# Notes to the Instructor

These labs are designed to be used during the second semester of a standard high school chemistry class. We hope to show students how chemistry principles can be used in the real-world industry of biodiesel production.

While each lab can stand on its own, each also builds on the previous labs, so using them in sequence can provide a richer experience.

Each lab can be photocopied and handed out to students.

Here are additional notes, instructions, and tips.

**Lab 1: The Molecules of the Biodiesel Reaction**

**Content Standards of High School Chemistry – Major Objectives**

- Students will distinguish and classify matter into appropriate categories (Idaho content standard 11-12-C.2.1.4)
- Students will correctly write symbols, formulas, and names for common elements, ions. and compounds (Idaho content standard 11-12-C.1.8.1)

**Lab 2: Chemical Reactions**

**Content Standards of High School Chemistry – Major Objectives**

- Students will use the periodic table to predict physical and chemical properties (Idaho content standard 11-12-C.1.1.1)
- Students will perform calculations related to the conversion of grams to moles to particles, atoms, molecules and volume (Idaho content standard 11-12-C.1.3.4)
- Students will correctly write symbols, formulas and names for common elements, ions and compounds (Idaho content standard 11-12-C.1.8.1)

**Calculating the molecular weight of calcium chloride:**

*Calcium chloride, $CaCl_2$ has 1 calcium atom and 2 chlorine atoms. The atomic weight of Ca is 40.078 and Cl is 35.453. Therefore:*

| *ATOM* | *NUMBER* | *ATOMIC WEIGHT Of the ATOM* | *TOTAL WEIGHT* |
|---|---|---|---|
| *Ca* | *1* | *40.078* | *40.078* |
| *Cl* | *2* | *35.453* | *70.906* |
| | | | *110.984* |

*The students will then weigh out 110.98 grams of calcium chloride, $CaCl_2$ and pour this into the flask with the $CaCl_2$ label.*

**Calculating the molecular weight of sodium carbonate:**

*Sodium carbonate ($Na_2CO_3$) has 2 sodium atoms, 1 carbon atom, and 3 oxygen atoms. The atomic weight of Na is 22.990, C is 12.011, and O is 15.999. Therefore:*

| *ATOM* | *NUMBER* | *ATOMIC WEIGHT Of the ATOM* | *TOTAL WEIGHT* |
|---|---|---|---|
| *Na* | *2* | *22.990* | *45.980* |
| *C* | *1* | *12.011* | *12.011* |
| *O* | *3* | *15.999* | *47.997* |
| | | | *105.988* |

*The students will then weigh out 105.99 grams of sodium carbonate, $Na_2CO_3$, and pour this into the flask with the $Na_2CO_3$ label. Attach the stopper and shake until all the $Na_2CO_3$ is in solution. There may be some cloudiness in one of the test beakers at the end of the lab. This could be from impurities in the reagents, such as moisture.*

## Lab 3: Acid Values of Vegetable Oils via Titration

**Content Standards of High School Chemistry – Major Objectives**

- Students will distinguish the common theories defining acids and bases (Idaho Content Standard 11-12-C.1.2.4)
- Students will analyze quantitative relationships involved in acid/base chemistry including pH (Idaho Content Standard 11-12-C.1.3.8)

**Potassium hydroxide-isopropyl alcohol solution, 0.1 N (the titrant)**

*Instructor should prepare by adding 6 g of potassium hydroxide to approximately 1 L of isopropyl alcohol, then accurately determine the exact concentration to 0.002N by titration using a known concentration of standard acid solution.*

**Titration solvent**

*Instructor should prepare by adding 5 mL distilled water to 495 mL of anhydrous isopropyl alcohol to one (1) liter of the solution, and then adding 500 mL toluene.*

## Lab 4: Chemical Equilibrium in Biodiesel Production

**Content Standards of High School Chemistry -- Major Objectives**

- Students will analyze and solve reaction stoichiometry problems (Idaho content standards 11-12-C.1.3.5)
- Students will correctly write symbols, formulas and names for common fatty acids and other compounds (Idaho content standards 11-12-C.1.8.1)
- Students will communicate scientific investigations and information clearly (Idaho content standards 11-12-C.1.8.2)

In this lab students will make a small batch of biodiesel in two stages. The instructions call for allowing the oil and alcohol mixture to sit for 60 minutes, in order to allow time for the reaction. If needed, it is fine to have the mixture sit for longer than 60 minutes (for example, overnight or over the weekend) if you need to continue the lab on another day.

## Lab 5: Transesterification of Vegetable Oil and Alcohol to Produce Ethyl Esters (Biodiesel)

**Content Standards of High School Chemistry – Major Objectives**

- Students will demonstrate the conservation of matter by balancing chemical equations (Idaho content standard 11-12-C.2.3.2)
- Students will classify, write and balance chemical equations for common types of chemical reactions and predict the products (Idaho content standard 11-12-C.2.5.2)
- Students will describe the factors that influence the rates of chemical reactions (Idaho content standard 11-12-C.2.5.3)

In this lab students will make a small batch of biodiesel. The instructions call for allowing the oil and alcohol mixture to sit for 60 minutes, in order to allow time for the reaction. If needed, it is fine to have the mixture sit for longer than 60 minutes (for example, overnight or over the weekend) if you need to continue the lab on another day.

## Lab 6: Physical and Chemical Solubility

**Content Standards of High School Chemistry – Major Objectives**

- Students will analyze and solve reaction stoichiometry problems (Idaho content standard 11-12-C.1.3.5)
- Students will express concentrations of solutions in various ways
- Students will explain the relationship and reactions of acids, bases, and salts (Idaho content standard 11-12-C.2.1.5)

**This lab was adapted from these two labs:**

- "Solubility of a Salt," on the Center for Precollegiate Study at the University of Florida's web site: http://www.cpet.ufl.edu/bestpractices/PDF/Physical%20Science/Changes%20in%20Matter/Investigating%20the%20Solubility%20Of%20a%20Salt%20and%20the%20Effects%20Temperature%20has%20on%20it.pdf
- "The Solubility of a Salt," on Central School site (Saskatchewan Schools, Canada): http://www.saskschools.ca/curr_content/chem30_05/4_solutions/labs/solubility_salt.pdf

## Lab 7: Using Differences in Solubility to Remove Contaminants from Biodiesel

**Content Standards of High School Chemistry – Major Objectives**

- Students will express concentrations of solutions in various ways including molarity (Idaho content standard 11-12.C.1.3.6)
- Students will evaluate the role of chemistry in energy and environmental issues (Idaho content standard 11-12.C.5.3.1)

**1 liter unwashed biodiesel**

*Instructor should dissolve 2.5 g KOH in 50 mL methanol. Add this to 1 liter of unwashed biodiesel. This will ensure that there is enough catalyst to measure in the biodiesel sample. This solution should be prepared immediately before the class because over time the KOH will react with the biodiesel to produce soap.*

**0.1 N Hydrochloric acid**

*Instructor should purchase or prepare 0.1 N HCl solution. To prepare, dissolve 9.85 g of concentrated (37%) HCl in 1 liter of distilled water. Standardize by titration against a known standard of base.*

## Lab 8: Density Measurement of Chemicals and Fuels

**Content Standards of High School Chemistry – Major Objectives**

- Students will create and interpret graphs of data (Idaho Content Standard 11-12-C.1.2.2)
- Students will select and use appropriate scientific equipment, materials and techniques (Idaho Content Standard 11-12-C.1.6.2)
- Students will demonstrate the ability to work safely and effectively in a chemistry laboratory (Idaho Content Standard 11-12-C.5.1.1)

**Standard Lab Report Format**

As the instructor, you may have your own laboratory report format. If not, here is a suggested format.

a) Cover page, containing the title of the lab, to whom, from whom, and date.
b) Objective(s) of the lab
c) Methodology
   - c.1 Equipment/devices
   - c.2 Chemicals used, if any
   - c.3 Set-up
   - c.4 Procedures
d) Data and Presentation
   - d.1 Phenomena observed
   - d.2 Raw data collected
   - d.3 Data processing/calculations
   - d.4 Data summary
e) Results and Discussions
   - e.1 Observations
   - e.2 Concepts learned
   - e.3 Discussions
f) Questions that remain/ newly raised