Mixtures And Separation Of Mixtures

8.1 Chromatography

Chromatography was first developed by the **Russian botanist Mikhail Tswett in 1906** while studying plant pigments. He used this technique to separate the different coloured constituents of chlorophyll. This method was named **chromatography** components of chlorophyll. The name chromatography comes from the Greek words chroma (colour) and graphein (to write). The technique is used to **separate the mixtures into components, purification of compounds and also to test the purity of compounds.**

Principle: The technique is based on the difference in the rates at which the components move through a stationary medium under the influence of moving phase..

Application: Today, chromatography is widely used in chemistry, biology, and medicine to **identify and separate different substances in a mixture**.

Column Chromatography

Modern method for the separation of mixtures into its components. The selective removal of the components may be due to adsorption or partition process.

When a mobile phase is allowed to move over a stationary phase, the components of the mixture move by varying distances over the stationary phase because of different adsorption tendencies. In this case the stationary phase can be held on a cylindrical column of solid . hence it is called column chromatography.

Principle: It is based on the fact that different compounds are adsorbed on an adsorbernt to different degrees

Procedure: In this technique, a long glass tube having a stop cock near the bottom, called a column is used. First a plug of cotton or glass wool is placed at the bottom of the column. Then it is filled with a solid material such as silica gel or alumina, which acts as the **stationary phase** (fixed in a place). The mixture to be separated is placed at the top of silica gel in the column, and then a little amount of glass wool is placed above the mixture. After this a suitable liquid solvent is poured from above and allowed to flow through the column under the influence of gravity. This is called an eluent or the **mobile phase** (which moves). The solvent coming out from the column is collected in different fractions. In this way, the components of the mixture get separated and are collected separately. Column chromatography is widely used in chemistry laboratories to purify compounds as well as to separate them from the mixtures.

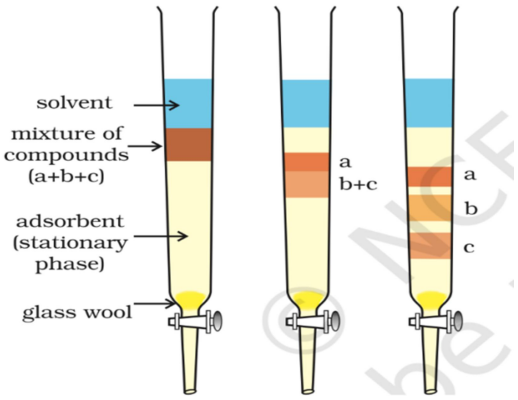


Fig 8.1: Column chromatography: Different stages of separation of components of a mixture.

Application: The method has been used:

- To separate blue and red dyes
- To separate and purify plant pigments

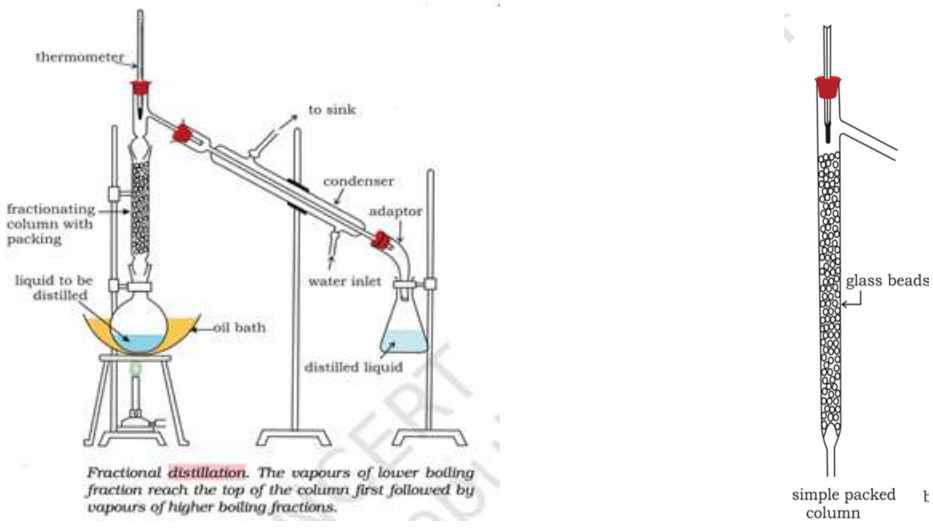
8.2.1 Fractional Distillation

This method is used for the purification of liquids which boil without decomposition and contain non volatile impurities.

Principle: Fractional Distillation is a technique to separate a mixture of two miscible liquids whose boiling points differ by less than 25^0C shown in Fig. 8.2 (a).

In this process, the mixture of liquids is heated in a distillation flask which is fitted with a fractionating column before the condenser as shown in figure 8.2(b).

Fractionating Column: The fractionating column is a long tube provided with obstructions to the passage of vapours moving upwards and liquid moving downwards. It increases the cooling surface area.



(a) **(b)**

Fig 8.2: (a) Fractional distillation apparatus and (b) A sample fractional distillation column

Procedure: When the mixture is added to distillation flask and the flask is heated the vapours of more volatile liquid having low boiling point rises up in the fractionating column.Due to the obstruction in the fractionating column,some of the vapours condense and fall back in the column.Some of the condensing liquid in the fractionating column gets heat from the ascending vapours and revaporizes. As a result the vapours become richer in low boiling component. These rise up in the fractionating column and condense while passing through condenser and collected in the receiver. The same process will occur again and again. This repeated condensation and vaporization helps in better separation of the liquids.By carefully controlling the temperature, different liquids in the mixture can be separated one after another according to their increasing boiling points.

8.2.2 How is it different from simple distillation?

- In fractional distillation, a fractionating column is placed between the distillation flask and the condenser. The column provides many surfaces where repeated condensation and vaporization occur. This allows better separation of liquids whose boiling points are close to each other.
- Simple Distillation is used to separate miscible liquid which differ in boiling point by at least 25^{o}C but in fractional distillation the boiling point differ by less than 25^{o}C

8.2.3 Application

Crude oil is a complex mixture of many hydrocarbons with different boiling points. In a refinery, the crude oil is heated, and the vapours enter a tall fractionating column. As the vapours rise in the column, they cool and condense at different levels according to their boiling points. Different fractions are collected at different heights of the column as shown in the figure below along with the temperature range. The various important fractions used in our daily life or industry are:

- Petroleum gas (LPG, contains butane and propane)
- Petrol (gasoline)
- Kerosene
- Diesel
- Fuel oils
- Lubricating oil and heavy oils

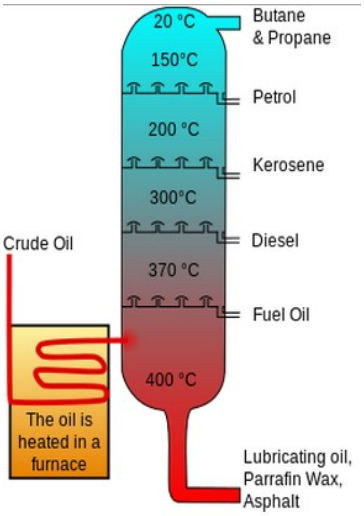


Fig 3: (a) Schematic representation of separation of different components of crude oil by fractional distillation

Questions

1. What is chromatography? Mention its two main phases.
2. Who discovered chromatography and in which year?
3. What is meant by stationary phase and mobile phase?
4. Name two common adsorbents used in column chromatography.
5. What is an eluent in column chromatography?
6. Why do different substances move at different speeds in column chromatography?
7. What is fractional distillation?
8. When is fractional distillation preferred over simple distillation?
9. What is the role of the fractionating column?
10. In column chromatography, a mixture of two compounds A and B is separated. A comes out first. What can you say about its interaction with the stationary phase?
11. A mixture of ethanol (b.p. 78°C) and water (b.p. 100°C) is to be separated. Which method will you use and why?
12. Explain why repeated condensation and vaporization improve separation in fractional distillation.
13. In a fractional distillation column, why does temperature decrease from bottom to top?
14. Why is simple distillation not suitable for separating liquids with close boiling points?
15. Assertion: In chromatography, separation occurs due to difference in boiling points.
    Reason: Components move at different speeds in the column.
    A. Assertion and reason, both are correct and reason is the correct explanation of the assertion.

B. Assertion and reason, both are correct but reason is not the correct explanation of the assertion.
C. Assertion is correct but reason is a wrong statement.
D. Assertion is wrong but the reason is a correct statement.

16. Assertion: Fractional distillation gives better separation than simple distillation.
Reason: It involves repeated condensation and vaporization.
A. Assertion and reason, both are correct and reason is the correct explanation of the assertion.
B. Assertion and reason, both are correct, but reason is not the correct explanation of the assertion.
C. Assertion is correct, but reason is a wrong statement.
D. Assertion is wrong, but the reason is a correct statement.

17. Difference in which property forms the basis for separating components in fractional distillation?
A. Solubility
B. Boiling points
C. Particle size
D. Chemical reactivity

18. What is the main purpose of the "fractionating column" in fractional distillation?
A. To heat the mixture faster.
B. To cool the vapours at fast rate.
C. To provide more surface area for vapours.
D. To let the vapours of two liquids mix properly

19. In column chromatography, the solid substance that is filled in the column is called the:
A. Mobile phase
B. Solvent
C. Stationary phase
D. Mixture

20. That component of a mixture moves down the column at a faster rate which is
A. most attracted to the stationary phase.
B. having the highest boiling point.
C. The one most soluble in the mobile phase (solvent)
D. The one with the largest particle

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