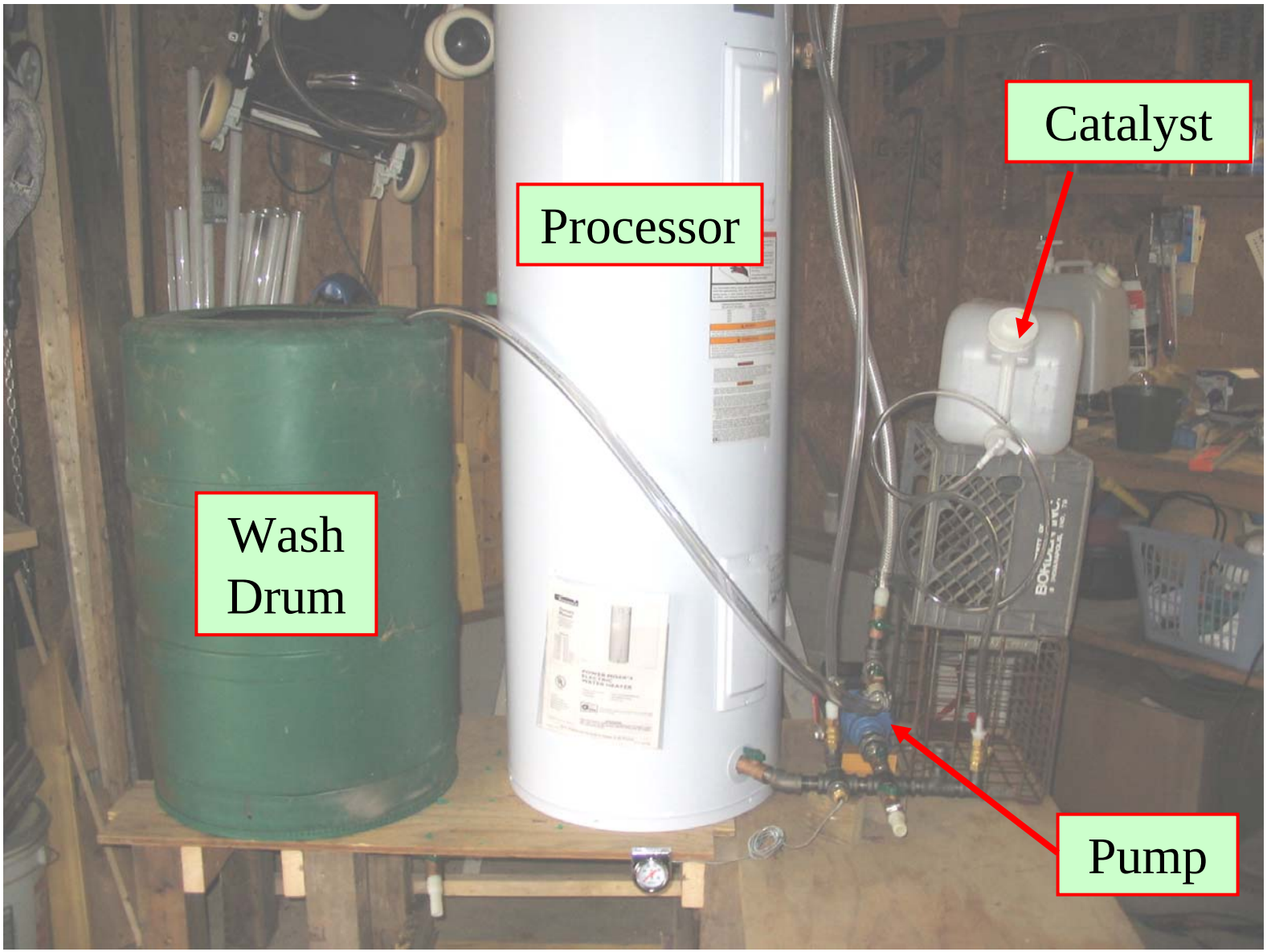
- **Premier** system start up cost = $6000
- Cost per Gallon = $0.57
  - Without labor cost
  - Has been as low as $0.47 (cheaper methanol)

“The Rookie” and the Appleseed Processor

Source:

www.biodieselcommunity.org

Basic Components



Cost Analysis

- Equipment Cost = $500

- Commuting Analysis
  - 450 miles per week
  - Was getting 25 mpg with Toyota Truck (18 gals/week)
  - Now get 45 mpg with VW Jetta TDI (10 gals/week)

- Assuming $0.60 / gallon for B100
  - Weekly Savings = (Gas$/gal x 18) - $6.00
  - Therefore…Assume 50 weeks per year

If Gas = $2.00 savings = $1500 per year
If Gas = $2.50 savings = $1950 per year
If Gas = $3.00 savings = $2400 per year

What if you don’t want to DIY?

- GO BUY AN EFFICIENT DIESEL !
  - Over 40% of cars in EU are diesel
  - Less than ½ % of passenger cars in USA

- Seek out the stations carrying BD
  - More and more prevalent
  - IT IS COMING !!!!!!

Resources

- **www.biodieselamerica.org**
- **www.biodieselcommunity.org**
- **www.localb100.com**
- **www.biodiesel.org**

- **Books in lobby**
- **Lists of filling station with BD**

Q&A and Invitation to take a Closer Look

Thank You !