Price: $0.75

H.M.S. Beagle

Amateur Scientist's Notebook

Biodiesel for the Home Experimenter

What follows is information related to biodiesel that H.M.S. Beagle has gleaned from various sources (including our own customers).

Brief background

Biodiesel is the name of a clean burning alternative fuel, produced from domestic, renewable resources. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create a biodiesel blend. It can be used in compression-ignition (diesel) engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics.

Biodiesel actually consists of esters or fatty acids. When made, whether in a chemical plant or at home, the fatty acids are derived from any number of domestic sources. The chemical reaction, called esterification, is what is done to create the desired product. The actual type of esterification being performed is call "transesterification."

The making of soap is a kind of esterification. In soap making one uses fats (lard, vegetable oils, etc.) and reacts it with **sodium hydroxide** (lye or caustic soda), NaOH, to get sodium salts of the fatty acids. In making biodiesel, the main difference is that instead of using water as the solvent for the reaction, one uses an alcohol. This is most often **methanol** (methyl alcohol or wood alcohol), CH_3OH. This is the simplest of the alcohols. One could use **ethanol** (ethyl alcohol or grain alcohol), C_2H_5OH, and with the push for more corn-based fuels, this might be a viable option in the future.

Ingredients

The actual **reactants** needed are: (1) **waste vegetable oil** (WVO) (used cooking oil, fryer grease, animal fats or lard), (2) **methanol*** (industrial grade methanol is completely acceptable, but one might wish to experiment with a reagent grade (= high purity) when starting out just so that theoretical limits can be established and (3) **sodium hydroxide*** (reagent grade (ACS), pharmaceutical (USP) or food grade (FCC), in that order, are the best grades of purity available, and these should be used for initial experimentation; once the process has been scaled up to actual production an inexpensive, technical grade can be used with relatively good results).

For the initial **titration** one needs: (1) **isopropanol** (2-propanol or isopropyl alcohol) (use reagent grade only; do not use rubbing alcohol), (2) **deionized water** (this is better than distilled water) and (3) **phenolphthalein solution** (this is an acid-base indicator that's colorless in acid and red in alkaline solutions). Do not use "phenol red" indicator that is found in most swimming pool test kits.

For the final washing of the finished product use: (1) **white vinegar** and (2) **water**. **Deionized water** can be used, and will usually perform better, but almost everyone uses ordinary tap water for this step.

The **sodium hydroxide** is extremely hygroscopic and will pick up moisture from the atmosphere. Additionally, it will react with carbon dioxide in the air to form sodium carbonate. Both moisture and CO_2 will adversely affect the **sodium hydroxide** and greatly reduce its suitability for both the reaction and the titration.

The Basic Procedure:

1. Heat the **WVO** to remove water. This step may not be needed if you are confident that the **WVO** is relatively anhydrous (= water free),.
2. Perform a titration to determine how much **sodium hydroxide** is needed for the **WVO** you're using.
3. Prepare sodium methoxide.
4. Heat the **WVO** and mix in the sodium methoxide while stirring.
5. Allow to the mixture to settle.
6. Remove the glycerin.
7. Wash and dry.
8. Check quality.

The Titration

To determine the correct amount of **sodium hydroxide** required, a titration must be performed on the **WVO** being transesterified. This is the most difficult step in the process, and the most critical. This is where it is necessary to use some techniques you may not have used since high school or college chemistry lab.

Make up a solution of one gram of **sodium hydroxide** with enough **deionized water** to make one liter of total solution (it is best to use a 1 L volumetric flask* for this task). Completely dissolve the **sodium hydroxide** in approximately 500 mL of **deionized water**, then dilute to a total of 1 liter with more **deionized water**. This solution is then used as a reference titrant for the titration process. This solution must be keep tightly closed and stored in a labeled plastic bottle with a tight-fitting cap to prevent the absorption of CO_2. Make fresh solution every month.

Mix 10 milliliters, 1 mL, of **isopropanol*** in a 100-mL Erlenmeyer flask* with a 1 mL sample of **WVO** (taken from the reaction vessel after it's been warmed up and stirred). Use appropriate pipettes and or graduated cylinders for measuring. Add to this solution 2 drops of **phenolphthalein solution***.

Using a 25-mL or 50-mL burette* carefully and slowly drop the **sodium hydroxide solution** into the **WVO/isopropyl/phenolphthalein mixture**. This is best done with an automatic stirrer, but stirring can be accomplished by swirling the flask after each small addition of the **sodium hydroxide solution**. Start out by adding no more than 0.1 to 0.2 mL at a time followed by swirling of the flask's contents to ensure complete mixing.

As each drop is added there will be a fleeting pink color that rapidly fades. As the titration continues and the end point is reached the pink, or magenta, color persists. If conditions are right eventually the solution turns pink (magenta), and stays pink for 10 seconds. This is the end-point.

It's a good idea to do this entire process more than once to ensure that your results are correct and that you can properly perform the titration.

Depending on the type of **WVO**, how hot it got in the fryer, what was cooked in it and how long it was used, the amount of **sodium hydroxide solution** needed to titrate it is usually 1.5 to 3 milliliters. To get an idea of how the titration goes try using fresh cooking oil from your kitchen too, it should need much less **sodium hydroxide solution** to reach the end-point.

The calculation

The next step is to determine the amount of **sodium hydroxide** needed for the actual reaction. This is done with two separate calculations. Each milliliter of the **sodium hydroxide solution** used in the titration of the 1 mL of **WVO** is equivalent to 1 gram of **sodium hydroxide** for each liter of **WVO** to be esterified. First take the number of milliliters of **sodium hydroxide solution** (***X***) used in the titration, multiply that by 1.0 g/mL, and multiply that result by the number of liters (***Y***) of **WVO** to be transesterified:

Eq. 1: (***X*** mL * 1.0 g/mL/L) * ***Y*** L = ***Z*** g (NaOH)

Next, for every liter of **WVO** to be used and additional 3.5 grams of **sodium hydroxide** will be needed for the reaction. So for every liter of **WVO** to be esterified add an additional 3.5 grams of **sodium hydroxide**:

Eq. 2: 3.5 g (NaOH)/L * ***Y*** L = ***z*** g (NaOH)

Therefore, the total weight (***T***) of NaOH needed for a given volume of **WVO** is:

Z g + ***z*** g = ***T*** g

For example: if the titration determined that it took 2.4 milliliters to reach the phenolphthalein end-point and you intend to esterify 150 liters of **WVO**:

(1) 2.4 mL times 1.0 g/mL/L times 150 L equals 360 grams of **sodium hydroxide**, (2) 3.5 g/L times 150 L equals 525 grams **sodium hydroxide**, and (3) 360 + 525 = 885 grams of **sodium hydroxide** to esterify 150 L of **WVO**.

If the titration result was 1.8 milliliters to reach pH 8-9, the final amount of **sodium hydroxide** needed for the reaction would be 795 grams. Experience has shown that the number of grams of **sodium hydroxide** needed per liter of **WVO** has generally been between 6 and 7.

References:

The followingreference list drawn from the internet (please note: due to the ephemeral nature of the internet these citations may, or may not, be currently available).

1. http://www.biodiesel.org/resources/faqs/

H.M.S. Beagle stocks these chemicals and laboratory equipment.