A Preliminary Design Report for

Biofuel

by

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INTRODUCTION:

The goal of this design project is to create a waste oil based alternative to diesel fuel. The idea for this project was brought to the attention of the Mechanical Engineering department by Villanova Dining Services. Dining Services employs a diesel powered truck which they use to transport all of their food around the campus to the different functions that they cater. The cost of fueling the truck is becoming increasingly high with the rising cost of diesel fuel. Furthermore Dining Services also uses 12 gallons of cooking oil a week which they must pay to have the waste oil removed. The best solution to all of these problems is to find a way for the used fuel to be processed into a usable fuel that could supply the truck. This report will outline the process which will be used to transform the waste oil into a usable substitute for diesel fuel.

BODY:

One particular solution to the major challenge of how to create a usable biofuel from used cooking oil is a relatively simple process known as esterification. We will examine two different methods of esterification. There is a two-phase process and a single phase process.

The single stage titration method is the recommended method for making biofuel for a novice. In this process you test the oil using titration to find out how much sodium methoxide to use. This is referred to as a single stage process since sodium methoxide is the only catalyst added.

In the first part of this process we will filter the waste vegetable oil (WVO) to remove impurities. We will warm the oil and then run it through a coffee filter.

In the second step we will remove the water in the oil. We will heat the oil to 100 degrees C and mix it until the water is gone. When boiling slows we will raise the temperature to 130 degrees C for 10 minutes.

In the third step we will titrate the oil to determine the required amount of sodium methoxide. We will completely dissolve one gram of sodium hydroxide with one liter of water. Then we will mix 10 mL of isopropyl alcohol with 1 mL warmed and mixed WVO. We will then add 2 drops of phenolphthalein to the WVO mix. Next we add small measured amounts of sodium hydroxide while mixing. When the WVO mix turns pink we record the amount of sodium hydroxide we added. The amount of sodium hydroxide solution needed is usually between 1.5 and 3 mL. We will use 2 mL for an example. We can now calculate the amount of sodium hydroxide needed for the batch. We add 3.5 to 2 and then multiply 5.5 by the number of liters of oil we want to process. This will give us the grams of sodium hydroxide required. So if we are doing 100 L we will need 550 grams of sodium hydroxide.

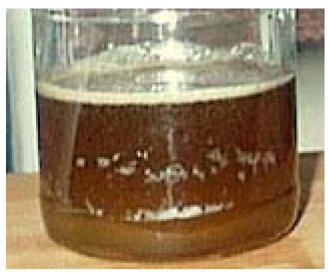
In the fourth step we use an amount of methanol equal to 1/5 the amount of WVO. We then mix it with the sodium hydroxide to create sodium methoxide. In this case we will mix 550 grams of sodium hydroxide with 20 L methanol.

In the fifth step we heat the WVO to 125 degrees C while mixing it. Then we add the sodium methoxide and mix for an hour.

In the sixth step we allow the solution to sit for a day. Then we heat the mixture to 100 degrees C. Next we drain the glycerin out of the bottom with a transparent hose. The glycerin is a dark brown color and the biodiesel is honey colored.

In the seventh step we will let the biodiesel sit for a week to allow impurities to settle. We will then filter the biodiesel a few times to remove any additional impurities. If this method is not sufficient then washing of the biodiesel will be required.

Our final product should have a ph of about 7 and it should be a light brown color. Unlike the single-phase process, the dual phase method does not employ titration or measurement of pH. The first part of this process is to filter out the large impurities in the used oil using a screen (window screen) and boiling off any water that might reside in the mixture. The oil will be heated to 212 F allowing for the water to fall to the bottom to be drained off until none is left. The next step is to measure the amount of volume that the oil occupies. The oil should be placed in a container that can be heated. Heating the oil to 95 F, add 0.08 liters of methanol (99%) for every liter of oil and stir for five minutes. Then add .001 liters of 95% sulfuric acid for each liter of oil to the mixture with an eyedropper and stir (without splashing) at a speed of 500-600 rpm using an electric stirrer. After one hour stop heating the mixture and after two hours stop stirring and let it sit for at least eight hours. The next part of the process is creating the sodium methoxide.



Fat/oil mixture after heating

Sodium methoxide consists of 0.12 liters of methanol and 3.1 grams of lye (NaOH, sodium hydroxide) for every liter of oil. Mix these two ingredients until the lye is completely dissolved. After the oil has settled for the eight hours add half of this created sodium methoxide to the mixture and stir for five minutes. Now the mixture is again heated to 55 C and the second half of the sodium methoxide is added while stirring at a speed of 500-600 rpm. After about two hours part of the heated/mixed oil will have a brown and sticky texture to it (we will see this since our containers will have a clear viewing window on the side). At this point the heater and stirrer are turned off and the mixture is allowed to sit for an hour.

Mixture after the sodium methoxide is added

The final stage of the process is called washing where water and an air pump are added to the mixture to bond with any of the residual soaps left in the mixture. Use one third the amount of water as the amount of biodiesel to be washed. After adding water to the solution, add the air pump and allow it to bubble for twenty four hours. The water will bond with the remaining soaps and fall to the bottom making the solution appear much lighter. The remaining biodiesel will be removed from the rest of the solution using a decanting or siphoning method. This process will then be repeated twice more. After the last washing the biodiesel will be placed in a clear storage jar and left to sit for three weeks. The remaining product will be a useable amount of biodiesel capable of fueling a diesel engine. Thus completes the process of esterification that poses as one option for creating a viable biodiesel.

Finished product biodiesel

Figure 1

Figure 2

Figure 1: The main components of the esterification process which include the holding tank and pump (left) and the heating tank (right).

Figure 2: The hazardous chemicals (sodium methoxide) are kept outside and mixed in these barrels for safety.

CONCLUSION:

The reason that the single phase titration method will be used is because of its ease. The ultimate goal of this project is to automate the process so that it can be easily performed by the Dinning Services' staff with no engineering background necessary. The only difficulty in the process will come in gaining the correct pH of the fuel. Once this problem is solved the process will become easy enough for anyone on Dining Services' staff to perform. Another benefit of the single phase method is that it uses less harmful chemicals than does the dual stage method. Less harmful chemicals allow for a safer work environment which is an additional benefit for Dining Services.