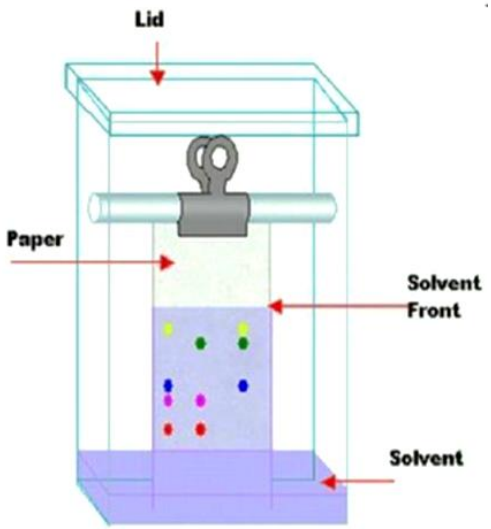
PAPER & TLC CHROMATOGRAPHY

Chromatography is used to analyse mixtures containing complex covalent compounds. The 4 main types of chromatographic techniques used for analysis are:

- Paper chromatography
- Thin layer chromatography
- High performance liquid chromatography (HPLC)
- Gas-liquid chromatography (GLC)

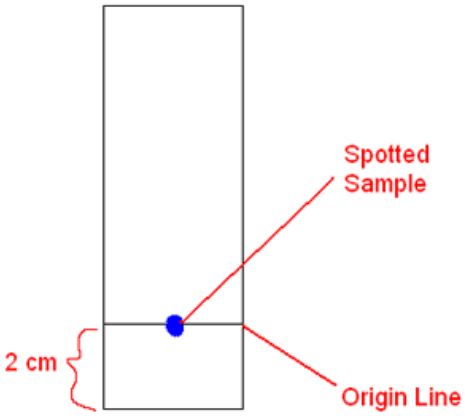
PAPER CHROMATOGRAPHY (A QUALITATIVE TECHNIQUE)



Paper Chromatography is a very simple method of qualitative analysis. It is used to analyze simple substances such as inks, dyes and plant pigments that contain covalent compounds. These substances are not pure. They are mixtures containing a variety of different compounds. For example, red ink is a mixture containing two compounds, one that is yellow and another that is blue. Below are the basic steps required for separating red ink into its two constituent compounds by paper chromatography.

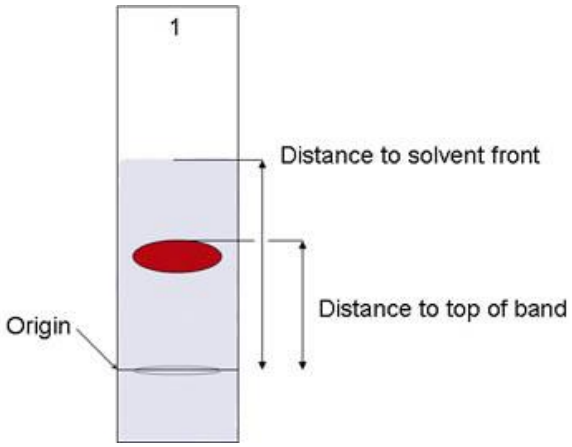
STEP 1

A strip of clean chromatography paper is required. This paper is very absorbent and filter paper can often be a suitable substitute. A straight horizontal line is drawn (only use a grey lead pencil!) across the paper about 2 cm from the bottom. This line is called the **origin**. Place a small dot of red ink either on the origin or just above it.

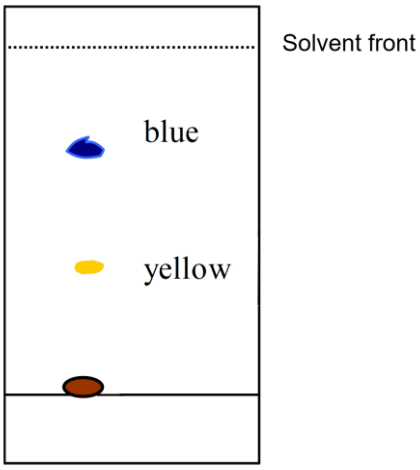


STEP 2

During the next step a small amount of solvent is added to a beaker. The level of the solvent in the beaker should be about 1 cm from the bottom. The chromatography paper with the ink sample is carefully placed in the beaker so that the bottom of the paper is immersed in the solvent. However, it is very important that the ink dot and the origin line are above the level of the solvent (this will be discussed later). The solvent will now soak into the paper and rise.



The solvent is known as the **mobile phase** because it is moving. The paper is known as the **stationary phase** because it just sits in the beaker doing nothing in particular. As the solvent rises up the paper it goes over the ink dot. The two compounds that are in the ink have different chemical and physical properties. As a result, they will interact with the paper and solvent differently. This interaction causes the compounds in the ink dot to separate and spread out up the paper. Below is the final result, which is known as a **chromatogram**. The chromatogram shows quite clearly that the red ink dot has separated into two different coloured compounds (blue and red). This chromatogram will be used to explain why the compounds have separated from each other.



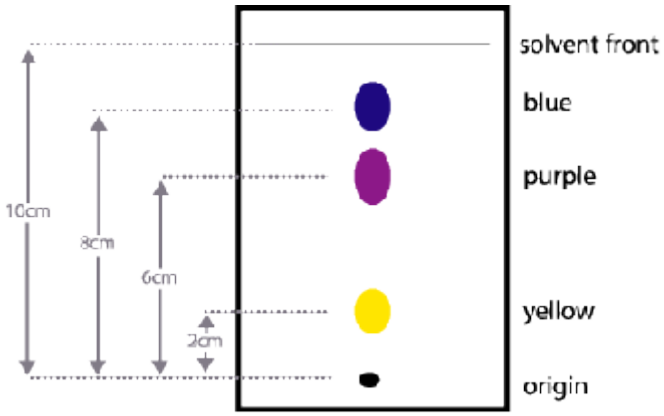
Chromatogram

The compounds in the ink dot interact with the solvent by desorbing (dissolving) into it. They interact with the paper by adsorbing ("sticking") to its surface. Some compounds will desorb into the solvent more readily than they adsorb to the paper. These compounds spend most of their time dissolved in the solvent and rise up the paper with it. The blue dot at the top of the chromatogram is such a compound. Other compounds will adsorb to the paper more readily than they desorb into the solvent. These compounds will spend most of their time stuck to the paper rather than dissolved in the moving solvent and will not move very far up the paper. Such a compound is the yellow dot that has moved a small distance just above the origin line. The paper must be removed from the beaker before the solvent reaches the top end of the paper. The line that shows the level of the solvent when the paper was removed from the beaker is known as the **solvent front.**

So it can be concluded that red ink is a mixture containing yellow and blue coloured compounds. However, most chemists would be unhappy with such a simple identification of the components of the ink. A more precise way of identifying the compounds is to calculate the **retention factor (R_f)** for each component. This is calculated by measuring the distance each component has moved from the origin and dividing this value by the distance the solvent has moved from the origin.

$$R_f = \frac{\text{Distance travelled by component}}{\text{Distance travelled by solvent}}$$

The R_f values can be compared to the R_f values of known compounds in order to identify the compounds in the ink.



Some points to remember when carrying out paper chromatography:

- Only use a grey lead pencil for the origin line because if you use ink it will interact with the solvent.

- When immersing the paper into the beaker, always ensure that the level of the solvent does not go over the origin. If this happens the mixtures that you wish to analyze will dissolve directly into the solvent and they will be lost.

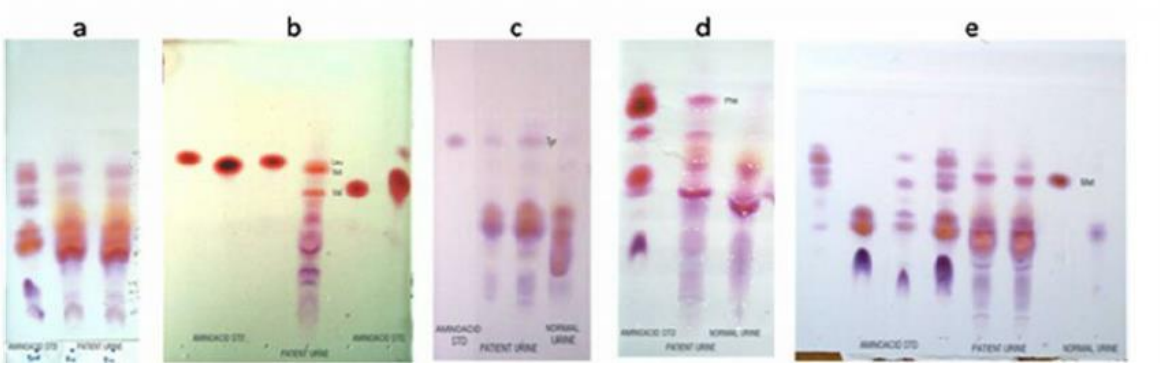
Applications of paper chromatography

- Limited to water soluble substances such as inks and plant pigments. Technique has been superseded by thin layer chromatography which allows the separation of less polar compounds.

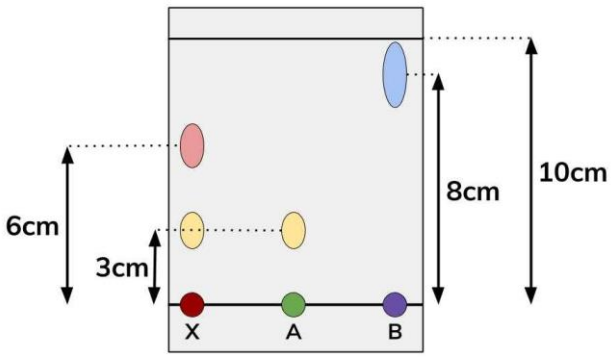
- Both paper and thin layer chromatography are cheap and easy.

THIN LAYER CHROMATOGRAPHY (A QUALITATIVE TECHNIQUE)

Thin layer chromatography is an almost identical technique to paper chromatography. The stationary phase is a thin layer of aluminium oxide spread over a glass plate. It has several advantages over paper chromatography which include faster separation of components and better separation of non-polar compounds.



QUESTION 1



(a) Calculate the R_f value for the component identified as A in the above chromatogram.

(b) Which component is more strongly attracted to the stationary phase, A or B? Give a reason for your answer.

(c) Which component is more strongly attracted to the mobile phase, A or B? Give a reason for your answer.

(d) Does sample X contain either component A or B?

(e) Why are R_f values always less than 1?

(f) Why must the origin line never be drawn with an ink pen?

Solution

SOLUTIONS

QUESTION 1

(a) Measure the distance from the origin to the solvent front. Measure the distance between the origin and the component labeled A. Then apply the rule:

$$R_f = \frac{\text{Distance travelled by component}}{\text{Distance travelled by solvent}}$$

$$R_f \text{ (A)} = \frac{8}{10}$$

(b) Component A is the most strongly attracted to the stationary phase. It didn't travel as far up the stationary phase as B, suggesting that it spent most of its time adsorbed (attraction to the stationary phase) to the stationary phase rather than desorbed in the mobile phase.

(c) Component B has moved the furthest up the paper. This suggests that it spent most of its time moving up with the paper with the solvent. Therefore, Component B is the most strongly attracted to the mobile phase.

(d) Sample X is made up of component A and another unknown component.

(e) R_f values are calculated by finding the fraction:

$$R_f = \frac{\text{Distance travelled by component}}{\text{Distance travelled by solvent}}$$

It is impossible for a component to move further up the paper than the solvent as the components can only move when they are desorbed into the mobile phase. Therefore, it is impossible to have R_f values greater than 1.

(f) Since paper chromatography is used to separate the components found in ink, an origin line made from an ink pen would move up the paper along with the solvent and components. A lead pencil is used because it will not interact with the solvent at all.