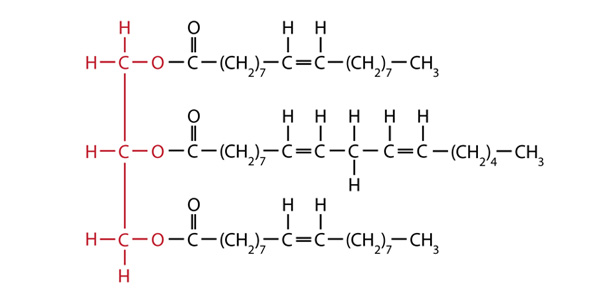
**Production of Biodiesel – Reaction at the *Molecular Level***

Biodiesel is made from canola oil, which is a plant oil. Plant oils are molecules made up of one glycerine molecule and three *long-chain fatty acids*.



three different fatty acids

glycerine

Structure 1: Canola oil: On the left glycerine, on the right three different fatty acids.

The long-chain fatty acids are different in every oil. The *functional group* that *connects* these fatty acids to the glycerine molecule is an **ester**.



Structure 2: The ester bond consists of one carbon atom connected to two oxygen atoms and a *hydrocarbon chain*. The R groups (R1 and R2) represent different hydrocarbon chains.

In a reaction called *esterification*, an ester and one water molecule are formed from a carboxylic acid and an alcohol.

  
 carboxylic acid alcohol ester water

The reverse reaction, the reaction of an ester with water to produce a carboxylic acid and an alcohol is called *hydrolysis*.

|  |  |  |
| --- | --- | --- |
|  |  |  |
| ester water |  | carboxylic acid alcohol |
|  |  |  |

To name an ester, the following formula is used

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name of the carboxylic acid | + | name of the alkyl rest of the   alcohol | + | ending: “ester” |

For example:

|  |  |  |
| --- | --- | --- |
|  |  |  |
| acetic acid ethanol |  | acetic acid ethyl ester water |

When canola oil reacts with methanol in the presence of a catalyst (sodium hydroxide - NaOH), the three ester bonds between the glycerine and fatty acids are broken (hydrolysis). Then, each methanol molecule reacts with one of the three long-chain fatty acid to produce three molecules of *canola methyl ester* known as biodiesel (esterification).

The characteristics of biodiesel are very similar to those of diesel, especially its *viscosity, density* and *heat of combustion*. Biodiesel is also easily stored and normal diesel can be mixed with biodiesel and combusted in the same engine. Unfortunately, a biodiesel molecule burns with 20% less energy than a diesel molecule. Therefore, more biodiesel is needed to drive one kilometer than diesel.

**C:\Users\Jana_User\AppData\Local\Microsoft\Windows\Temporary Internet Files\Content.IE5\GZ0O8FHI\MC900438012[1].wmfQuestion**

1. Canola oil reacts with methanol to produce one glycerol molecule and three canola methyl esters during   
   1. **hydrolysis** (reaction of canola oil with water to produce glycerol and three carboxylic acids) and  
    2. **esterification** (reaction of three carboxylic acids with methanol to produce three water molecules and three canola methyl esters).
2. Write the reaction equations using structural formulas for both hydrolysis and esterification.



glycerol

1. Why did the biodiesel have to be “washed” three times with water?