

## Joint Science Class (Chemistry)

### Making Biofuel from vegetable oil and Testing its ignition performance

Teacher : Yuki Kutsunugi(Chemistry)

Background and today's overview ~ From the viewpoint of SDGs ~

This class focuses on biofuel called " FAME (Fatty acid methyl ester)" . FAME is made from oil and fat, and it has similar properties as diesel oil and kerosene. Vegetable oil is used as cooking oil in the world.

So, If used cooking oil can be reused as fuel, we'll be able to reduce environmental load, right?

If you think so, this lesson is related with the following three SDGs.

Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all

Goal 12. Ensure sustainable consumption and production patterns

Goal 13. Take urgent action to combat climate change and its impacts

First, we make FAME from vegetable oil with alkaline catalyzer. Next, we test the quality of FAME we make. Finally, we discuss about how to use and make biofuel.

#### Principle

\* What is "Vegetable oil" ?

Fat and oil are ester of higher fatty acids (fatty acids with a large number of carbon atoms) and glycerin.

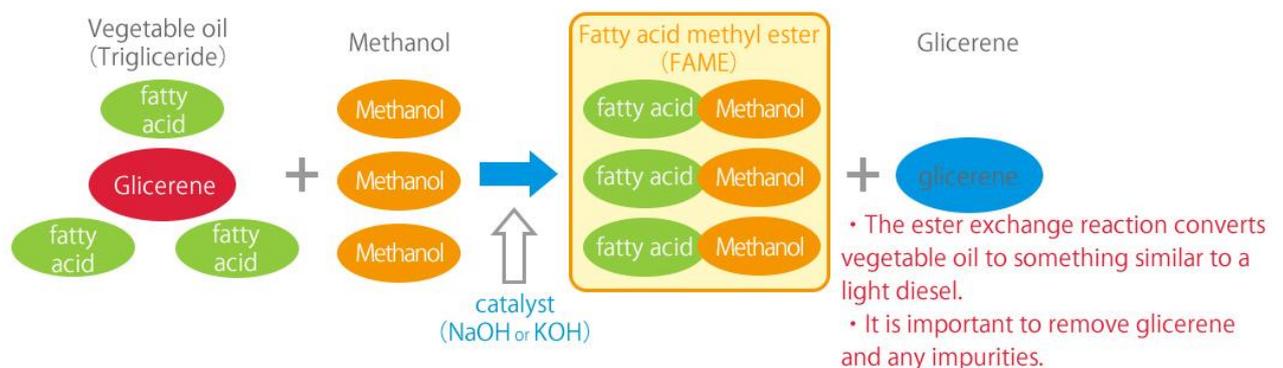
The higher the proportion of unsaturated fatty acids, the lower the melting point of the fat and oil.

\* FAME is a magic fuel?

The physical and chemical properties of vegetable oils are different from the properties of diesel oil.

So we need to change vegetable oils into other liquid fuel. Today, we do this by way of a chemical reaction called ester exchange reaction. This reaction converts vegetable oils to methyl esters.

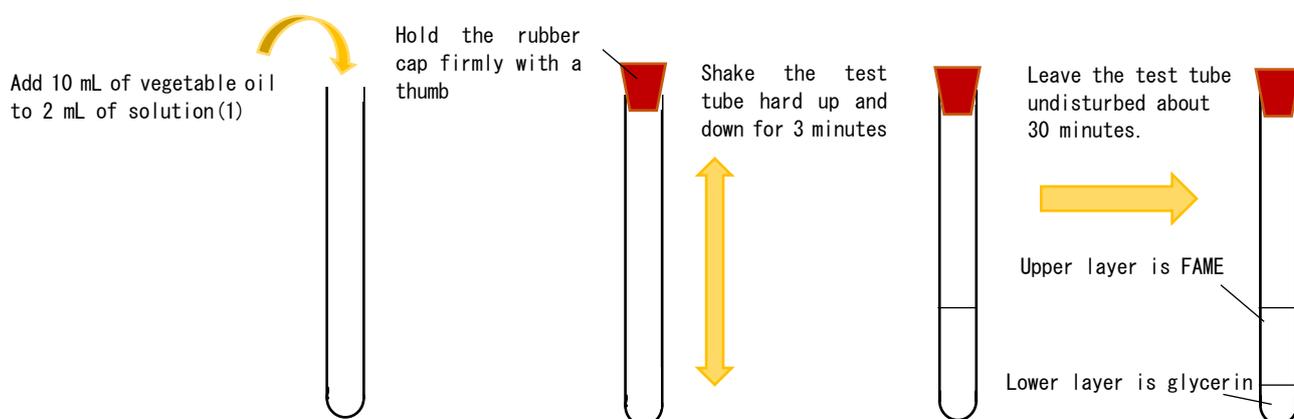
#### Ester Exchange Reaction



## Experiment①

\* Make FAME from vegetable oil

- (1) Weigh out about 0.7 g of sodium hydroxide, put it in a mortar, make it as small as possible, transfer it to a beaker (50 mL), add 20 mL of methanol, and completely dissolve it (equivalent to 10 times).
- (2) In a test tube with a scale, add 10 mL of vegetable oil and 2 mL to solution (1). And put a rubber cap in the test tube.
- (3) Hold the rubber cap firmly with a thumb and shake the test tube hard up and down for 3 minutes (observation ①).
- (4) Leave the test tube undisturbed until the solution splits into two layers. The rubber cap must be on, the process will take about 30 minutes (observation ②).
- (5) The upper layer is (crude) FAME (observation ③)



FAME is a kind of fatty acid ester that can be produced by an alkali-catalyzed reaction of fat or fatty acid with methanol. 1 ton of fat and 0.1 ton of methanol yield 1 ton of FAME and 0.1 ton of glycerin.

FAMEs made from vegetable oils are liquid at room temperature, FAME partially contains a double bond derived from an unsaturated fatty acid that reacts with oxygen in the air, and crosslinks between molecules to form a resin. FAME must be stored with minimum exposure to the air.

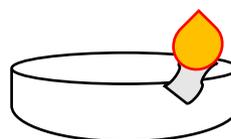
## Experiment②

\* Compare FAME with vegetable oil and kerosene (and diesel oil).

Smell, Colour, Viscosity, Flammability, Ignitability...

※ Flammability test

Put 1mL sample into metal dish, and put a fire with match.



Observe smoke volume, smoke color, flame size...

Observation of a firing experiment with a “Fire Piston”.

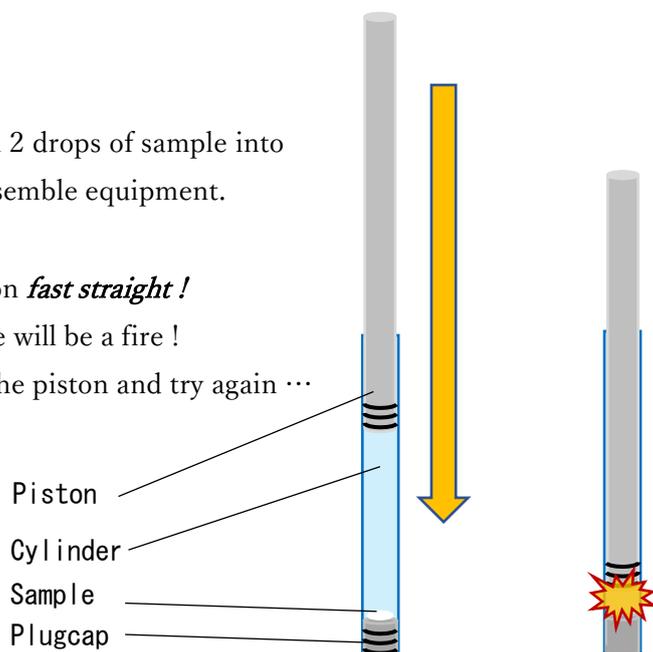
\* Make a fire by compressing the air!

Put wipe paper with 2 drops of sample into the cylinder, and assemble equipment.

Push down the piston *fast straight!*

If you succeed, there will be a fire!

If you fail, pull out the piston and try again ...



\* Why can we make a fire by pushing down the piston?

Especially in the case of fluids (e.g. gas, air...), compressing is an external force that works on the system, and the temperature rises because of a phenomenon called “adiabatic compression”.

Since heat hardly moves in instantaneous compression, the temperature rises in adiabatic compression.

The fire piston and diesel engine as an igniter uses this principle. This device has a structure in which a piston is contained in a closed cylinder, and the temperature rises by rapidly compressing the air in the cylinder with the piston, which ignites the crater.

## Results

Experiment① and ②

	Smell/Colour	Viscosity	Flammability	Ignitability
Vegetable oil				
FAME				
Diesel oil				
Kerosene				

## Discussion

How, or for what purpose can we use used cooking oil (Vegetable oil) ... using it as raw fuel? Translating it to FAME? or other biofuels? Discuss based on today's experiments and the backgrounds in your country.

Your Opinion...

Group Discussion

Name \_\_\_\_\_