Problem set 2

Lipids

1. For the following triacylglycerol, write the reduction reaction (hydrogenation). Use a transition metal as a catalyst. Identify the following molecule as an oil or a fat:

\[
\begin{align*}
\text{CH}_2\text{O-C-(CH}_2)_2\text{-CH=CH}-\text{CH}_2\text{-CH}=&\text{CH-(CH}_2)_2\text{-CH}_3 \\
\text{CH}_2\text{O-C-(CH}_2)_2\text{-CH=CH-(CH}_2)_2\text{-CH}_3 \\
\text{CH}_2\text{O-C-(CH}_2)_3\text{-CH=CH-(CH}_2)_2\text{-CH}_3 \\
\text{CH}_2\text{-O-} &\text{Ni} \rightarrow \\
\text{CH}_2\text{-O-} &\text{Ni} \rightarrow \\
\text{CH}_2\text{-O-} &\text{Ni} \rightarrow \\
\end{align*}
\]

\[
\begin{align*}
\text{CH}_2\text{-OH} &\text{Na}_2\text{O}_2\text{-C-(CH}_2)_n\text{-CH=CH-(CH}_2)_m\text{-CH}_3 \\
\text{CH}_2\text{-OH} &\text{Na}_2\text{O}_2\text{-C-(CH}_2)_n\text{-CH=CH-(CH}_2)_m\text{-CH}_3 \\
\text{Glycerol} &\text{Na}_2\text{O}_2\text{-C-(CH}_2)_n\text{-CH=CH-(CH}_2)_m\text{-CH}_3 \\
\text{Soap (salt of fatty acid)} &\text{Na}_2\text{O}_2\text{-C-(CH}_2)_n\text{-CH=CH-(CH}_2)_m\text{-CH}_3 \\
\end{align*}
\]

2. For triacylglycerol in question 1, write the saponification reaction. What do we need for this reaction? Balance the reaction at the end.

\[
\begin{align*}
\text{CH}_2\text{-OH} &\text{Na}_2\text{O}_2\text{-C-(CH}_2)_n\text{-CH=CH-(CH}_2)_m\text{-CH}_3 \\
\text{CH}_2\text{-OH} &\text{Na}_2\text{O}_2\text{-C-(CH}_2)_n\text{-CH=CH-(CH}_2)_m\text{-CH}_3 \\
\text{Glycerol} &\text{Na}_2\text{O}_2\text{-C-(CH}_2)_n\text{-CH=CH-(CH}_2)_m\text{-CH}_3 \\
\text{Soap (salt of fatty acid)} &\text{Na}_2\text{O}_2\text{-C-(CH}_2)_n\text{-CH=CH-(CH}_2)_m\text{-CH}_3 \\
\end{align*}
\]

3. For triacylglycerol in question 1, write the hydrolysis reaction. Use heat and an acid as a catalyst. Balance the reaction at the end.

\[
\begin{align*}
\text{CH}_2\text{-OH} &\text{H}_2\text{O} \text{heat} \rightarrow \\
\text{CH}_2\text{-OH} &\text{H}_2\text{O} \text{heat} \rightarrow \\
\text{Glycerol} &\text{H}_2\text{O} \text{heat} \rightarrow \\
\text{Fatty acid} &\text{H}_2\text{O} \text{heat} \rightarrow \\
\end{align*}
\]

4. Using your textbook as a reference, build a triacylglycerol made with palmitoleic, oleic and myristic acids. Draw a line structure of the molecule. Circle the hydrophobic region of the molecule. Put a box around the hydrophilic region of the molecule. Predict the state this substance would be in at room temperature. Explain your reasoning.
5. Using your textbook as a reference, draw structures for the following molecules/ions. Construct and name the type of lipid containing these molecules/ions. Circle the hydrophobic region. Draw a box around the hydrophilic regions.

a) Oleic acid  
\[ HO-\overset{\delta}{\overset{o}{\text{C}}}- (CH_{2})_{7}-CH=CH-(CH_{2})_{4}-CH_{3} \]  
Oleic acid

b) Linoleic acid  
\[ HO-\overset{\delta}{\overset{o}{\text{C}}}- (CH_{2})_{8}-CH=CH-(CH_{2})_{4}-CH_{3} \]  
Linoleic acid

6. Using your textbook as a reference, draw line structures for and construct the following molecules/ions. Then, construct and name the type of lipid containing these molecules/ions.

a) 1 molecule of lauric acid  
\[ HO-\overset{\delta}{\overset{o}{\text{C}}}- (CH_{2})_{10}-CH_{3} \]  
Lauric acid

b) Sphingosine  
\[ HO-CH_{2}CH(CH_{2})_{13}CH_{3} \]  
Sphingosine

7. What type of lipids found in cell membranes? What type of lipids found in hormones?

Phospholipids - Steroids (Cholesterol)

Because there are two unsaturated fatty acids.
8. Identify the components contained in the following lipids:

1. phosphoacylglycerol → two fatty acids, phosphate ion, glycerol, alcohol
2. sphingomyelin → one fatty acid, sphingosine, phosphate ion, alcohol
3. triacylglycerol → three fatty acids, glycerol
4. fatty acids → carboxyl group, long chain of carbon (unbranched)
5. wax → hydroxyl group, amino group, fatty acid and long chain alcohol
6. cephalin

9. A sink drain can become clogged with solid fat such as glyceryl tristearate.

a) How would adding NaOH to the sink drain remove the blockage?
b) Write an equation for the reaction that occurs.

After saponification (reaction with NaOH), product become polar and they are soluble in water.

\[ CH_2-C-O-(CH_2)_8-C=CH_2 + 3NaOH \rightarrow CH_2-OH + CH_2-OH + CH_2-OH \]

10. Identify the type of the following glycerophospholipid and list its components:

- Type: Cephalin
- Fatty acids
- Phosphate ion
- Ethanolamine (Amino Alcohol)

11. Describe the difference between triacylglycerols and glycerophospholipids.

Triacylglycerol: nonpolar (not soluble in water and our blood). It consists of three fatty acids and one glycerol. We store energy using triacylglycerols.

Glycerophospholipids: half polar-half nonpolar (soluble in water and our blood). It consists of two fatty acids, glycerol, phosphate ion, alcohol. It is part of cell membrane.

12. Draw the structure of an ester in beeswax formed from myricyl alcohol, \( CH_3(CH_2)_{26}OH \), and palmitic acid \( CH_3(CH_2)_{14}COOH \).

\[ CH_3(CH_2)_{14}O-C-OH + HO-(CH_2)_23-C=CH_3 \rightarrow CH_3(CH_2)_{14}O-C-O-(CH_2)_{23}-CH_3 + H_2O \]

Fischer Esterification

Wax (an ester)
Similarities: Both have carbonyl group (-C=O). Both are long-chain unbranched carbon.

13. Describe some similarities and differences in the structure of a saturated fatty acid and an unsaturated fatty acid.

Saturated fatty acids: they have only C-C single bond. They are solids at room Temp. we can find them in animal sources food.

Unsaturated fatty acids: they have one or more C=C double bond. They are liquids at room Temp. we can find them in plant sources food.

14. Which of the following solvents might be used to dissolve an oil or fat?

a) water  b) CCl₄  c) benzene  d) NaCl solution  d) ethanol

Oil and fat are nonpolar and they are soluble in nonpolar solvents.