Teacher packs in Experimental Science

CHE Pack 5

Determination of purity of Food Colours using Paper Chromatography

Pack contents:

A. Teacher's Guide
B. Students Guide
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Curriculum areas covered:

Homogenous and heterogeneous mixtures, separation of mixtures

Produced as part of DelPHE-funded collaboration between University of Cape Coast and The Open University, UK

Title: Determination of purity of Food Colours using Paper Chromatography

Target group: *DBE students*

Also suitable for: SHS students

Learning outcomes:

1. Knowledge and understanding

After going through this pack the student should be able to:

KN1 explain how coloured pigments can be separated by paper chromatography
KN2 identify the stationary phase and the mobile phase
KN3 define the term, R_f value

2. Cognitive skills

After going through this pack the student should be able to:

CS1 interpret the qualitative and quantitative results of a paper chromatogram

3**. Key Skills**

After going through this pack the student should be able to

KS1 calculate R_f values, by simple multiplication and division, based on the results of a paper chromatogram

KS2 draw and label the developed paper chromatogram

4. **Practical skills**

After going through this pack the student should be able to

PS1 Set up and use appropriate equipment for paper chromatography
PS2 Record experimental results in a table
PS3 separate the components in the various food colours

A. Teacher's Guide

- It is important not to touch the paper with the fingers because sweat and dirt deposits can cause confusion on the final chromatogram. Handle the paper with clean forceps and only by the edges.
- Provide each student/ pair of students with a complete set of apparatus.

Assessment Questions

1. Why do the different pigments travel to different distances in paper chromatography? (KN)
   (Answer: The different pigments are attracted differently to molecules in the paper and to the solvent molecules. So they travel at different speeds up the paper and so in a given time, some will travel further than others).

2. A chromatography experiment used felt tipped pens to make the initial spots on the paper, and dipped the paper into water. What is the mobile phase and what is the stationary phase? (KN)
   (Answer: The water, which moves, is the mobile phase, and the paper is the stationary phase)

$$Rf = \frac{\text{distance moved by colour spot}}{\text{distance moved by solvent}}$$

3. a. Explain the term, R_f value (KN)
   b. What is meant by an R_f value of 0.7 for a pigment?

(Answer: The R_f value is a way of recording how far the pigment has travelled compared to the solvent. So an R_f value of 0.7 means that the pigment travelled only 7/10 of the distance travelled by the solvent [or similar acceptable way of expressing what 0.7 means])

4. Calculate the an R_f value for a red pigment where the coloured spot appeared at 4.5 cm above the base line, while the solvent front had reached 8.7 cm (Ky). [or could provide a picture for interpreting here]
   (R_f value would be 4.5/8.7 = 0.52)

5. Copy and complete the following table

Food colour	Mixture (Yes/No)	How many dyes are in the food colour?
Blue		
Yellow		
Green		
Red		

6. Draw and label your developed chromatographic paper.

Practical skills could only be tested by getting students to prepare their own chromatogram

B. Student Guide

Purpose:

To determine the colour components in 'food colour' using the technique of paper chromatography.

Background information

Paper chromatography is a modern method used to separate mixtures. Paper chromatography uses paper as the stationary phase and a liquid solvent as the mobile phase.

You will use paper chromatography to test food colourings to see if the colour results from a single dye or a mixture of dyes. If you cannot get food colouring you can use coloured felt pens or other water soluble colouring pens. Your exercise is simple but uses very essential principles. An optional part of the activity is to check a household product for the presence of the same dyes that are in food colouring.

The technique relies on the idea that the solvent and the paper both have an attraction for the components in a mixture. The solvent creeps along the surface of the paper. If a material is placed on one spot on the paper and is soluble in the liquid solvent, the material will be dissolved when the solvent moves over it. The material will move along with the solvent. Each compound in a mixture will have its own characteristic balance of attractions to solvent and to paper, so all will not move at the same speed. Eventually this difference in speed will separate the compounds

In paper chromatography, a particular compound always travels at a fixed percentage of the distance travelled by the solvent front. The ratio of the distance the compound travels to the distance the solvent travels is called the R_f value. The symbol R_f stands for "retardation factor" or "ratio-to-front". It is expressed as a decimal fraction and it is useful in identifying compounds.

$$Rf = \frac{\text{distance moved by colour spot}}{\text{distance moved by solvent}}$$

Substances that are not coloured can also be separated by chromatography. They are detected using ultraviolet or black light. These substances appear to glow in the dark.

Equipment/ Materials Needed

- glass jar (300ml) /drinking glass/300ml plastic cups/jam bottle
- ten capillary tubes/ten pieces of toothpicks
- 10cm x 10cm chromatographic paper /filter paper/coffee filter
- ruler
- pencil
- assorted powdered food colours (red, blue, green and yellow)

- scissors
- stapler
- 4 small containers
- paper napkin
- 50 ml of isopropyl alcohol (rubbing alcohol)*
- 100ml water
- Glass plate/aluminium foil

Read and obey warnings on rubbing alcohol label.

Other requirements

working bench/table, open space, laboratory coat/apron, eye goggles, hand gloves

Experimental Procedure

It is important not to touch the paper with the fingers because sweat and dirt deposits can cause confusion on the final chromatogram. Handle the paper with clean forceps and only by the edges.

Preparation of developing tank:

1. Measure 20ml of the isopropyl alcohol (rubbing alcohol) into the glass jar
2. Cover it with the glass plate or aluminum foil and leave it to stand undisturbed.

Sample preparation and application

3. Use a pencil to draw a line across the strip about 10 mm from one end of the paper
4. Mark four positions at equal intervals on the straight line.
5. Put 1g of each food colour sample into each container
6. Add 3 to 4 drops of organic solvent to each colour sample and stir to dissolve
7. Using the capillary tubes/toothpick spot a small amount of each sample along the line drawn on the paper as shown in Figure 1. (four colours –four spots on the paper)
8. Roll the paper into a cylindrical form and staple the ends together and hold with a clip as shown in the Fig. 2. **The ends should not overlap**

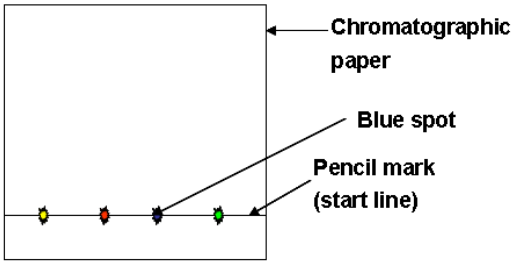

Fig. 1

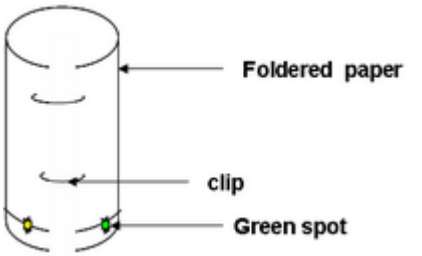

Fig. 2

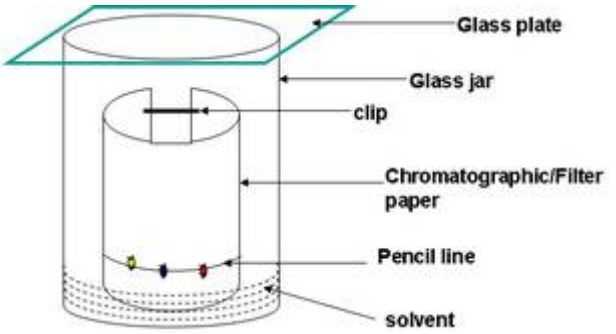

Fig. 3

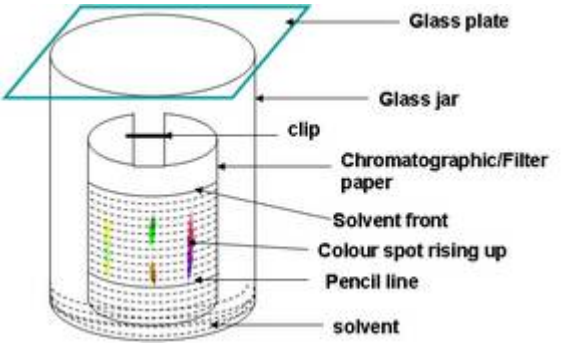

Fig. 4

Development of the chromatogram

9. Carefully open the glass jar and lower the paper into it so that the solvent touches the bottom of the paper as shown in Fig. 3
10. Cover the jar and allow the solvent to wick/soak up the paper. Watch what happens to the colour spots (Fig. 4).

Note: - where the solvent wets the paper, the top of the wet area is the "solvent front". The solvent will wick up the first few centimetres quickly. The food colour will probably trail behind the solvent.

11. When the front edge of the solvent reaches three fourths of the way up the paper, remove the paper from the glass jar.
12. Use a pencil (**not a pen**) to mark the front edge of the solvent. Air-dry the paper. Use the pencil to mark the "center of gravity" of the dye spot. The "center of gravity" of the dye spot is its "average" position on the paper.
13. Note if more than one colour appears on the paper. If so, find the "center of gravity" for each dye.
14. Measure the distance between the start line (where the spots were placed) and the mark for the upper edge of the solvent front. Record this distance in Table 1

Table 1 Results

Colour spot	Distance travelled/cm	R_f value
Green spot		
Blue spot		
Red spot		
Yellow spot		
Solvent front		

15. Record your observations and calculate the R_f values using the equation below.

$$Rf = \frac{\text{distance moved by colour spot}}{\text{distance moved by solvent}}$$

Reflection on the experiment

Think about the separation of the different colours on the paper. These different colours represent molecules in the food colour mixture. These molecules have different characteristics (such as size and solubility) and they travel at different speeds when pulled along a piece of paper by a solvent. For example, black ink contains several colours. When the solvent flows through a word written in black, the molecules of each one of the colours behave differently, resulting in a sort of "rainbow" effect.

C. Assessment – Student's sheet

On completion of the experiment, you should answer the following questions:

1. Why do the different pigments travel to different distances in paper chromatography? (KN1)

2. A chromatography experiment used felt tipped pens to make the initial spots on the paper, and dipped the paper into water. What is the mobile phase and what is the stationary phase? (KN2)

3. a. Explain the term, R_f value (KN3)
   b. What is meant by an R_f value of 0.7 for a pigment? (CS1)

4. Calculate the R_f value for a red pigment where the coloured spot appeared at 4.5 cm above the base line, while the solvent front had reached 8.7 cm (KS1).

5. Copy and complete the following table

Food colour	Mixture (Yes/No)	How many dyes are in the food colour?
Blue		
Yellow		
Green		
Red		

6. Draw and label your developed chromatographic paper

D. Extensions to experiment

Use the same procedure to separate the chemical components in 'Waakye' leaves and 'bisap' flower.
Do you think that other substances like vegetable dyes or inks could be tested using this chromatography method? Justify your answer

E. Useful links

http://www.800 mainstreet.com/
http://www.gcsescience.com/el.htm
http://dbhs.wvusd.k12.ca.us/
http://www.yesmag.ca/projects/paper_chroma.html

F. Health and Safety

BASIC SAFETY RULES:

1. Do not eat, drink or chew whilst doing the experiment.
2. Avoid breathing in the food colours. When smelling solutions, gently wave the air above the solution towards your nose with your hand.
3. Wash any spilled solutions from your skin with plenty of water.
4. Report any accident, no matter how minor, to the instructor/ health officer.

Wear the following items before doing the experiment:

a. Long-sleeved overcoat/apron that is long enough to cover the hips, worn closed at all times.
b. Safety glasses. Please note that contact lenses do not provide eye protection and in some cases may complicate an emergency (caustic liquids which splash into the eye can be trapped behind the contact lens). You are advised to avoid wearing contact lenses in the laboratory, if possible.
c. Closed, flat-heeled shoes (no open sandals).
d. Long hair and loose scarves must be tucked away or tied up.

Tidy working

- Keep your working area tidy. A cluttered bench is a common contributory factor to accidents. Cleaning the glassware after use should be done immediately.
- Always clean up a chemical spill without delay
- Clean up and dispose of your unknown substances according to your teacher's instructions.

G. Evaluation

- How did you like this experiment?
- What would you like to improve in the use of this pack?
- Suggest other methods/skills/material which can be included in this pack.

- Were the experimental procedures easy to follow? Explain
- Was it difficult/easy to have access to the experimental materials listed?