Storage Stability of Biofuel

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Abstract

Biofuel is one of the prime candidates to take over the role played by fossil fuel as the main source of energy in the future. Numerous studies have been done on the potential of biofuel to produce similar power output generated by the current petrol and diesel which are depleting without any drawbacks. The objective of this particular study is to investigate 4 of the more established vegetable oil in the energy industry namely jatropha, palm, coconut and canola oil in terms of storage stability of biofuel at room temperature and 80ºC. The biofuels were tested in terms of density, kinematic viscosity, Total Acid Number (TAN), flash point and oxidation stability every 2 weeks for 10-12 weeks or 3 months at 2 different temperatures to obtain a conspicuous result. At the end of the experiment and test, it is found that palm oil is the biofuel with the best storage stability. The next biofuel that followed is jatropha oil, canola oil and finally coconut oil. Although palm oil showed poor kinematic viscosity, however it has good stability in terms of density, Total Acid Number (TAN) and also relatively stable oxidation and flash point in comparison with the 4 samples tested. The experiment result and data also showed that effect of continuous heating at 80ºC promotes oxidation process, higher Total Acid Number (TAN), lower flash point as well as increase in density and kinematic viscosity.

Next, experimental investigations were carried out to evaluate the storage stabilities of various biodiesel fuels. The biodiesel fuels were palm methyl ester (PME), jatropha methyl ester (JME), coconut methyl ester (COME), 20% blends of PME with diesel fuel and 20% blends of JME with diesel fuel. The ordinary diesel fuel was used for comparison purposes. The biodiesel were tested in terms of density, kinematic viscosity, Total Acid Number (TAN), flash point and oxidation stability every week for 3 months. The results show that almost all fuel samples met the standard specifications regarding oxidation stability. The trends for density, viscosity and TAN increased due to oxidation. For the flash point, the trend also decreased, but the rate was very low. In overall consideration, among the biodiesel, COME was found to be better with respect to storage stabilities. The results of this investigation will be used for sustainable development of biodiesel fuel from various feedstocks.

Keywords: Biofuel, jatropha, palm, coconut, canola, storage stability, biodiesel

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Presenter: Mahendra Varman

Introduction

- Biofuel?

Type of fuel whose energy is derived from biological carbon fixation – Vegetable oil, Bioalcohols, Biodiesel (Wikipedia, 2012)

- Storage Stability?

In this study – oxidation stability, kinematic viscosity, density, flash point, total acid number (TAN)

Objectives

- Investigate the storage stability of different types of vegetable oil (biofuel) namely Jatropha, Palm, Coconut and Canola oil
- To study the effect of temperature (80 ºC) on the storage stability of the vegetable oil (biofuel)
- Investigate the storage stability of different types of biodiesel namely Jatropha, Palm, Coconut methyl ester

Background

According to International Energy Agency (IEA):

Biofuels hold 1% of global road transportation consumption in 2006, could increase to 4% by year 2030

Biofuel development in Malaysia:

- Introduced National Biofuel Policy in 2006 by Ministry of Plantation Industries and Commodities
- Palm oil biodiesel (B5) program was officially launched on June 1st 2011

Methodology

- Vegetable oil samples stored in room temperature & heated 80°C for 10 weeks
- Biodiesel samples stored in room temperature for 10-12 weeks
- Every 2 weeks, these samples are tested for their storage stability

Terminology

Properties	Descriptions
Density	Measure of mass per unit volume
Kinematic Viscosity	Measure of resistance of a fluid flow which is being deformed by either shear or tensile stress.
Total Acid Number	Amount of potassium hydroxide (KOH) in milligrams that is needed to neutralize the acids in one gram of oil. (Acidity)
Flash Point	Lowest temperature at which the vapour of a combustible liquid can be made to ignite momentarily in air
Oxidation Stability	Measure of an oil or fat's resistance to oxidation

(in terms of induction period)

Apparatus

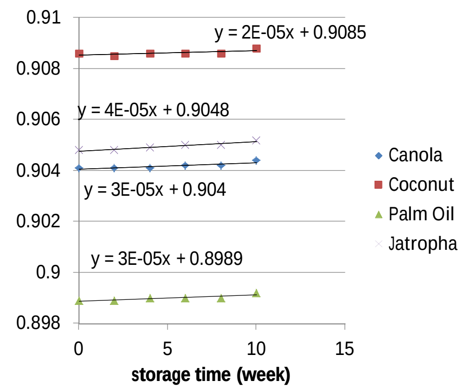

Anton PaarSVM 3000 Stabinger Viscometer


Metrohm885 Titrosampler

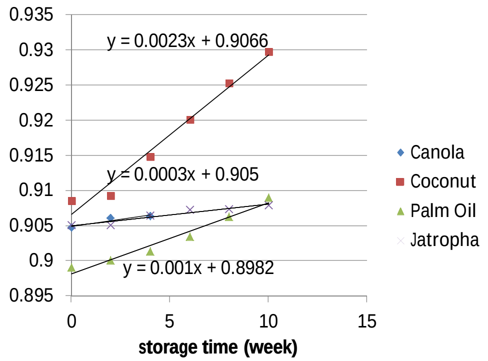

Petrotest Flash Point Meter


Metrohm 873 Biodiesel Rancimat

Results: Density (Room Temp)



Results: Density (80°C)



Discussion

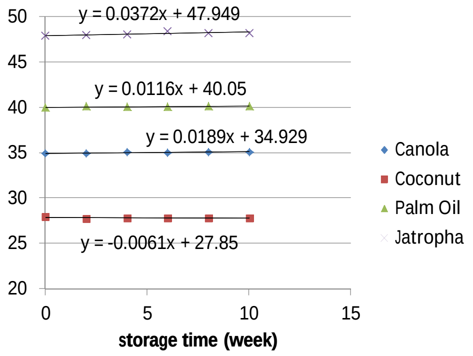
1. Increase in density is due to the formation of sediments, insolubles etc.

(C D Bannister, C. J. (2011). Oxidative Stability of Biodiesel Fuel. *Journal of Automobile Engineering*, 99-114.)

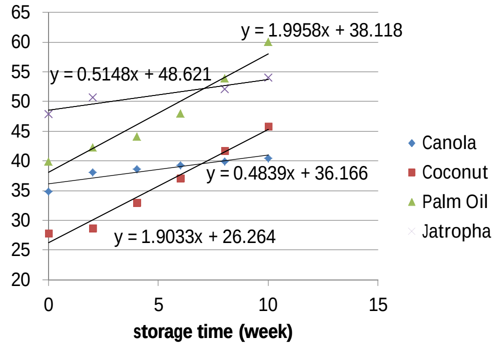
2. Effect of heat accelerates formation of sediments and chemical components, causing density of oil higher at 80°C.

(Redzuan, M. (2010). The Study of Oxidation and Thermal Stability of Biodiesel Fuel)

Results: Viscosity (Room Temp)



Results: Viscosity (80°C)

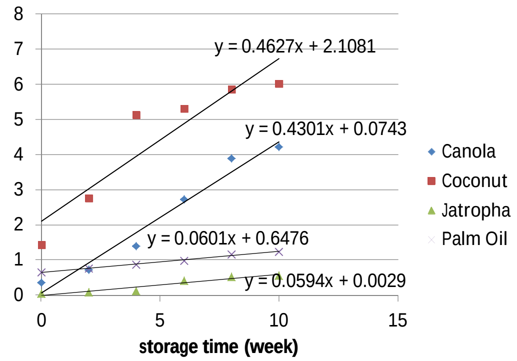


Discussion

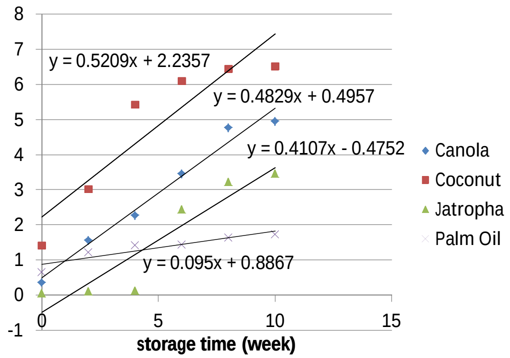
1. Heat accelerates the overall oxidation process. This leads to formation of Free Fatty Acid, therefore increasing the kinematic viscosity of oil

(Yuan Wenqiao, H. A. (2005). Temperature dependent kinematic viscosity of selected biodiesel fuels and blends with diesel fuel. *Journal of the American Oil Chemists Society*)

Results: TAN (Room Temp)



Results: TAN (80ºC)



Discussion

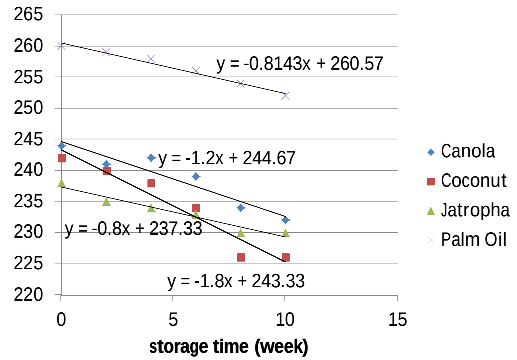
1. Increase in acidity for oil samples is due to formation of peroxides which are the products of oxidation

   (Kiritsakis, A. (. (n.d.). *Chemical-characteristics of Olive Oil.* Retrieved 2nd May, 2012, from http://www.oliveoilsource.com/page/chemical-characteristics)

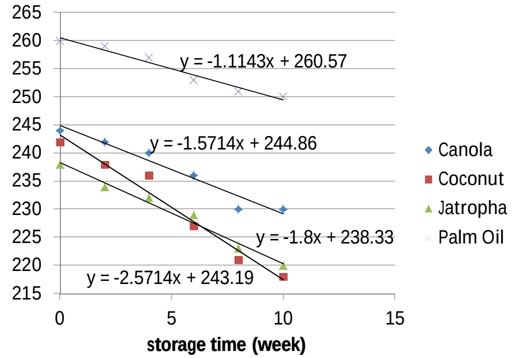
2. Heating effect accelerates the formation of hydroperoxides which will later be oxidized into acid

   (Redzuan, M. (2010). The Study of Oxidation and Thermal Stability of Biodiesel Fuel)

Results: Flash Point (Room Temp)



Results: Flash Point (80°C)



Discussion

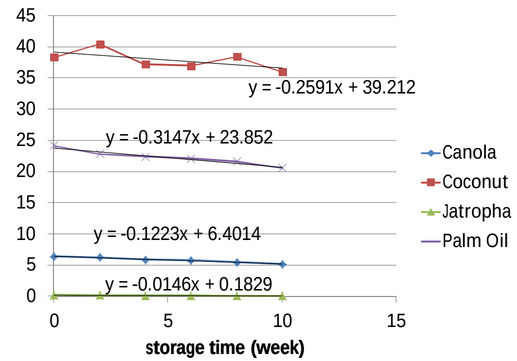
1.Factors that affect the flash point of biofuel are types of molecules;

For e.g., weak dipole-dipole forces between molecules lowers the flash point of the oil sample when compared to strong hydrogen bonding interactions

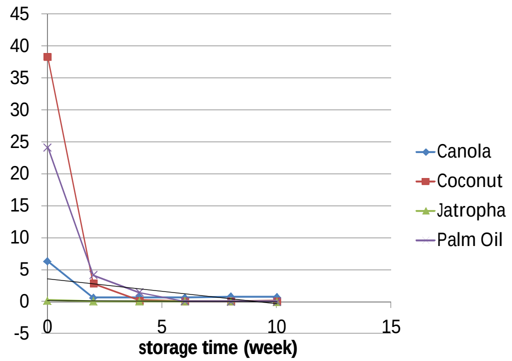
(Chem Purdue. (2008). *Boiling*. Retrieved 3rd May, 2012, from http://www.chem.purdue.edu/gchelp/liquids/boil.html)

2.By heating the oil, heat energy actually weakens the dipole-dipole forces between molecules of methyl ester. The end result of this is a lower flash point for oil samples heated at 80°C.

Results: Oxidation Stability (Room Temp)



Results: Oxidation Stability (80^oC)



Discussion

1. Reason for decrease in oxidation time is due to formation of fatty acids and presence of double bond.
   (Redzuan, M. (2010). The Study of Oxidation and Thermal Stability of Biodiesel Fuel)

2. Heating decreases oxidation stability of biofuel
   (Robert, D. (2008). Effect of temperature on the oil stability index (OSI) of. *Energy & Fuels*)

Experiment Summary Result for oil heated at 80^oC for 10 weeks

	Density	Kinematic Viscosity	TAN	Rancimat Oxidation Test	Flash Point	Choice
Canola Oil	Excellent	Average	Poor	Poor	Poor	3
Coconut Oil	Very Poor	Poor	Poor	Poor	Very Poor	4
Jatropha Oil	Excellent	Average	Average	Very Poor	Average	2
Palm Oil	Good	Poor	Excellent	Average	Average	1

Effect of each property on Implications to the engine

1. Density- Affect the air-fuel ratio of the engine
2. Kinematic Viscosity- Fuel viscosity increases the fuel flow rate decreases
3. TAN- Accelerate the process of oxidation and will have an adverse effect to the engine - corrosion
4. Flash Point-Ensure ignition at the right timing and position of the piston.
5. Oxidation Stability- . Oil samples that are easily oxidized promotes the formation of sediment

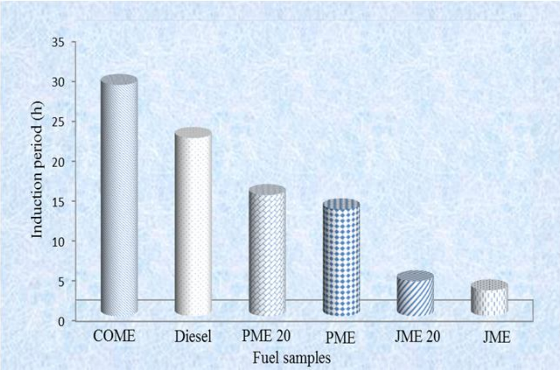
Objective 3: Biodiesel samples

Fuel samples	Compositions
PME	100% Palm methyl ester
PME 20	20% PME and 80% Diesel
Diesel	100% Petroleum diesel
JME	100% Jatropha methyl eater
JME 20	20% JME and 80% Diesel
COME	100% Coconut oil methyl ester

Biodiesel properties

Property	Unit	DIESEL	PME 100	PME 20	JME 100	JME 20	COME 100	Test method
Density	kg/m^3	816.18	843.96	839.15	864.02	847.32	843.11	ASTM D1298
Viscosity at 40°C	cSt	3.63	4.92	4.61	4.81	4.49	3.68	ASTM D445
Acid value	mgKOH/gm	0.25	2.54	2.2	1.18	1.05	0.85	ASTM D664
Base value	mgKOH/gm	13.33	9.29	9.94	10.62	10.9	11.82	ASTM D2894
Flash point	°C	75	259	195	238	206	242	ASTM D93

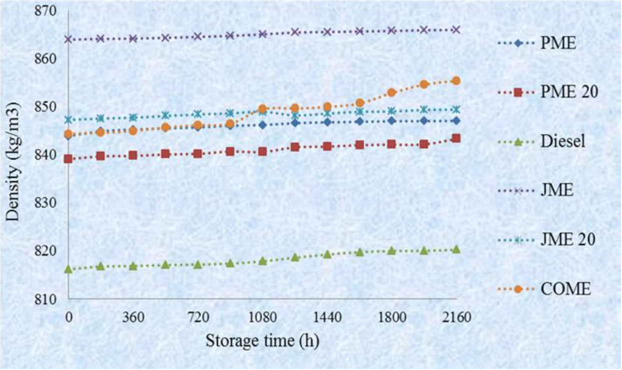
Results: Oxidation stability



Discussion

- Among the biodiesel samples, all met with the standard specification of EN 14112 (min 6 h), except for JME and its blend

Results: Density

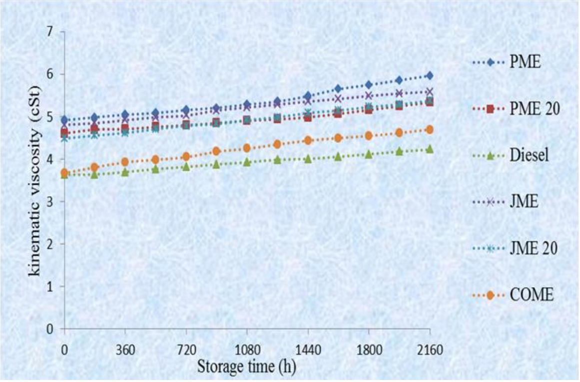


Discussion

1. Similar trend with increase in density

2. Increase in density is due to the formation of sediments, insolubles etc.
(C D Bannister, C. J. (2011). Oxidative Stability of Biodiesel Fuel. *Journal of Automobile Engineering*, 99-114.)

Results: Viscosity (40°C)

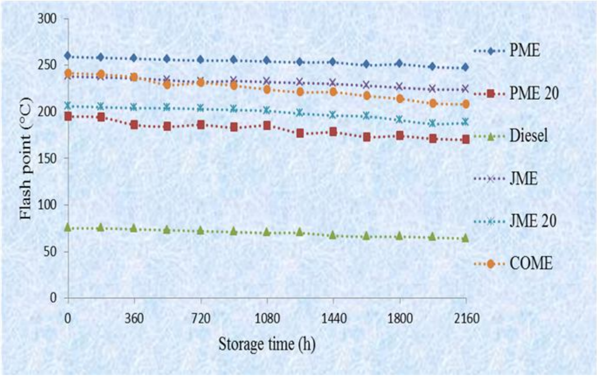


Discussion

1. Viscosity of PME increased from 4.92 to ~ 6 cSt (astm max limit = 6 cSt) after a storage time of 12 weeks (2160 h)

2. Prolonged storage leads to formation of Free Fatty Acid, therefore increasing the kinematic viscosity of oil

Results: Flash point



Discussion

1. The flash points for all biodiesel samples were adequate and above the limiting value (>93°C)

Conclusion

- ✓ Vegetable oil - Palm oil is the biofuel with the best storage stability
- ✓ Biodiesel- COME is the biofuel with the best storage stability
- ✓ Proper biodiesel production technology will further improve storage stability of PME, JME (e.g. acid catalyzed method)
- ✓ JME shows strong potential in terms of storage stability and considering its non-edible source