Steam distillation

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Experimental Theory

A mixture of two immiscible liquids, each liquid has its own vapor pressure and does not depend on the vapor pressure of the other substance. When the temperature of the mixture increases, the vapor pressure of each component increases until the total vapor pressure (which is the sum of the vapor pressures of the components) becomes equal to the atmospheric pressure. At this point, boiling begins at a temperature lower than the true boiling point of each component separately. In other words, the mixture distills at a temperature lower than the true boiling point of any of the components of the mixture.

Ptotal = P1 + P2

Ptotal = total pressure and is equal to atmospheric pressure.

P1 = vapor pressure of liquid (1).

P2 = vapor pressure of liquid (2).

Steam distillation is used for the purpose of:

1.Separation of volatile compounds from non-volatile compounds.

2.Purification of many water-insoluble compounds, both solid and liquid, which have high boiling points and decompose at their boiling points.

A mixture of water and nitrobenzene boils at a temperature of 99°C, where the vapor pressure of water is 733 mmHg at this temperature, and the vapor pressure of nitrobenzene is 27 mmHg. The sum of their pressures is 760 mmHg. Since the boiling point of nitrobenzene is 211°C, this means that nitrobenzene can boil at a temperature lower than its boiling point by 112°C, and water boils at a temperature lower than its boiling point as well.In this process, steam is used to heat the liquid rather than distill it directly, as the steam coming from the steam generator carries it from the distillation flask to the condenser.

Organic compounds are generally miscible with each other; therefore, water is often used as one of the liquids in steam distillation because:

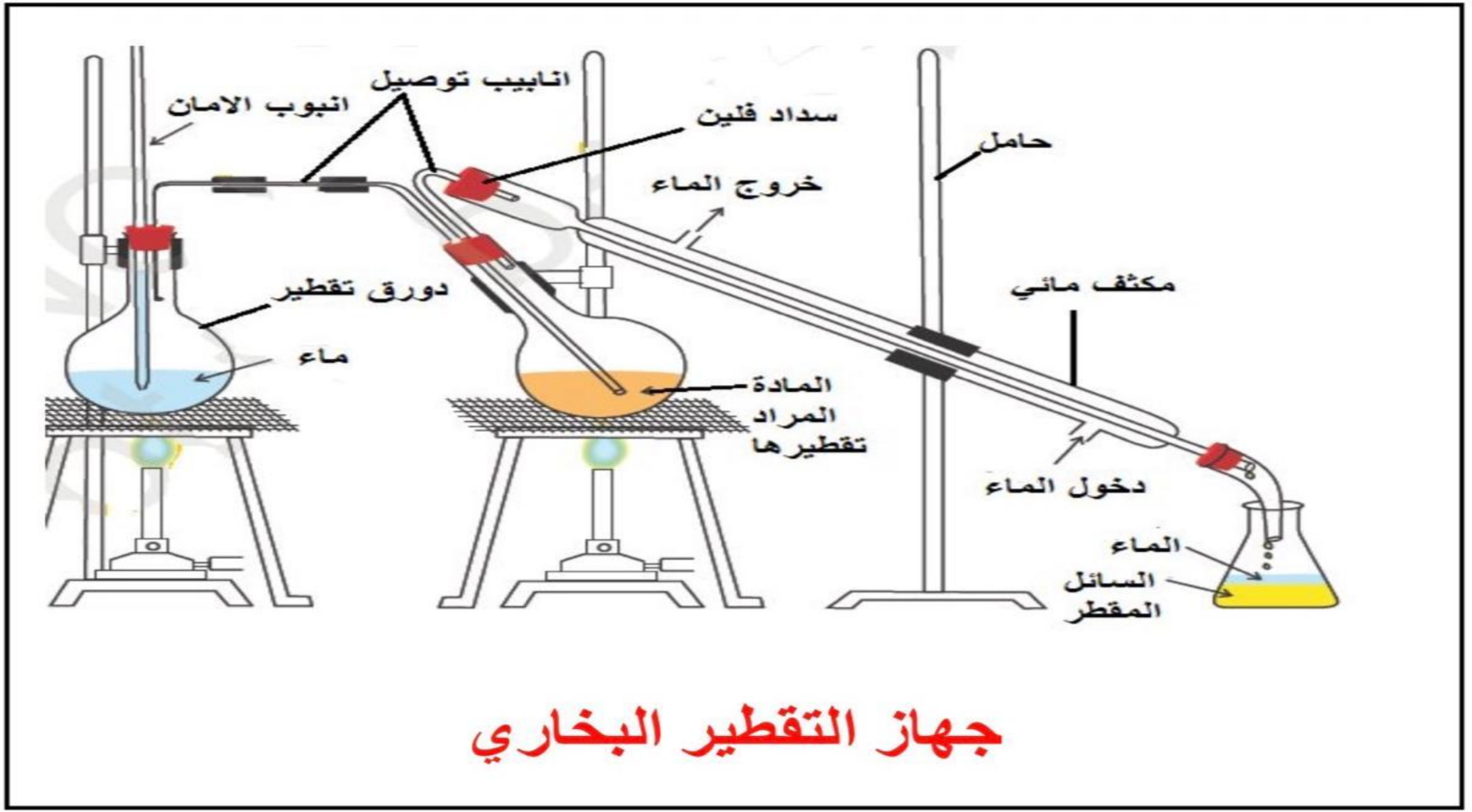
1. It has a high vapor pressure.
2. It does not mix with most organic compounds.
3. It is available, non-flammable, and non-toxic.

Procedure:

1. Set up the apparatus as shown in the figure.
2. Place impure n-butyl acetate in the round-bottom flask connected on one side to the steam generator and on the other side to the condenser.
3. Start heating the water in the steam generator (which is a distillation flask closed with a stopper through which a long glass tube passes to equalize pressure, called a safety tube). Then collect the distilled liquid that contains the pure substance and water. Continue heating until the mixture is finished and drops of water begin to distill from the condenser. At that point, remove the flame and disconnect the steam generator from the apparatus immediately to prevent the liquid from flowing back into the generator due to pressure reduction.
4. ransfer the mixture to a separatory funnel and leave it aside until the boundary between the two liquids becomes clear. To speed up the separation process, a saturated solution of sodium chloride can be added. This process is called salting out and can be explained as follows: if some organic liquids are partially soluble in water, they can be easily separated by adding a substance to the water such that the solubility of this added substance in water is greater than the solubility of the organic substance to be separated. In this case, salt, which is highly soluble in water, is added. It dissolves in water, and thus the water leaves the organic liquid, allowing it to separate quickly.
5. After adding the saturated salt solution (NaCl), shake the separatory funnel, then leave it for a while. After that, separate the organic layer from the water and place it in a dry flask. Then add a drying agent to remove the remaining water, which is magnesium sulfate ($MgSO_4$), and leave it for 15 minutes. After that, filter using a funnel, a dry flask, and folded filter paper.
6. Record the volume of the pure liquid obtained from the steam distillation process.Salting out is also performed when the boundary between the two liquids is not clear.

Note:

A round-bottom flask is used in which the substances to be separated or purified are placed. This flask is closed with a stopper through which two tubes pass one of them is connected to the condenser and is short, while the other is long and immersed in the liquid inside the flask. Its other end is connected to the steam generator by a rubber tube.



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