Lab Activity H5
Paper Chromatography of M&M's

OUTCOMES

After completing this lab activity, the student should be able to:

- explain basic principles of chromatography in general.
- describe important aspects of paper chromatography.
- identify the number and nature of the components found in different color M&M's.

DISCUSSION

Chromatography is one of the most important and widely used analytical techniques known to chemists. It is a technique that is used for separating, purifying, and identifying certain chemical compounds. Chromatography means literally, "written in color", since it was a technique originally used to separate colored materials, like the pigments in flowers. Today it is used to separate very complex mixtures, often containing several hundred compounds. Modern instruments are equipped with various sensitive detectors that allow chromatographic techniques to be carried out with colorless compounds, often with very minute quantities. Chromatography is used in the separation of petroleum, natural and artificial flavorings, amino acids, perfumes, and many others. It is also used to identify components in these mixtures or drugs that may be present in a urine or plasma sample.

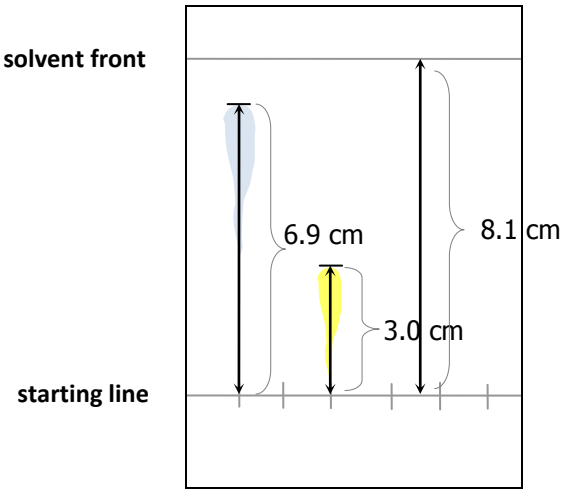
There are many different types of chromatographic techniques used today. These include high-pressure liquid chromatography (HPLC), gas chromatography (GC), column chromatography, thin-layer chromatography (TLC), and the technique you will be using in this experiment — paper chromatography. All types of chromatography involve a stationary phase and a mobile phase.

In paper chromatography, the substance to be analyzed is dissolved in a solvent. The resulting solution is then spotted onto a rectangular piece of filter paper, near the bottom, and allowed to dry. The paper is then lowered into a sealed chamber containing a small amount of a solvent or mixture of solvents, keeping the spots above the surface of the solvent. Once lowered into the chamber, the solvent begins to wick up the paper through capillary action. The paper is considered the stationary phase, since it does not move, while the solvent is considered the mobile phase, since it moves up the paper.

As the solvent moves up the paper, compounds are carried up at different rates. Compounds that have a greater affinity for the solvent than for the paper are carried further up the sheet, while those that have a greater affinity for the paper than for the solvent will move more slowly. This allows one to determine the minimum number of components in a sample and often leads to the identity of those components.

The identity of a component is confirmed through the calculation of its retention factor, R_F. The retention factor of a substance is constant under uniform experimental conditions. The retention factor is a ratio of the distance traveled up the paper by the component spot to the distance traveled by the solvent:

$$R_F = \frac{\text{distance traveled by component spot}}{\text{distance traveled by solvent}}$$



For sample calculations of the retention factor, refer to the figure to the right. As you can see, the retention factor is dimensionless, i.e. it has no units. If $R_F = 0.50$ for a spot, that means the spot traveled halfway up the sheet. In the case of the yellow spot, where the $R_F = 0.37$, that means the spot traveled 37% of the distance up the sheet. According to the formula, retention factors are expressed as their decimal equivalents only, **not** as percentages.

$$R_F \text{ (blue spot)} = \frac{6.9 \text{ cm}}{8.1 \text{ cm}} = 0.85$$

$$R_F \text{ (yellow spot)} = \frac{3.0 \text{ cm}}{8.1 \text{ cm}} = 0.37$$

Figure 1

There are many variations possible for this lab activity. Instead of using dyes extracted from M&M's to spot the filter paper, one may substitute food coloring or felt tip pens, or grind some flowers into some alcohol or fingernail polish remover (which is acetone or ethyl acetate). These materials may be spotted onto the paper using a capillary tube or toothpick. One may also try different solvents or combinations of solvents in varying ratios. The only requirement is that the solvents must be miscible with each other. Experiment and have some fun! Report any interesting findings to your instructor.

MATERIALS (Provided By Student)

M&M's. 1 or 2 pieces of each color are needed – blue, green, yellow, brown, red, and orange. Any variety – plain, dark, or with peanuts – may be used. However, avoid pastel colors, since the dyes used in these candies will not be dark enough.

Wide mouth jar or plastic container. Many things could work – Tupperware, a bowl, an old cottage cheese container or ice cream round. The container must be able to fit the narrow dimension of the filter paper inside the opening without touching the sides of container or opening and deep enough so that the paper does not touch the bottom of the container when the paper is suspended from the top.

Bowl/jar/plastic container. This second container should be able to hold at least 3 cups of solution.

MATERIALS (Provided By Student) - continued

Measuring spoon (⅛ tsp, ¼ tsp, or ½ tsp)
Pencil
Plate
Salt
Tape
Water (tap water or distilled water works)

MATERIALS (From Kit)

Beral pipet
Filter paper. Cut filter paper to a rectangular size of 8 cm x 10 cm.
Ruler
Safety Goggles/Safety Glasses
Toothpicks (3 needed, break each in half)

PROCEDURE

SAFETY GOGGLES/GLASSES MUST BE WORN FOR THIS EXPERIMENT!

1. Prepare a 0.1% salt solution by dissolving approximately ⅛ tsp salt in 3 cups of water inside a bowl. Pour the salt solution into a wide mouth jar (see materials list) to a depth such that no more than 0.5 cm of the filter paper would touch the solution if the paper was suspended from the top of the container.

2. Using a pencil and ruler, draw a line about 1 cm from the bottom edge of the filter paper. Draw 6 evenly spaced hash marks onto the pencil line.

3. Place 6 drops of water onto a plate, spacing each drop far enough apart to place a different colored M&M onto each drop. Roll each M&M back and forth on the drop to remove the dye from the candy. Avoid cross-contamination of the dyes. Since it is only the dye that is of interest, avoid removing much of the white undercoating on each candy. If a darker color is desired, try rolling a second candy in the respective drop of water – this is particularly true for the yellow and green M&M's. You may also allow time for some of the water to evaporate to concentrate the dyes.

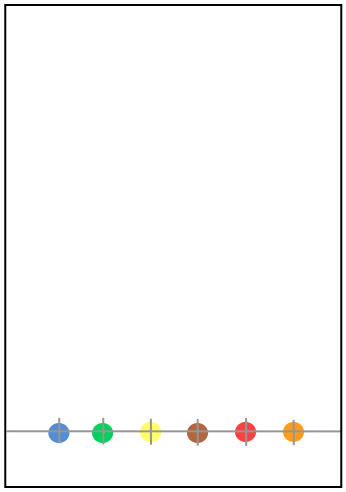


Figure 2

4. Lay the filter paper onto a towel or napkin. Dip one end of a half-toothpick into one of the dyes and spot it onto one of the hash marks on your filter paper. Avoid making the spot very large – it should be about 0.2-0.3 cm in diameter at most. Try the small end of the toothpick first. If the spot is too small, try the larger end. Using a different toothpick and hash mark for each dye, spot the

other dyes onto the remaining hash marks. If the color is not very dark, spot the mark a second or third time, allowing time for the drops to dry in between and after the final spotting. A blow dryer may be used to speed the process. **REQUIRED PHOTO: Includes your face and/or clearly shows a Picture I.D. (with name), with M&M candies, plate/lid with colored water drops, and your spotted paper.**

5. Tape the top of the filter paper to a pencil or ruler. Without touching the walls of the container, slowly lower the paper into the container. Recheck the depth of the solution. There should be enough for the entire bottom edge of paper to touch the solution, but not touch the dyes spotted onto the paper. The goal is for the solution to carry the dyes up the sheet and to avoid washing them into the solution. If necessary add or remove solution. Once the correct depth is achieved, lower the filter paper into the water and allow it to migrate up the sheet without disturbing the container. **Do not allow the paper to touch the walls of the container.**

   REQUIRED PHOTO: Includes the date clearly shown on a calendar, newspaper, cell phone, or written on a sheet of paper, along with the filter paper suspended in the container immediately before removing the paper from the container. It should be apparent that the colors have migrated up the sheet in the photo.

6. Remove the paper once the solution has migrated within 1-2 cm from the top of the sheet and place it onto a towel or napkin. Using a pencil, draw a line to mark the solvent front before the liquid evaporates. Allow the sheet to dry. This final product, or dried sheet, is referred to as a *chromatogram*.

EXTENSIONS (not required)

1. Repeat this experiment with different candies, such as Skittles.
2. Repeat this experiment with different colored marking pens.
3. Repeat this experiment by extracting and concentrating the dyes from natural sources such as berries or flowers. You might try grinding them into rubbing alcohol or fingernail polish remover.

Name_____ Lab Section_____

PRELAB QUESTIONS

1. Briefly describe chromatography. Why do compounds separate in chromatography?

2. Why should you not use a single toothpick for more than one type of M&M?

3. Which safety precautions, if any, must be observed during this lab activity?

PHOTOS - Please compress photos and save your file **before** uploading to the dropbox. Photos should come close to filling the boxes below and all required items should be **clearly visible**.

Required Photo 1:
Required Photo 2:

Name_____ Lab Section_____

DATA AND QUESTIONS

1. An example of a *dye* is Yellow 5. A dye is different than a *lake*. Lakes are very tiny particles of aluminum hydroxide onto which dyes have been absorbed or precipitated, so a lake such as Yellow 5 Lake is comprised of Yellow 5 dye absorbed onto a surface of aluminum hydroxide. Since aluminum hydroxide is quite insoluble, it should not migrate up the paper at all and should be found on the original mark on the chromatogram.

   Look at the ingredients on your package of M&M's and find the dyes that are present. List the names of each dye present in the package. Do **not** count lakes.

Blue	Red	Yellow

   Were there any other dyes listed besides blue, red, or yellow? If so, which ones?

   Which variety of M&M's was used (plain, peanut,dark chocolate, etc.)?

2. Considering your answers above, how many dyes, of which color(s), appear to be in each of the different colored M&M's? (Note: Some M&M's may contain more than one dye of the same color, which would be indicated by more than one spot of the same color above a single hash mark.) Do **not** count lakes.

M&M color	Number of Dyes and Which Color(s)
Blue	
Green	
Yellow	
Brown	
Red	
Orange	

3. Prepare an organized table that includes the information requested below. If you prefer, you may reorganize the table from #2 to include this information.

   a) Measure the distance from the starting pencil line to the top edge of each dye for the six different M&M's. Record the distances. Use your best judgement as to where the top edge of each spot lies. If an M&M contains more than one dye, there should be more than one distance recorded.

   b) Measure and record the distance from the starting line to the solvent front.

   c) Calculate the retention factor (R_F) for each of the dyes in each M&M. If an M&M contains more than one dye, there should be more than one R_F calculated.

4. Why must the spots not be lowered into the solution in this experiment?

5. Why was a pencil used to draw the line instead of an ink pen?

Lab Report Submission Checklist

Complete the appropriate checklist and **submit this page** along with your lab activity.

Lab Activity Submitted Via the D2L Dropbox

	Prelab assignment is complete.	
	Remainder of lab activity is complete (data, questions, photos. etc.).	
	Required photos of the procedure included.	
	At least one photo shows face or photo I.D. At least one photo clearly shows the date.	
	Document filename in format of **Lastname Firstname HX**.	
	File size is no larger than 10 MB.	
	Only one document submitted for this lab activity.	
	Lab submitted on time.	
		If late, this is your first extension.

Lab Activity Submitted Via the US Postal Service or In Person

	Prelab assignment is complete.	
	Remainder of lab activity is complete (data, questions, photos. etc.).	
	Required photos (at least one showing face or photo I.D.; at least one shows the date) of the procedure or a tangible artifact or product from the lab activity is included.	
	If return is desired, a self-addressed stamped envelope **with sufficient postage** is included*.	
	Lab submitted on time (postmarked by due date if sent via USPS).	
		If late, this is your first extension.

*You may find a postage calculator at http://postcalc.usps.gov. Use the balance in your kit to find the weight.