



# The Chemistry of Biodiesel

# Organic Chemistry

- Organic chemistry is the chemistry of the element carbon.
- Carbon atoms have a great flexibility in bonding with themselves and other atoms
- Around 90% of all known compounds are organic compounds
- There are close to 10 million organic compounds

# Common Elements in Organic Chemistry

**Table 3. Some elements of importance to organic chemistry.**

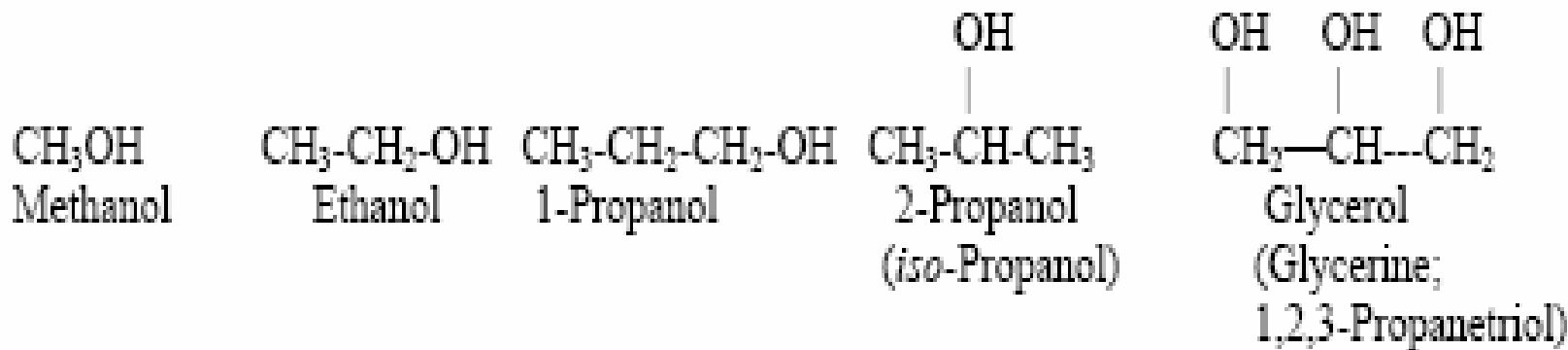
Name	Symbol	Atomic Number	Atomic Weight
Carbon	C	6	12.011
Hydrogen	H	1	1.008
Nitrogen	N	7	14.007
Oxygen	O	8	15.9994
Phosphorus	P	15	30.974
Sulfur	S	16	32.06

# Important Families of Organic Compounds in relation to biodiesel

- Alcohols
  - Methanol
  - Ethanol
- Carboxylic acids
  - Free fatty acids
- Lipids
  - Triglycerols
  - Glycerophospholipids
  - Waxes
- Esters
  - Methyl esters
  - Ethyl esters

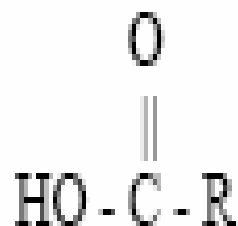
# [ Alcohols ]

- There are many different types of alcohols
- The common feature present in all alcohols is an -OH, or hydroxyl, functional group
- This functional group often dictates the behavior and reactivity of the organic molecule

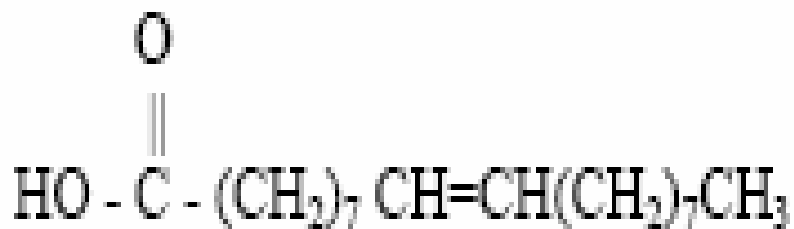


# [ Carboxylic acids ]

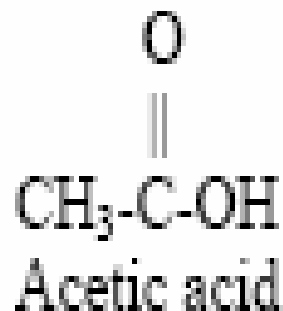
An organic compound containing the  $\text{-COOH}$ , or carboxyl functional group



Carboxylic Acid (R is a carbon chain)



Oleic Acid



# [ Lipids ]

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- Lipids come in a variety of molecular structures:
  - Triacylglycerols – fats and oils
  - Phospholipids
  - Sphingolipids
  - Steroid hormones
  - Cholesterol

# [ Triglycerols ]

- Triglycerols, or triglycerides, are the most prevalent type of storage lipid in plants and animals.
- They are also the most common biodiesel **feedstock**
- There are several different types of triglycerols
  - Saturated – no C=C double bonds
  - Unsaturated – one or more C=C double bonds
  - Hydrogenated or Trans fats –catalyzed, trans-saturated oils



# [ Triacylglycerols ]

## ■ Saturated

Palmitic:  $R = -(\text{CH}_2)_{14} - \text{CH}_3$

16 carbons, (including the one that R is attached to.) (16:0)

## ■ Unsaturated

### ○ Monounsaturated

Oleic:  $R = -(\text{CH}_2)_7 \text{CH}=\text{CH}(\text{CH}_2)_7\text{CH}_3$

18 carbons, 1 double bond (18:1)

### ○ Polyunsaturated

Linoleic:  $R = -(\text{CH}_2)_7 \text{CH}=\text{CH}-\text{CH}_2-\text{CH}=\text{CH}(\text{CH}_2)_4\text{CH}_3$

18 carbons, 2 double bonds (18:2)

# [ Esters



Ester

- Esters are formed by the reaction of an acid with an alcohol
  - This is known as an **esterification** reaction
  - The hydrolysis of an ester with a strong base is known as **saponification**, the process of making soap

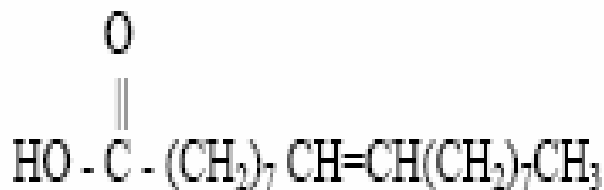


Figure 6. Oleic Acid

+



Methyl oleate (biodiesel)

# [ Transesterification ]

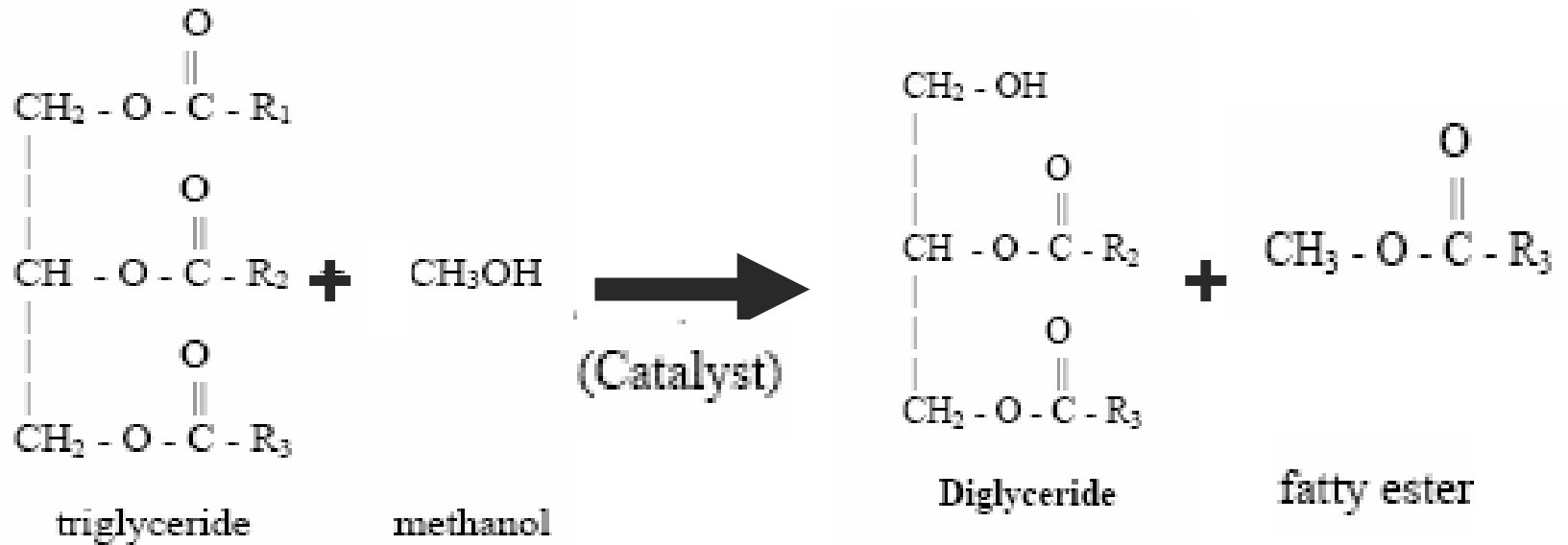
a step-by-step visual guide



Catalyst



# [ Step 1 ]



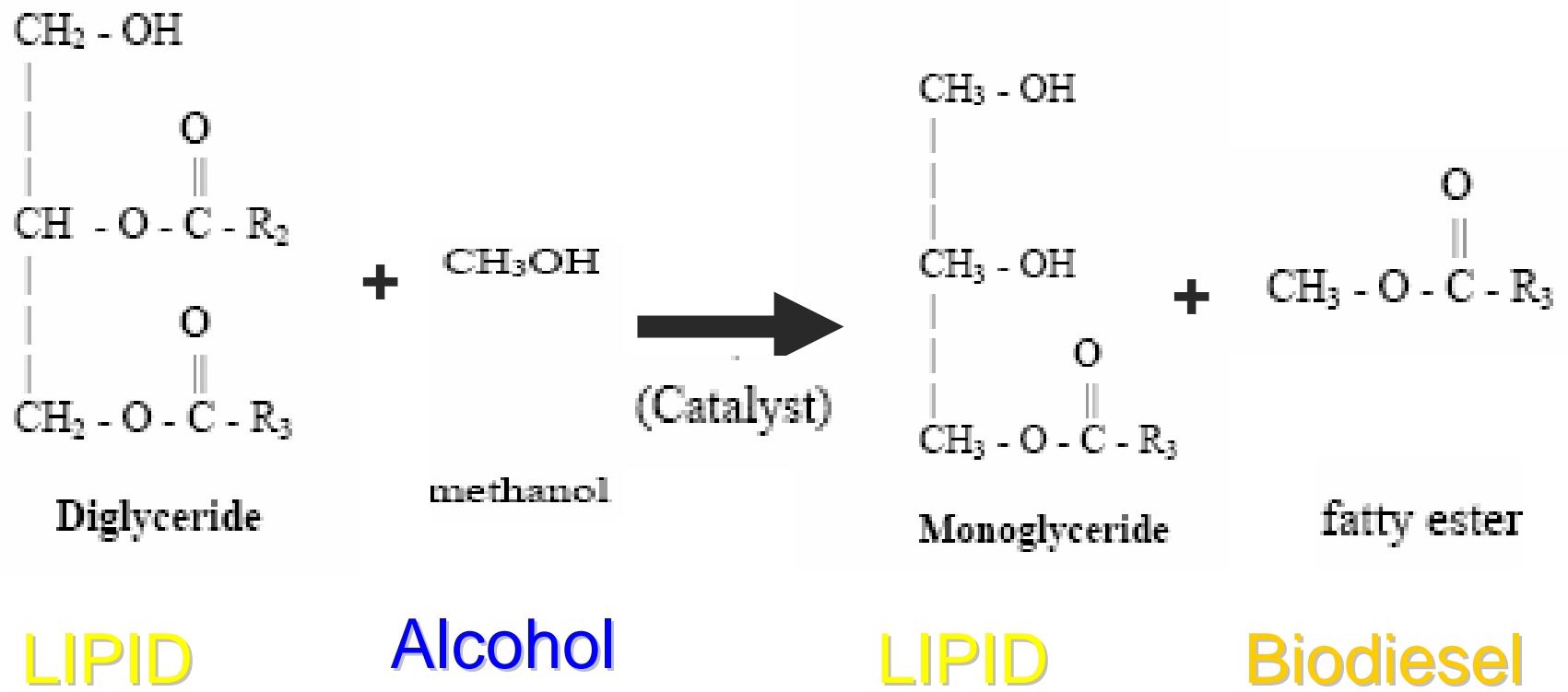
LIPID

Alcohol

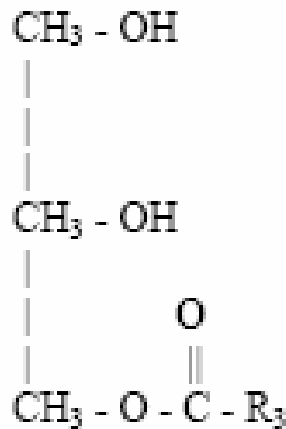
LIPID

Biodiesel

# [ Step 2: ]



# Step 3

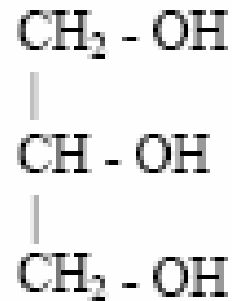


Monoglyceride

+



methanol



glycerol

+



fatty ester

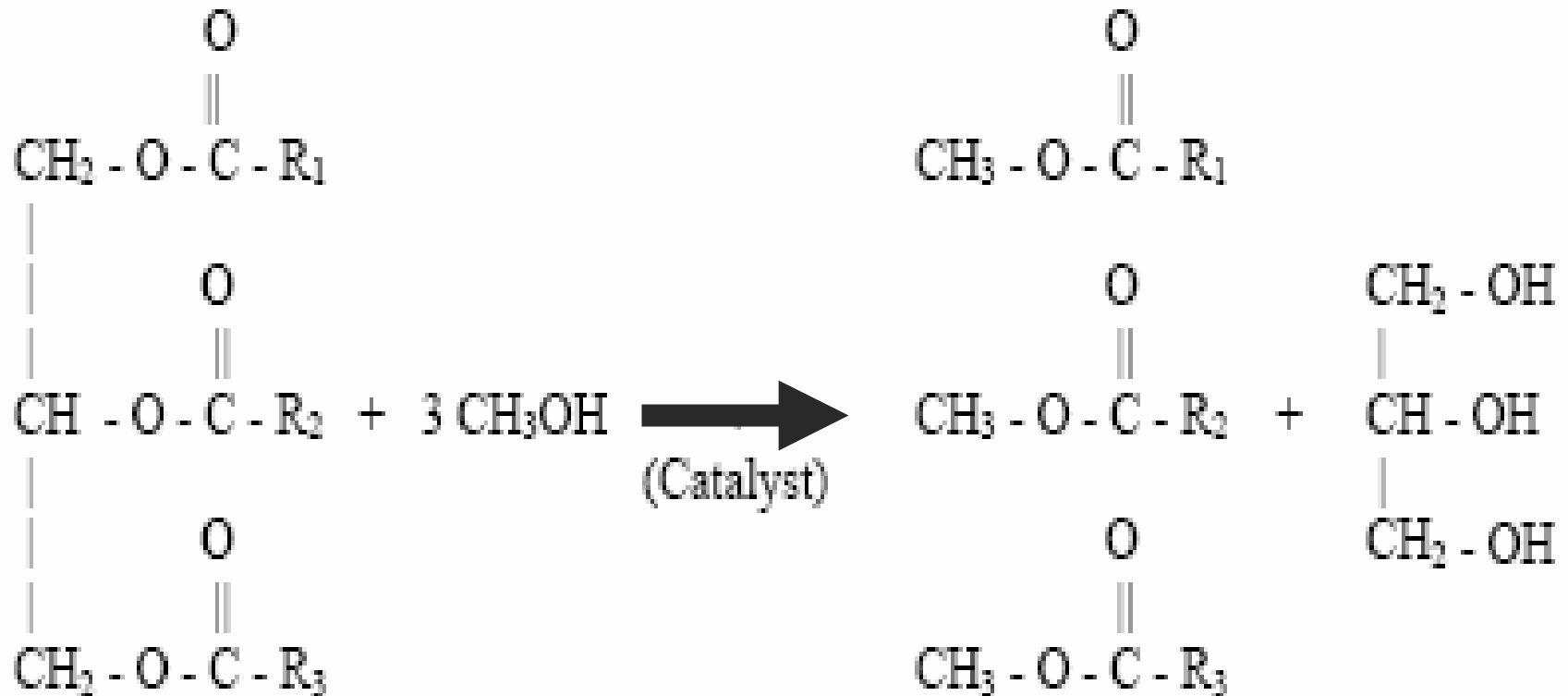
LIPID

Alcohol

glycerol

Biodiesel

# Overview



triglyceride

methanol

mixture of fatty esters

glycerol

**LIPID**

**Alcohol**

**Biodiesel**

**glycerol**