Paper Chromatography: Is Black Ink Really Black?

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You will also need from home:

- Scissors
- Pencil
- Plastic wrap
- Metric ruler
- Measuring cup and container for 4 cups of water
- 1/8 or 1/4 teaspoon (tsp) measuring spoon
- Salt
- Water
- Lab notebook

Summary

<table>
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<tr>
<th>Prerequisites</th>
<th>None</th>
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Frequently Asked Questions

http://www.sciencebuddies.org/science-fair-projects/project_ideas/Chem_p008.shtml#help

Abstract

Have you ever looked at sunlight through a prism? If so, you know that the prism can separate the sunlight into many different colors of light — a rainbow. Like sunlight, chemical mixtures can also be broken into their component parts. One way of doing this is a simple technique called paper chromatography. What do you think you will see if you use paper chromatography to look at the components of black ink? Is black ink just black? Find out for yourself!

Objective

The objective of this project is to use paper chromatography to analyze ink components in black markers/pens.

Introduction

What color is black ink? Sounds like a trick question doesn't it! But sometimes things are not just what we think they are. Often things can be broken down into component parts. For example, milk looks like one thing but it is actually made up of several components including water, fat, and protein. Which brings us back to black ink — it looks like one thing, but is it actually made up of more than one component? One way to find out is to use a common chemistry technique called chromatography.

Chromatography is a technique used to separate the various components in a complex mixture or solution. There are two parts: a stationary phase and a mobile phase. The stationary phase does not move. It is the platform on which you put the mixture you want to analyze on. The mobile phase does exactly what you would expect given the name — it moves. It sweeps the components in the mixture along the stationary phase separating them by how much they "stick" to each other. It is also referred to as the solvent.

In this science project you will use paper chromatography to see if black ink can be separated into components. The ink will be spotted onto strips of filter paper and put in a beaker containing a solution of alcohol and water. The paper is the stationary phase and the alcohol and water solution is the solvent (mobile phase). The solvent will move by capillary action. The attraction of the solvent to the paper (adhesion force) is larger than the attraction of the solvent to itself (cohesion force), hence the solvent moves up the paper. The ink will also be attracted to the paper, to itself, and to the solvent differently, and thus a different component will move a different distance depending upon the strength of attraction to each of these objects. As an analogy, let's pretend you are at a family reunion. You enjoy giving people hugs and talking with your relatives, but your cousin does not. As you make your way to the door to leave, you give a hug to every one of your relatives, and your cousin just says "bye." So, your cousin will make it to the door more quickly than you will. You are more attracted to your relatives, just as some chemical samples may be more attracted to the paper than the solvent, and thus will not move up the solid phase as quickly. Your cousin is more attracted to the idea of leaving, which is like the solvent (the mobile phase).

In paper chromatography, you can see the components separate out on the filter paper and identify the components based on how far they travel. To do this, we calculate the retention factor ($R_f$) value of each component. The $R_f$ value is the ratio between how far a component travels and the distance the solvent travels from a common starting point (the origin). For example, if one of the sample components moves 2.5 centimeters (cm) up the paper and the solvent moves 5.0 cm, as shown in Figure 1 below, then the $R_f$ value is 0.5. You can use $R_f$ values to identify different components as long as the solvent, temperature, pH, and type of paper remain the same. In Figure 1, the light blue shading represents the solvent and the dark blue spot is the colored solution sample.
In this science project you can use a simple paper chromatography setup to see if black ink is just one such as plants.

Chemists and biologists also use chromatography to identify they can easily find out when the products start to form and when the reactants have been used up (i.e., when the reaction is complete).

Chromatography in labs to track the progress of a reaction. By looking at the sample spots on the chromatography plate, they are creating the right combination with expensive equipment is used to make sure a food company’s processes are working correctly and identify clues at a crime scene like blood, ink, or drugs. More accurate chromatography in combination with expensive equipment is used to make sure a food company’s processes are working correctly and they are creating the right product.

This type of chromatography works the same way as regular chromatography, but a scanner system in conjunction with a computer can be used to identify the different chemicals and their amounts. Chemists use chromatography in labs to track the progress of a reaction. By looking at the sample spots on the chromatography plate, they can easily find out when the products start to form and when the reactants have been used up (i.e., when the reaction is complete). Chemists and biologists also use chromatography to identify the compounds present in a sample, such as plants.

In this science project you can use a simple paper chromatography setup to see if black ink is just one component or a mixture of several components. Will the answer be the same for all types of black ink?

## Experimental Procedure

To make sure you can compare your results, as many of your materials as possible should remain constant. This means that the temperature, type of water used, size of paper strips, where the ink is placed onto the paper etc. should remain the same throughout the experiment.

1. Cut the filter paper into strips approximately 2 centimeters (cm) wide by 7 cm long. You will need a total of 15 chromatography strips.
   - Science Buddies Kit: The kit comes with 10 circles of filter paper; 3 strips can be cut from each circle.
2. Take one of the chromatography strips and use a ruler and pencil to draw a line across it horizontally 1 cm from the bottom. This is the origin line, see Figure 2 below for details. Repeat this step for all 15 of the chromatography strips.

## Terms and Concepts

- **Chromatography**
- **Solution**
- **Stationary phase**
- **Mobile phase**
- **Solvent**
- **Capillary action**
- **Adhesion force**
- **Cohesion force**

### Questions

- Why do different compounds travel different distances on the paper?
- How is an Rf value useful?
- What is chromatography used for?

### Bibliography

- Science Buddies Kit: The kit comes with 10 circles of filter paper; 3 strips can be cut from each circle.

### Figure 1.

Values are how different components are compared to each other in paper chromatography. Rf values are calculated by looking at the distance each component travels on the filter paper compared to the distance traveled by the solvent front. This ratio will be different for each component due to its unique properties, primarily based on its adhesive and cohesive factors.

When measuring the distance the component traveled, you should measure from the origin (where the middle of the spot originally was) and then to the center of the spot in its new location. To calculate the Rf value, we then use Equation 1 below.

**Equation 1:**

\[
R_f = \frac{\text{Distance traveled by the sample component}}{\text{Distance traveled by the solvent}}
\]

In our example, this would be:

\[
R_f = \frac{2.5 \text{ cm}}{5.0 \text{ cm}} = 0.5
\]

Note that an Rf value has no units because the units of distance cancel.

Chromatography is used in many different industries and labs. The police and other investigators use chromatography to identify clues at a crime scene like blood, ink, or drugs. More accurate chromatography in combination with expensive equipment is used to make sure a food company’s processes are working correctly and they are creating the right product. This type of chromatography works the same way as regular chromatography, but a scanner system in conjunction with a computer can be used to identify the different chemicals and their amounts. Chemists use chromatography in labs to track the progress of a reaction. By looking at the sample spots on the chromatography plate, they can easily find out when the products start to form and when the reactants have been used up (i.e., when the reaction is complete). Chemists and biologists also use chromatography to identify the compounds present in a sample, such as plants.

In this science project you can use a simple paper chromatography setup to see if black ink is just one component or a mixture of several components. Will the answer be the same for all types of black ink?

### Figure 2.

Each chromatography strip will have an origin line. The pen/marker ink to be tested will be spotted in the middle of the origin line.

3. Using one of the pens/markers, place a small dot of ink at the center of the origin line of a chromatography strip. This is your spotted sample as shown in Figure 3 below.
   - Use a pencil to label which pen/marker you spotted on the chromatography strip. Do not use a pen labeling
the strips: the ink will run when the solvent passes through the strips.

b. Repeat this step until you have spotted ink on 5 chromatography strips for each pen/marker.

Figure 3. A marker or pen should be used to put a single spot of black ink in the middle of the origin line on the chromatography strip.

4. Make a 50% isopropyl alcohol solution to use as your chromatography solvent.
   a. Pour 20 milliliters (mL) of isopropyl alcohol into the 150 mL beaker. Add 20 mL of water to the beaker so that the final volume is 40 mL. Stir thoroughly with the wooden splint.
   b. Pour the solution into the 400 mL beaker. Cover the beaker with plastic wrap, so that the solution does not evaporate. This is your solvent.

5. Pour a small amount of the solvent back into the 150 mL beaker.
   a. Clip two of the prepared chromatography strips to a wooden splint. Make sure the two strips do not touch each other and the bottoms align. Rest the splint on top of the beaker so that the strips hang into the jar.
   b. If necessary, add more solvent to the small beaker. The goal is to have the end of the chromatography strip just touching the surface of the solvent solution as shown in Figure 4 below. Add solvent as needed to achieve this goal.
   c. Cover the top of the beaker with plastic wrap.
   d. Set aside the remainder of the unused solvent (covered with a lid or plastic wrap) for additional runs.

Figure 4. The edge of the chromatography strips should just barely touch the solvent. Remember to cover the top with plastic wrap so that the solvent does not evaporate.

6. Let the solvent rise up the strip (by capillary action) until it is about 0.5 cm from the top, then remove the strip from the solvent. Keep a close eye on your chromatography strip and the solvent front — if you let it run too long the dye may run off the paper and become distorted.

7. Use a pencil to mark how far the solvent rose.

8. Allow the chromatography strip to dry, then measure (in centimeters) and calculate the R_f value for each pen/marker dye component. Record your results in your lab notebook.
   a. Tip: The equation for calculating the R_f value is given in the Introduction (located in the Background tab).

9. Repeat steps 5 - 8 until you have run all of the chromatography strips.
   a. Each time you run the experiment make sure there is enough solvent in the beaker. The chromatography strips should be just touching the surface of the solvent. Add more solvent (50% alcohol solution) as needed.

10. Using the five repeated strips for each pen/marker, calculate the average R_f for each dye component.

Questions
- Did the inks from the different pens/markers separate differently? By looking at the R_f values, can you tell if any of the ink components from the different pens/markers are the same?
- If the ink components separated differently for each marker, why did this happen? Hint: Think about the strength of the attractions.

Variations
- You could try using other solvents than water (or mixture of solvents) and see if the inks are separated differently (rubbing alcohol, vinegar, nail polish remover, and turpentine would be good to try). Which solvent separates the ink the best? Why? (Remember to account for attractions between chemicals.)
- After buying a black light, you could try to see if any more components are visible on the paper. Some chemicals are invisible under white light, but can be seen with a black light. If you decide to do this variation, you should analyze the paper strips the same day or the next day, otherwise the spots will fade! Why are some chemicals visible under one type of light but not another? Read more here:
For more advanced chromatography projects, see:
- Paper Chromatography: Advanced Version 1
- Paper Chromatography: Advanced Version 2

Related Links
- Science Fair Project Guide
- Other Ideas Like This
- Chemistry Project Ideas
- My Favorites
- Chemistry Safety Guide

If you like this project, you might enjoy exploring these related careers:

Materials Scientist and Engineer
What makes it possible to create high-technology objects like computers and sports gear? It's the materials inside those products. Materials scientists and engineers develop materials, like metals, ceramics, polymers, and composites, that other engineers need for their designs. Materials scientists and engineers think atomically (meaning they understand things at the nanoscale level), but they design microscopically (at the level of a microscope), and their materials are used macroscopically (the level the eye can see). From heat shields in space, prosthetic limbs, semiconductors, and sunscreens to snowboards, cars, hard drives, and baking dishes, materials scientists and engineers make the materials that make life better.

Chemist
Everything in the environment, whether naturally occurring or of human design, is composed of chemicals. Chemists search and use new knowledge about chemicals to develop new processes or products.

Chemical Engineer
Chemical engineers solve the problems that affect our everyday lives by applying the principles of chemistry. If you enjoy working in a chemistry laboratory and are interested in developing useful products for people, then a career as a chemical engineer might be in your future.

Credits

Contact Us
If you have purchased a kit for this project from Science Buddies, we are pleased to answer any question not addressed by the FAQs on our site. Please email us at help@sciencebuddies.org after you have checked the Frequently Asked Questions for this project at http://www.sciencebuddies.org/science-fair-projects/project_ideas/Chem_p008.shtml

In your email, please follow these instructions:

1. What is your Science Buddies kit order number?
2. Please describe how you need help as thoroughly as possible:

Examples

Good Question I'm trying to do Experimental Procedure step #5, "Scrape the insulation from the wire..." How do I know when I've scraped enough?

Good Question I'm at Experimental Procedure step #7, "Move the magnet back and forth..." and the LED is not lighting up.

Bad Question I don't understand the instructions. Help!