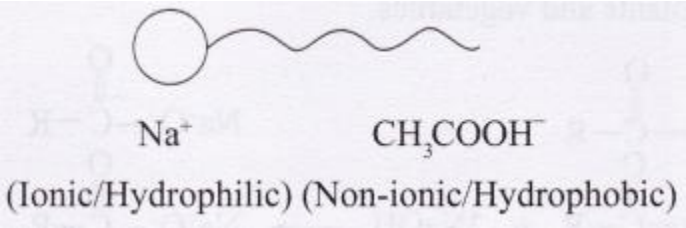
Soap Preparation

Introduction

> Traditional soap is a product obtained by the hydrolysis of fats from animals and vegetable oils from plants.
> Soaps are molecules of sodium or potassium salts of long chain carboxylic acids.
> It has tadpole shape with long carboxylic acid chain, non-ionic (hydrocarbon) and ions attached to it like Na+.



> The ionic-end of soap dissolves in water while the carbon chain dissolves in oil.
> Soaps containing sodium salts are formed by heating fat (i.e., glyceryl ester of fatty acid) with aqueous sodium hydroxide solution. This reaction is known as saponification.
> In this reaction, esters of fatty acids are hydrolysed and the soap obtained remain in colloidal form.
> It is precipitated from the solution by adding NaCl.
> The stearic acid molecule $C_{17}H_{35}COOH$ or $CH_3(CH_2)_{16}COOH$ is a typical long chain fatty acid obtained from naturally occurring plant oils and used to make traditional soaps.
> The salt sodium stearate $C_{17}H_{35}COO^-Na^+$, formed when stearic acid is neutralised with sodium hydroxide is a typical soap molecule.
> Only sodium and potassium soaps are soluble in water.
> Sometimes fillers are added to the soap to increase their value. For e.g., medicated soaps contain substances of medicinal value. Laundry soaps contain sodium rosinate for better lather formation. Perfumes, glycerol, etc. are also added.
> Generally, potassium soaps are soft to the skin than sodium soaps. These can be prepared by using KOH instead of NaOH.

Advantages of Soap

> Soaps are easily degradable.
> Soaps are soft to the skin.
> It is used in cleaning laundry.

Disadvantages of Soap

> Soap is less effective in cleaning stubborn stains of clothes/laundry.
> Soap forms scum with hard water. Hence, larger amount of soap is needed to wash clothes in hard water.

EXPERIMENT – 6

Aim

To study saponification reaction for preparation of soap.

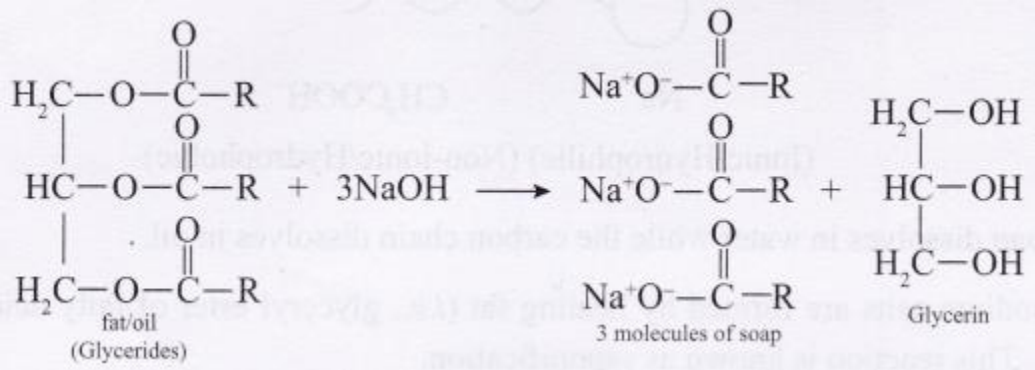
Theory

Chemically soap is the sodium or potassium salt of a long chain carboxylic acid or glycerol. These carboxylic acids contain 15-18 carbon atoms i.e., long chain of hydrocarbon.

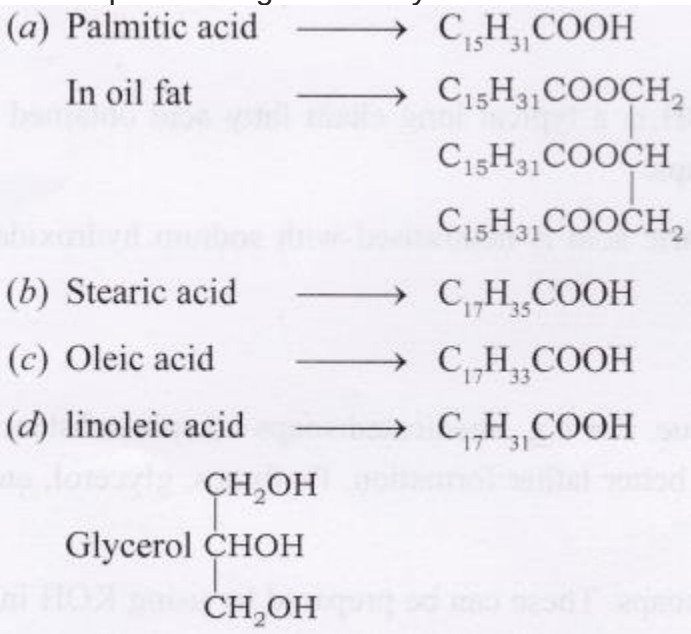
> **Hydrophobic end:** The end of soap molecule that repels water, it is the hydrocarbon chain.

> **Hydrophilic end:** The end of soap molecule that is ionic and attracts water.

> **Glycerides:** They are esters of glycerol, an alcohol containing three hydroxyl groups and fatty acids. Glycerides are present



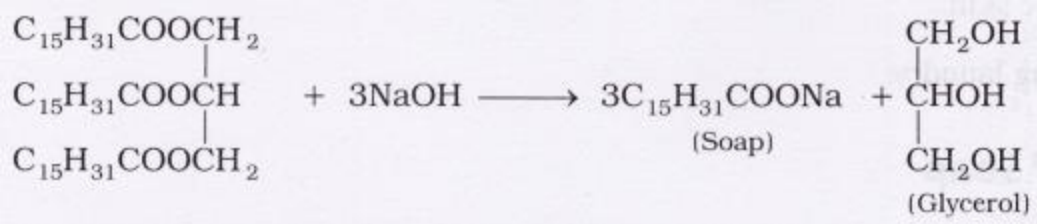
> Examples of long chain fatty acid.



> Saponification: It is the process in which esters are split with the help of an alkali. Esters are reacted with sodium hydroxide salt to form sodium salt of acid and alcohol.

Chemical reaction of soap

Oil or fat + sodium hydroxide —> soap + glycerol



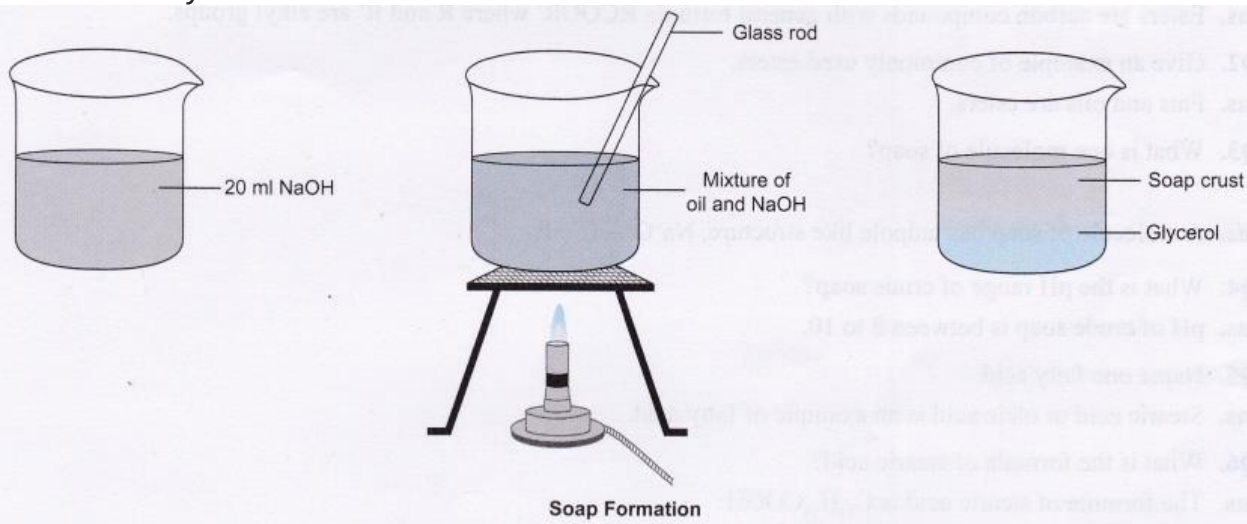
> In the above reaction, esters of fatty acids are hydrolysed and the soap obtained remain in colloidal form.
> Soap is then precipitated from the solution by adding NaCl.

Materials Required

Beakers, a glass rod, red litmus paper strip, knife, tripod stand, bunsen burner, wire gauze and pair of tongs.
Chemical required: Sodium hydroxide solution, plant oil (Use castor oil + oleic acid) and common salt.

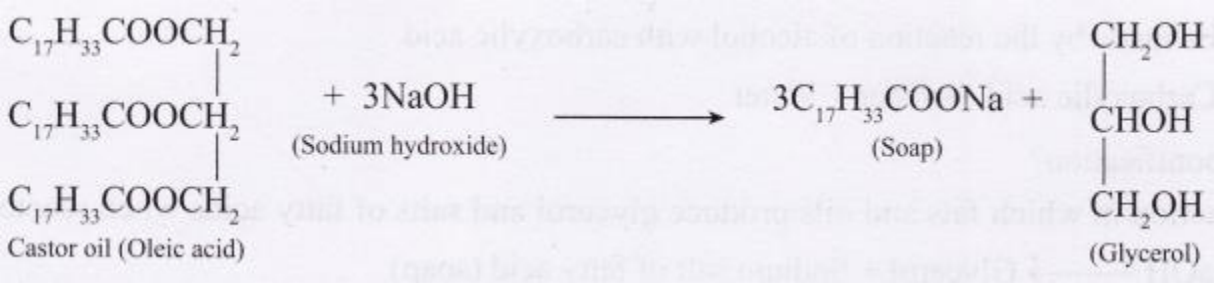
Procedure

1. Take a beaker and add 20 mL of castor oil into it. Heat the oil by constant stirring.
2. Take 20 mL of concentrated sodium hydroxide solution in another beaker.
3. Add the sodium hydroxide solution into the beaker containing hot castor oil. Heat the mixture slowly to boil for about 10 minutes.



4. Dip the red litmus paper strip into this reaction mixture. Note and record your observation.
5. Now, add 5 g of sodium chloride into this mixture with constant stirring and then allow it to cool. Addition of common salt decreases the solubility of soap. The soap molecules get separated from the solution and floats on the surface. This is called salting out of soap.
6. On cooling the beaker, a crust is formed on the surface of the liquid. This crust is called soap.
7. Remove the soap cake and cut it into desired shapes and sizes.
8. The castor oil will produce a soap molecule named sodium oleate ($C_{17}H_{33}COONa$).

Chemical Equation



Observations

1. The heated mixture of oil and caustic soda forms a pale yellow thick liquid.
2. The red litmus turns blue in this soap solution.

Conclusion

The reaction mixture of (oil) carboxylic acid with sodium or potassium hydroxide produces a soap molecule.

ilk Precautions

1. Be careful while handling concentrated sodium hydroxide as it is corrosive in nature.
2. Do not overheat the beaker while heating.
3. Stir the soap solution carefully so that it does not spill out.
4. Add very small amount of common salt for salting out of soap.

Viva Voce

Question 1:

What are esters?

Answer:

Esters are carbon compounds with general formula RCOOR' where R and R' are alkyl groups.

Question 2:

Give an example of commonly used esters.

Answer:

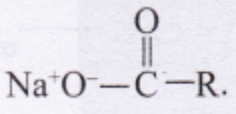
Fats and oils are esters.

Question 3:

What is one molecule of soap?

Answer:

A molecule of soap has tadpole like structure,



Question 4:
What is the pH range of crude soap?
Answer:
pH of crude soap is between 8 to 10.

Question 5:
Name one fatty acid.
Answer:
Stearic acid or oleic acid is an example of fatty acid.

Question 6:
What is the formula of stearic acid?
Answer:
The formula of stearic acid is $C_{17}H_{35}COOH$.

Question 7:
What is the formula of the soap with stearic acid?
Answer:
The formula of the soap with stearic acid is $C_{17}H_{35}COONa$.

Question 8:
What is the nature of the soap?
Answer:
Soap is basic in nature. It turns red litmus blue.

Practice Based Questions

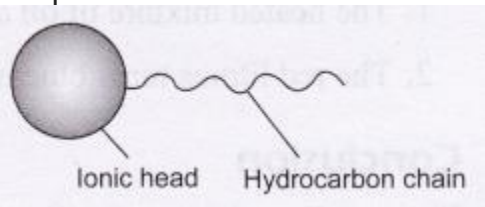
Question 1:
What is glycerol?
Answer:
It is an alkanol with 3 hydroxyl groups and the formula is $CH_2OH\text{-}CHOH\text{-}CH_2OH$.

Question 2:
How are esters made?
Answer:
Esters can be made by the reaction of alcohol with carboxylic acid.
Alcohol + Carboxylic acid —> Ester + Water

Question 3:
What is saponification?
Answer:
It is the reaction in which fats and oils produce glycerol and salts of fatty acids when reacted with a base.
Fat/oil + NaOH —> Glycerol + Sodium salt of fatty acid (soap)

Question 4:
What happens when soap is dissolved in water?
Answer:
The ions making the soap is dissolved.

Question 5:
What does hydrophobic and hydrophilic parts of soap mean to you?
Answer:
A soap molecule has ionic head which attracts water and is called hydrophilic.
The long hydrocarbon chain stays away from water and is called hydrophobic part of soap.



Question 6:
What is soap?
Answer:
Soap is the sodium or potassium salt of fatty acid.

Question 7:
Name one by-product of soap formation.
Answer:
Glycerol is the by-product of soap formation.

Question 8:
Name the part of the soap molecule which attracts water.
Answer:
The part of the soap molecule which attracts towards water is called hydrophilic part.

Question 9:
Give one advantage of soap over detergent.
Answer:
Soap is biodegradable but detergent is not.

Question 10:
Give one advantage of detergent over soap.
Answer:
Detergent shows its cleansing property in hard water but soap does not show cleansing property in hard water.

Question 11:
What happens when soap is added in hard water?
Answer:
Soap reacts with the salts present in hard water and forms scum and loses its cleansing property.

Question 12:
What are detergents?
Answer:
Detergent are sodium salts of long chain benzene sulphonic acid.

NCERT Lab Manual Questions

Question 1:
Why does a red litmus paper changes its colour when dipped in soap solution? Explain your observation.
Answer:
The red litmus paper changes to blue colour when dipped in soap solution. This is because soap is a basic in nature and has pH more than 7.

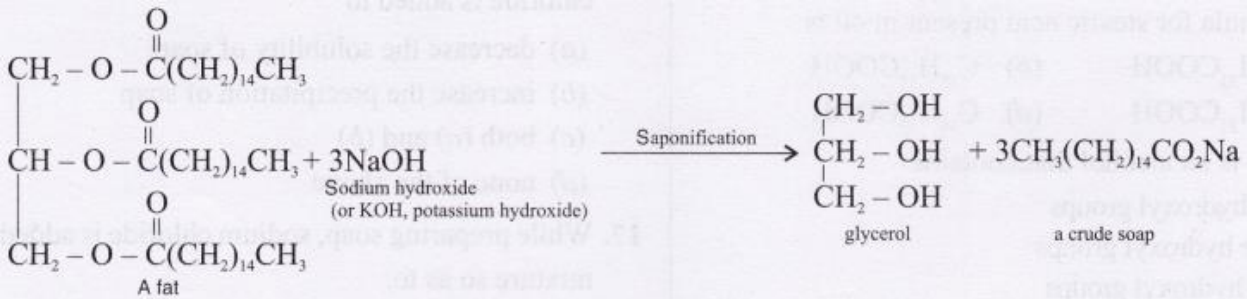
Question 2:
Why is it advised to add common salt while preparing the soap?
Answer:
Addition of common salt decreases the solubility of soap.

Question 3:
Can we use Na_2CO_3 instead of NaOH? Explain.
Answer:
On using Na_2CO_3 instead of NaOH the yield will be less and hence it is not advisable to use weak base like Na_2CO_3 for soap preparation.

Question 4:
Was heat evolved or absorbed when sodium hydroxide was added to oil?
Answer:
Heat is evolved when sodium hydroxide is added to oil.

Question 5:
What is the chemical reaction involved in the manufacture of soap?
Answer:

The chemical reaction involved in the preparation of soap is:



Question 6:
Can you devise a method to separate glycerine from the reaction mixture?
Answer:
Glycerine can be separated by adding salt. The soap mixture gets separated into different layers. The top layer is soap and bottom layer is glycerine. The top layer is drained out.

Multiple Choice Questions (MCQs)

Questions based on Procedural and Manipulative Skills

1. Soap is formed from
(a) two hydrophobic compounds
(b) two hydrophilic compounds
(c) reaction of fats and oils on heating
(d) reaction of oil/fat with alkali

2. Soaps act by
(a) forming micelles and trapping the fat/grease with the micelles.
(b) hydrolysis of Na in water
(c) a chemical reaction between dirt and soap
(d) a chemical reaction of fat and dirt.

3. Soaps are precipitated by salting it out with saturated
(a) sodium carbonate
(b) sodium chloride
(c) sodium hydroxide .
(d) sodium bicarbonate

4. Saponification is the hydrolysis of an ester under basic conditions to form a salt of carboxylic acid and
(a) alcohol
(b) ethanol

(c) alkane
(d) aldehyde

5. In soap preparation, the alkali bond on hydrolysis breaks the ester bond to release
(a) fatty acid salt and glycerol
(b) linoleic acid salt and glycerol
(c) ethanoic acid salt and alkane
(d) fatty acid, salt and glycol.

6. Ester is formed by the reaction of
(a) alcohol and base
(b) alcohol and acid
(c) acid and base
(d) base and salt

7. The functional group of acid used in making soap is
(a) —COOH
(b) —COOOH
(c) —CH_3OOH
(d) — $HCOOH_2$

8. The formula for stearic acid present in oil is
(a) $C_{17}H_{35}COOH$
(b) $C_{15}H_{31}$ COOH
(c) $C_{17}H_{31}$ COOH
(d) $C_{15}H_{37}$ COOH

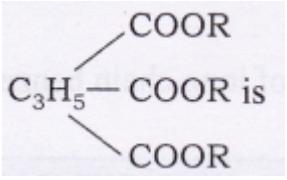
9. Glycerol is an alcohol that contains
(a) two hydroxyl groups
(b) three hydroxyl groups
(c) four hydroxyl groups
(d) one hydroxyl group

10. The reaction used for preparation of soap is
(a) esterification
(b) glycolysis
(c) saponification
(d) neutralisation

11. The by-product obtained during preparation of soap is
(a) salt
(b) sodium hydroxide
(c) glycol
(d) glycerol

12. Oil and fats commonly used for preparation of soap are called
(a) carboxylic acids
(b) esters
(c) alcohol
(c) glycerol

13. The pH-range of crude soap obtained during saponification of fats/oil and caustic soda is
(a) 7-8
(b) 8-10
(c) 5-7
(d) 10-12

14. 

(a) 3 molecules of glyceride
(b) one molecule of glyceride
(c) 1 compound of glyceride
(d) 3 compounds of glyceride

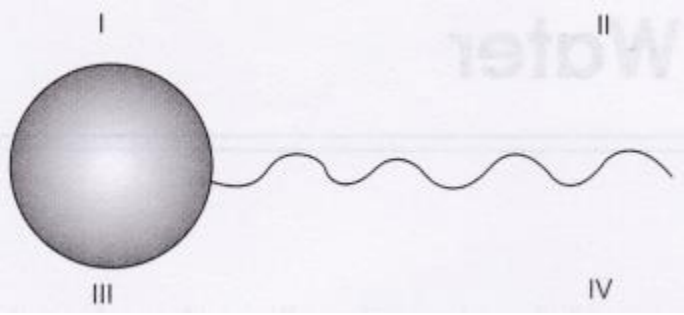
15. In the preparation of soap, a small amount of sodium chloride (common salt) is added to the mixture of fat and sodium hydroxide. The role of common salt is to **[*Outside Delhi* 2013]**
(a) favour the precipitation of soap
(b) enhance the cleansing capacity of soap
(c) increase the weight of the soap to earn money
(d) decrease the acidity of the soap

Questions based on Observational Skills

16. During preparation of soap, common salt, i.e., sodium chloride is added to
(a) decrease the solubility of soap
(b) increase the precipitation of soap
(c) both (a) and (b)
(d) none of the above

17. While preparing soap, sodium chloride is added in the mixture so as to:
(a) complete saponification
(b) complete precipitation
(c) increase the bulk
(d) dissolve the soap.

18. A molecule of soap has four parts labelled on it. The correct pair is



(a) I-hydrocarbon chain
(b) II-hydrophilic
(c) Ill-ionic head
(d) IV-hydrophobic.

19. Soap solution is:
(a) acidic lb) basic
(c) neutral (d) highly acidic.

20. Soaps are better than detergents because:
(a) soaps are biodegradable
(b) soaps show maximum foaming
(c) soaps are basic in nature
(d) soaps have better cleansing action.

21. Detergents are better than soaps because:
(a) detergents are biodegradable
(b) they work better with hard water
(c) they are acidic in nature
(d) they are cheaper than soaps.

Questions based on Reporting and Interpretation Skills

22. In order to study saponification reaction we first prepare 20% solution of sodium hydroxide. If we record the temperature of this solution just after adding sodium hydroxide flakes to water and also test its nature using litmus, it may be concluded that the process of making this solution is: **[Delhi 2014]**
(a) exothermic and the solution is alkaline.
(b) endothermic and the solution is alkaline.
(c) endothermic and the solution is acidic.
(d) exothermic and the solution is acidic.

23. While studying saponification reaction for the preparation of soap, the teacher suggested to a student to add a small quantity of common salt to the reaction mixture. The function of common salt in this reaction is to: **[Delhi 2014]**

(a) reduce the alkalinity of the soap.
(b) reduce the acidity of the soap.
(c) enhance the cleansing capacity of soap, or
(d) favour precipitation of soap.

ANSWERS

1. (*d*)	2. (*a*)	3. (*b*)	4. (*a*)	5. (*a*)
6. (*b*)	7. (*a*)	8. (*a*)	9. (*b*)	10. (*c*)
11. (*d*)	12. (*b*)	13. (*b*)	14. (*b*)	15. (*a*)
16. (*c*)	17. (*b*)	18. (*c*)	19. (*b*)	20. (*a*)
21. (*b*)	22. (*a*)	23. (*d*)		

Scoring Key With Explanation

1. (d) Soap is the sodium salt of fatty acid.
2. (a) Cleansing property of soap is due to micelles formation.
3. (b) Sodium chloride reduces the solubility of soap.
4. (a) As glycerol is the by product of soap formation.
5. (a) The reaction of saponification.
6. (b) Alcohol and carboxylic acid react together to form an ester.
7. (a) Carboxylic acid group is—COOH.
8. (a) Stearic acid is a saturated fatty acid with an 18-carbon chain.
9. (b) Three—OH groups are present in glycerol.
10. (c) Saponification is used for making of soap.
11. (d) 3-OH groups product named glycerol is by product of soap formation.
12. (b) Oils and fats contain esters.
13. (b) Soaps are mild basic compounds.
14. (b) Glycerides are esters of glycerol.
15. (a) Salt helps nfs precipitation of soap.
16. (c) Common salt helps in both the properties.
17. (b) NaCl helps in quick and more precipitation of soap.
18. (c) Mouth of tadpole part is ionic and hydrophilic in nature.
19. (b) Soaps are basic in nature.
20. (a) Bacteria acts on soap molecules to decompose them.
21. (b) Soaps cannot show cleansing property in hard water but detergents can.
22. (a) NaOH in water releases heat and the solution is alkaline in nature.
23. (d) NaCl helps in making more precipitates of soap during saponification.