Proposal for Biodiesel Production Facility

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Abstract

Student group CU Biodiesel is seeking a location to develop the infrastructure for a waste oil recycling service to convert yellow grease into biodiesel fuel. In order to decrease University of Colorado's dependence on foreign oil, and reduce local and global emissions a pilot project has been set up to power the Buff Bus with this alternative fuel. In order to continue this and future biodiesel production efforts, an appropriate facility is required.

Introduction

Biodiesel is a nontoxic and biodegradable alternative to petroleum based diesel fuel. It is made from vegetable oils, recycled cooking grease, or animal fats. Biodiesel can be used to power any diesel engine (compression ignition) without making any modifications to the engine. It is considerably safer to handle and store than petroleum diesel. Use of biodiesel greatly reduces harmful emissions relative to petroleum diesel[1].

CU Biodiesel

CU Biodiesel was formed from an engineering projects class in the fall 2002 semester. A 60 gallon batch processor was designed and constructed by four students from this class with funding from the engineering excellence fund. In conjunction CU Transportation Department, CU Housing Department, CU Environmental Center, and Boulder Biodiesel, CU Biodiesel has set up a pilot project in which one Buff Bus will be powered by biodiesel fuel made from recycled cafeteria grease. Production of this fuel has already begun using space in the transportation garage. The Buff Bus will begin to run on biodiesel on April 2nd, 2003. This space in the transportation department will not be available for much longer and CU biodiesel will need space to produce this fuel, and expand future production capability. After the pilot project CU Biodiesel hopes to expand biodiesel production, and power all of University of Colorado's diesel fleet on this vegetable based fuel.

Funding

After receiving a small grant to construct the biodiesel processor, CU Biodiesel has been funded by the CU Environmental Center. Three main possible funding sources exist to finance the rent for a processing facility. The CU environmental center has expressed interest in funding a biodiesel production facility for CU Biodiesel but needs **time….** Boulder Biodiesel a local biodiesel coop has offered to help fund our production facility. CU Biodiesel will be running for UCSU referenda in April, in order receive funding from student fees. If CU Biodiesel passes referenda there will be funding guaranteed for the next four years. With these possible sources of funding the next step is to find the appropriate facility, and determine the rent. Since CU Biodiesel will be producing fuel to power University of Colorado buses, the Exabyte building seems to be a logical production facility. Representatives from CU Biodiesel have taken a tour of this building; some of the available spaces could be retrofitted to accommodate biodiesel production requirements.

Chemical Analysis

Biodiesel is made by reacting vegetable oil, a triglyceride (three vegetable oil esters attached to a glycerin molecule) with pure alcohol (methanol or ethanol) and a strong base (NaOH or KOH), which acts as a catalyst. The alcohol reacts with the vegetable oil

[1] See Appendix A for emission test results

and 'breaks' the triglyceride into three methyl/ethyl esters plus a glycerin molecule. After settling the denser glycerin sinks to the bottom of the vessel and can be separated out. The remaining methyl or ethyl esters are the product, known as biodiesel. This process is called transesterification[2].

Processing

Our process of making biodiesel begins by collecting waste vegetable oil. The next step is to screen filter and pump this oil into the main reaction vessel. The oil is then mixed for 3 minutes, to ensure complete mixing, and a titration is performed to find its free fatty acid concentration. Next the appropriate amount of KOH (as determined by titration) and CH_3OH (methanol) is added to the secondary reaction vessel and mixed for five minutes until the KOH is completely dissolved. The newly created potassium methoxide is then pumped into the main reactor. The main reactor is then agitated for one hour, to ensure a complete transesterification. The mixture is then left to settle for eight hours, after which the glycerin is drained and removed, followed by the biodiesel. The biodiesel is then filtered and pumped into storage tanks.

The biodiesel reaction is a one-to-one conversion from waste oil to biodiesel fuel. The reaction requires 20% alcohol by volume and approximately 0.5% catalyst by weight depending on the quality of oil used. Crude glycerin is formed as a byproduct of the reaction, which makes up for 20% by volume. So, 100 liters of vegetable oil would require 20 liters of methanol and 500-1000 grams of catalyst and would produce 100 liters of biodiesel and 20 liters of glycerin.

Facility Requirements

A minimum of 350 square feet of enclosed space with a ceiling of at least nine feet is needed to accommodate our processing unit, a small lab station, and storage. This processing facility will require electricity, running water, and ventilation. The floor needs to be made of a non-absorbent material that does not react with methanol. The facility must be maintained at a minimum of 45° Fahrenheit. At the current production level we will access the facility two to three days a week for a few hours at a time of an estimated twelve hours a week.

Health & Environmental Safety

Our facility will meet all Environmental Safety requirements and OSHA regulations. Biodiesel is non-toxic and contains no hazardous materials both by definition and characteristics[3]. The National Institute for Occupational Safety and Health (NIOSH) classifies the aquatic toxicity as "insignificant". Skin contact may produce mild irritations, however results produced less irritation than a 4% soap and water solution. Inhalation of fumes causes negligible danger unless the biodiesel is heated to produce

[2] See Appendix B for chemical reaction illustration and B100 standard fuel properties
[3] See Appendix C for regulatory classification information

vapors. Biodiesel has a flash point of over 130° C, and produces negligible flammable fumes at room temperature. In the event of a spill, the spill will be contained to as small of an area as possible and cleaned using adsorbent materials such as sand or cat litter.

Methanol is volatile and the vapors can be toxic. Processing methanol requires eye, skin, and nose protection. This requires appropriate clothing to prevent skin from being exposed, a respirator to protect against vapors, an eye wash station, and a flame retardant. Large quantities of methanol present a significant fire hazard. Therefore, we will operate in a way that minimizes the need to store quantities of unprocessed methanol. Our methanol storage and use practices will be in compliance with Colorado laws. We will be consulting Mansour Alipour-fard , the University of Colorado Fire Marshall on proper methanol storage, handling, and accident remediation.

NaOH and KOH are both caustic substances requiring proper handling. Both can burn skin and mucous membranes. They are safe to handle using standard laboratory safety procedures, and can be stored with little safety concerns. We will keep vinegar or acetic acid on hand in the event of a chemical burn.

Appendix A:

AVERAGE BIODIESEL EMISSIONS COMPARED TO CONVENTIONAL DIESEL		
Emission Type	**B100**	**B20**
Regulated		
Total Unburned Hydrocarbons	-67%	-20%
Carbon Monoxide	-48%	-12%
Particulate Matter	-47%	-12%
NOx	+10%	+2%
Non-Regulated		
Sulfates	-100%	-20%*
PAH (Polycyclic Aromatic Hydrocarbons)**	-80%	-13%
nPAH (nitrated PAH's)**	-90%	-50%***
Ozone potential of speciated HC	-50%	-10%

*** Estimated from B100 result**
**** Average reduction across all compounds measured**
***** 2-nitroflourine results were within test method variability**

Source: Biodiesel Emissions. National Biodiesel Board.
http://www.biodiesel.org/pdf_files/emissions.PDF

Appendix B:

Detailed Requirements for Biodiesel (B100)[A]			
Property	**Test Method[B]**	**Limits**	**Units**
Flash Point (closed cup)	D 93	130.0 min	°C
Water and sediment	D 2709	0.050 max	% volume
Kinematic viscosity, 40°C	D 445	1.9-6.0[C]	mm^2/s
Sulfated ash	D 874	0.020 max	% mass
Sulfur[D]	D 5453	0.05 max	% mass
Copper strip corrosion	D 130	No.3 max	
Cetane number	D 613	47 min	
Cloud point	D 2500	Report[E]	°C
Carbon residue[F]	D 4530	0.050 max	% mass
Acid number	D 664	0.80 max	mg KOH/g
Free glycerin	D 6584	0.020	% mass

Total glycerin	D 6584	0.240	% mass
Phosphorus content	D 4951	0.001 max	% mass
Distillation temperature, Atmospheric equivalent temperature, 90 % recovered	D 1160	360 max	°C
[A]To meet special operating conditions, modifications of individual limiting requirements may be agreed upon between purchaser, seller, and manufacturer.			
[B]The test methods indicated are the approved referee methods.			
[C]The 6.0 mm^2/s upper viscosity limit is higher than petrodiesel and should be taken into consideration when blending.			
[D]Other sulfur limits can apply in selected areas in the United States and in other countries.			
[E]The cloud point of biodiesel is generally higher than petrodiesel and should be taken into consideration when blending.			
[F]Carbon residue shall be run on the 100 % sample.			

Source: Biodiesel Standards, Codes, and Legislation. Alternative Fuel Data Center. http://www.afdc.nrel.gov/altfuel/bio_standard.html

Appendix C:

Regulatory:
UN HAZARD CLASS: N/A
NMFC (National Motor Freight Classification):
PROPER SHIPPING NAME: Fatty acid ester
IDENTIFICATION NUMBER: 144920
SHIPPING CLASSIFICATION: 65
OSHA: This product is not hazardous under the criteria of the Federal OSHA Hazard Communication Standard 29 CFR 1910.1200. However, thermal processing and decomposition fumes from this product may be hazardous as noted in fire fighting section.

TSCA: This product is listed on TSCA.

CERCLA: (Comprehensive Response Compensation and Liability Act). NOT reportable.

SARA TITLE III: (Superfund Amendments and Reauthorization Act), Section 312 Extremely Hazardous Substances, None. Section 311/312 Hazard Categories, Non-hazardous under Section 311/312. Section 313 Toxic Chemicals, None.

RCRA: If discarded in its purchased form, this product would not be a hazardous waste either by listing or by characteristic. However, under RCRA, it is the responsibility of the product user to determine at the time of disposal whether a material containing the product or derived from the product should be classified as a hazardous waste (40 CFR 261.20-24).

CALIFORNIA PROPOSITION 65: The following statement is made in order to comply with the California Safe Drinking Water and Toxic Enforcement Act of 1986. This product contains no chemicals known to the state of California to cause cancer.

Source: Biodiesel Handling and use Guidelines. National Renewable Energy Laboratory. NREL/TP-580-30004. September 2001. http://www.afdc.doe.gov/pdfs/5845.pdf