BIOFUELS: A HANDS-ON APPROACH, LEARNING THE POTENTIAL OF UTILIZING NON-FOOD SOURCES

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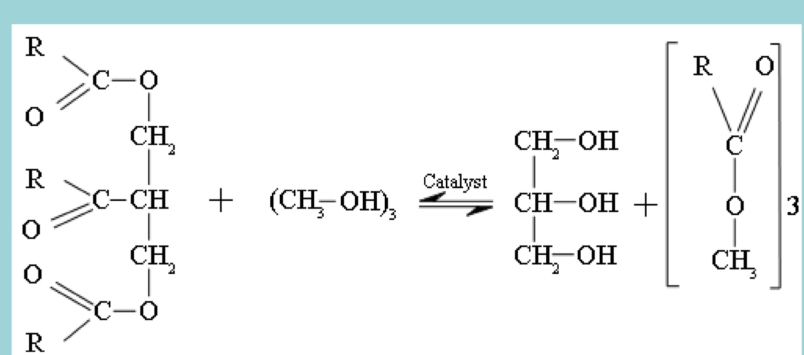
ABSTRACT

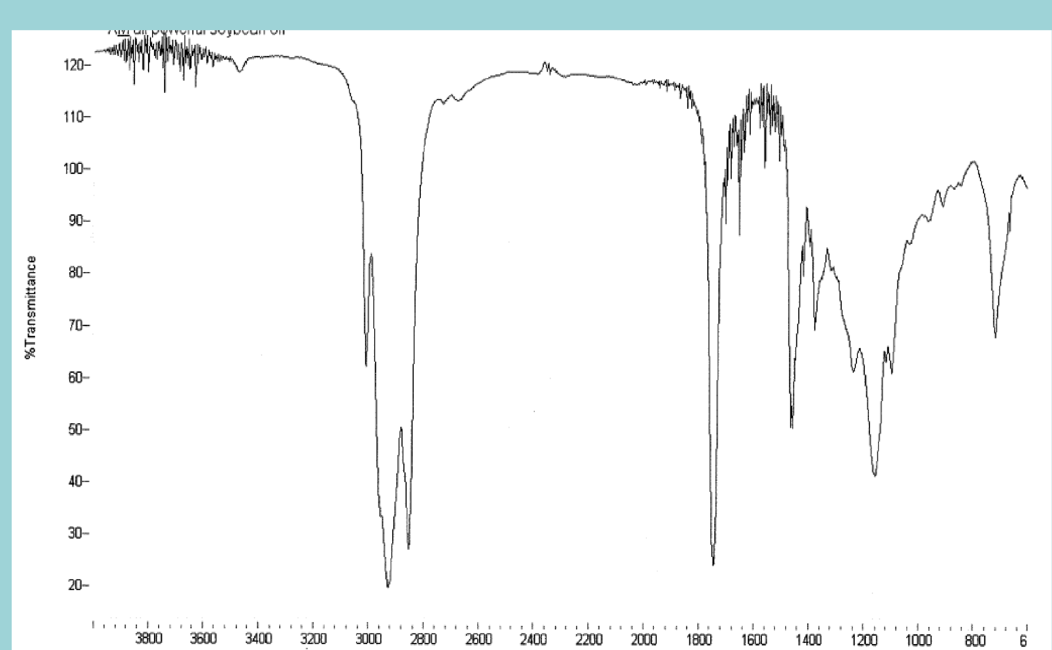
The global energy economy is huge and thoughts of replacing large amounts of petroleum based fuels by massive levels of fermentation of grains are not realistic. On an energy basis what global agriculture produces for food will almost cover the energy demands if all of it is redirected to the production of fuels—either as alcohols for gasoline or as fat derivatives for diesel fuel. This means that chemical processes need to be developed that allow inclusion of non-food based agricultural and urban wastes as well as forest debris into the energy economy. These represent opportunities to capture new sources of energy that would otherwise not be captured. This project is based on the idea that every little bit helps, and focuses on a hands-on approach to isolating chemicals from fallen vegetation with an emphasis on adding to the transportation fuel pool. Hydrolysis of cellulosic wastes from various sources easily collected on our campus has been explored seeking ways to break them down to fermentable sugars. These sugars are then fermented to form alcohols suitable for inclusion in gasoline. Extraction of vegetable oils has also been explored. Finally an attempt has been made to quantify the impact such a strategy might have on global energy supplies if practiced on a wide-scale basis.

PROCEDURE

Eucalyptus bark source



Transesterification reaction



IR spectrum of soybean oil

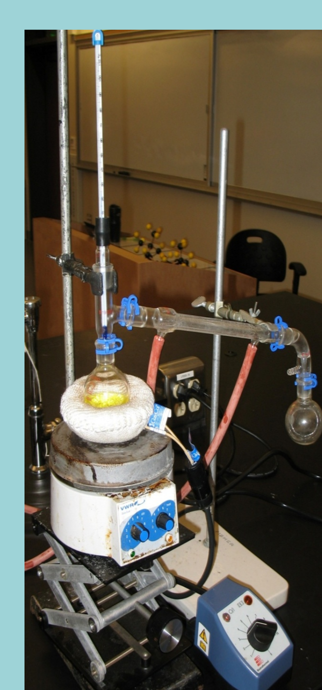
To create bioethanol from natural resources, we used fermentation followed by fractional distillation to isolate the alcohol. The fermentation took place after hydrolysis of a sugar or starch. Sucrose produced from hydrolysis was fermented by adding 175 mL of water, 20 mL of Pasteur's salt and 2.0 g of dried baker's yeast or brewer's yeast, allowing fermentation to take place. These are the basic measurements, but must be scaled up or down depending on the amount of sucrose from the hydrolysis. The mixture was contained in a 250-mL Erlenmeyer flask that was connected to a trap containing a calcium hydroxide mixture. Mineral oil was added to the trap to protect it from air. This will protect the fermentation from oxidizing the ethanol further than the desired amount. Carbon dioxide should be present in the flask during fermentation to produce ethanol. The fermentation must be in an environment with a temperature of 30-35° C to help provoke ethanol production.

After one week, the clear part of the mixture was filtered in order to keep all of the yeast out of the product ethanol. Running a vacuum filtration on filter aid will help filter the small particles from the ethanol reaction mixture by creating a thin layer of filter aid on top of the filter paper. The clear ethanol product will pass through the filter aid as well as the filter paper during its vacuum filtration process. The filtration left ethanol mixed with water and miniscule amounts of metabolites produced from the yeast as well as the salts in the original mixture. When vacuum filtration was completed, a fractional distillation apparatus was assembled. The fractionating column was created using a condenser packed uniformly with steel wool. Potassium carbonate (10 g) was added for every 20 mL of distillation sample. The distillation sample was added to the round bottom flask of the distillation apparatus after the Potassium carbonate was fully dissolved in the sample. The sample was distilled slowly for the ideal separation. Distillation began once the temperature rose to 78°C and continued to rise until distillation had ceased. Only the product collected from 78°C to 88°C should be collected. The residue left in the distillation flask should be discarded. 4-5 mL of product was collected and the distillation was interrupted by removing the heating mantle from the apparatus, cutting of its source of heat. The weight of the distillate product and the volume were measured. The measurements were used to determine the density of the product ethanol. This enabled us to determine the percent yield of ethanol from the original product.

In order to yield methyl ester from certain oils, one must go through a process called transesterification. This process involves the replacement of the alcohol group of an ester compound to another alcohol group. This process is ideal for creating biodiesel from household oils. To begin the process, we extracted the glycerol from the oil. In this case, a mixture of sodium hydroxide and methanol was created and added to the oils during reflux condensation. Once the two layers formed in the mixture, they were separated through a funnel. Then, we took the ester and vacuum condensed the solution in order to lower the boiling point of the mixture. The result yielded from this condensation is a methyl ester.

Distillates from coconut oil, peanut oil & bacon fat

Eucalyptus bark



Peanut oil distillation

Soybeans

Soybean/hexane mixture being filtered

DATA TABLE

	Soybean	**Eucalyptus Bark**	**Peanut Oil**
% of Extracted Material = Renewable Liquid	4.78%	30.4%	6.76%
Amt. of Resource in World (1 Year)	3.35 million metric tons		1.37 million metric tons
	Coconut Oil	**Bacon Fat**	
% of Extracted Material = Renewable Liquid	9.37%	**39.3%**	
Amt. of Resource in World (1 Year)	469 million metric tons		

CONCLUSION

With the world oil reserves dwindling, it is important to have adequate knowledge about alternative fuel sources and their potential. These experiments helped us learn about some of the possible fuel sources the global economy can use in the future instead of fossil fuels. Through the experiments we did, we have been able to show that common fats, oils and cellulosic waste can be a source for fuel. More specifically, the main focus was extracting renewable liquid products from plants, household oil, and algae. To focus on plants, the group used eucalyptus bark and recovered 29.4% of oil and yielded 30.4% of sugar. Along with the bark, the group conducted the same experiment using garden waste. In addition, the group analyzed how much oil there is in grass. For household oil, the group used vegetable oil, soybeans, bacon fat, peanut oil and coconut oil. With the hydrogenated vegetable oil (Crisco), the group determined recovered methyl ester from fatty acids, and verified that not a lot of product was recovered from the initial product (30.8%). During the extraction of oil from dry soybeans, a yield of 4.78% was recovered. With the transesterification of bacon fat, the calculated yield was 39.3%. For coconut oil and peanut oil the group determined that the yield is 9.37% and 6.76% respectively. The resources that were mentioned, but a yield was not given are part of an ongoing effort to obtain biodiesel. Overall, we concluded that fuels made from plant resources can be a useful way to extend the overall fuel supply, but much is left to do to optimize the processes we have used.