Physical Separations – Candy Chromatography

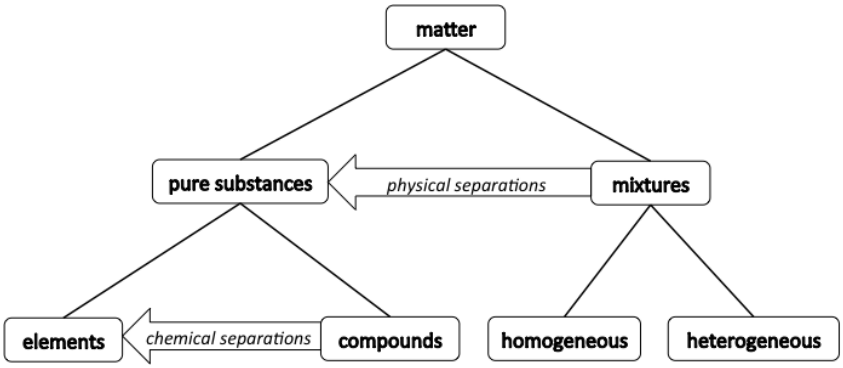
Goals

1. To physically separate and identify dyes in candy by comparison to commercial food dyes using paper chromatography.

2. To become familiar with common lab equipment and techniques.

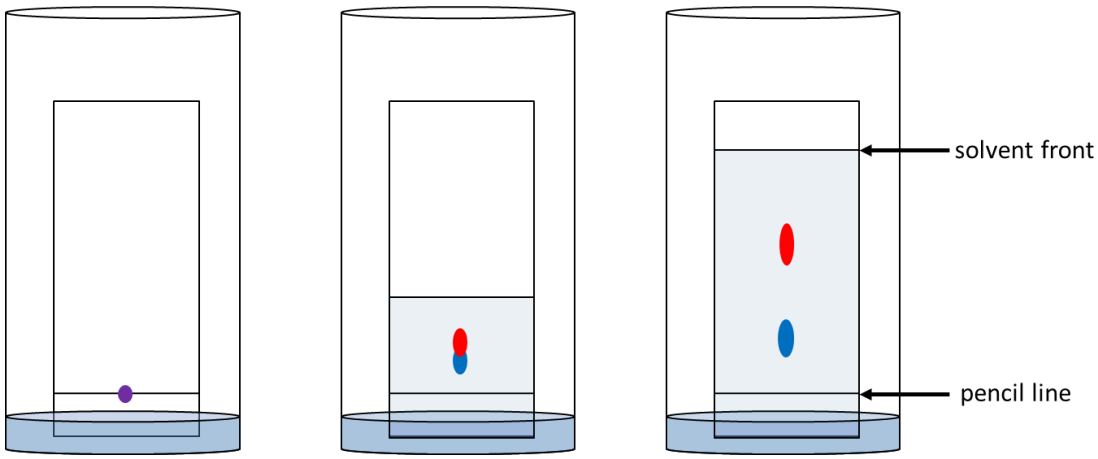
Introduction

All matter can be classified as either a pure substance or a mixture. Pure substances, which have fixed compositions, can be elements such as gold and oxygen, or compounds such as water (H_2O) or salt (NaCl). Separating compounds into elements requires chemical reactions. Mixtures consist of two or more pure substances and can have variable compositions. Mixtures can be either homogeneous – uniform throughout down to the molecular level, such as a solution of salt in water, or heterogeneous – having distinct parts such as a slurry of sand and water. Mixtures can be separated into pure substances by physical methods; for instance, a sand and water mixture can be filtered and the water in a saltwater solution can be evaporated.



This lab will use several physical separation techniques, first to separate dyes from candy, then to separate the different dyes from each other. Chromatography is a technique that separates mixtures based on their attraction to other substances. Gas chromatography is widely used by forensic chemists to separate and identify mixtures found at crime scenes. In this lab we will use paper chromatography to separate dyes used in M&Ms, Skittles and food coloring. All of these products contain one or more dyes that can be separated.

To separate the dyes, we will put a small sample of a mixture on chromatography paper. The spot is put on a pencil line drawn to keep track of the starting point. The edge of the paper is placed in a liquid called the solvent. The solvent travels up the paper due to capillary action and as it does, it separates the dyes. The edge of where the solvent traveled is known as the <u>solvent front</u>.



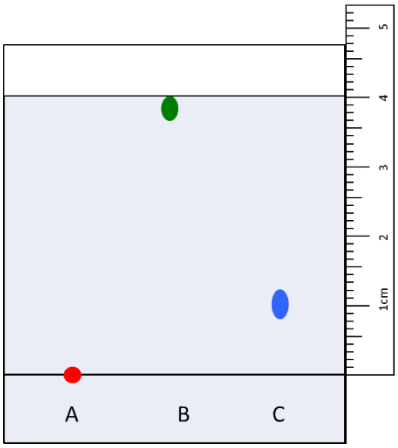
Each dye will move up the paper at a different rate. Two factors are at work in the physical separation of the dyes: the dye's attraction to the paper and its solubility in the solvent. The more a dye is attracted to the paper, the less it will move up – you can think of it as the dye molecules getting stuck to the paper. Solubility also plays a role in how a

dye will move up the paper. The more soluble a dye is in the solvent, the farther it be carried up the paper. Since attraction and solubility are different for each dye, the dyes move different distances and get separated on the paper.

Calculating R_f

The retention factor (Rf) is used to compare how far different spot travel up the paper. The Rf is calculated as follows:

$$R_f = \frac{distance\ from\ pencil\ line\ to\ center\ of\ spot}{distance\ from\ pencil\ line\ to\ solvent\ front}$$

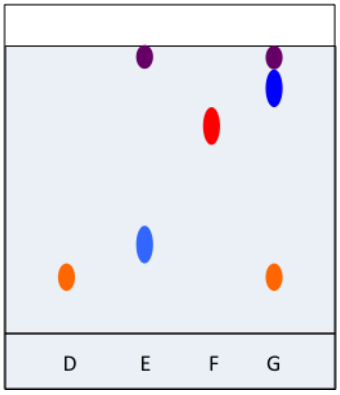


Note that all measurements taken from the spot's starting point – the pencil line. We divide the distance a spot traveled from its starting point, by the maximum distance it could have traveled, from the starting point to the solvent front. All R_f values will be between 0 and 1. If a spot did not move from the pencil line, it will have an R_f, of zero, such as spot A in figure (2) – this spot is very attracted to the paper. If a spot moves with the solvent front, it will have an R_f of 1, such as spot B which is not very attracted to the paper.

Example, for spot C on the right, the distance from the pencil line to the center of the spot is 1.0 cm, from pencil line to the solvent front is 4.0 cm,

making the R_f = $\frac{1.0\ cm}{4.0\ cm} = 0.25$. Report the R_f as a decimal and watch your sig figs.

Comparing Different Samples



The retention factor (R_f) is used to determine if spots from different samples are the same compound. In the figure to the right, four samples (D-G) were developed with paper chromatography. Samples D & F were pure substances –one spot on the chromatography papers indicates that they contained only one dye. Sample E contained two dyes and sample G contained three dyes.

If spots have similar color and similar R_f, they are probably the same dye. The dye in D is likely the same as dye with the lowest R_f in G. The spot with the highest R_f in E and G are also probably the same dye. Currently, there are only 7 dyes approved for use in food by the Food and Drug Administration.

Laboratory Activity

Materials to collect:

5 M&Ms (not brown) **or** Skittles **(all the same color)** test tube holderwatch glass

(2) 600 or 1000 mL beakers	2 pieces chromatography paper	stirring rod
3 test tubes (cleaned)	10 mL graduated cylinder	box of food coloring
white household vinegar	clear household ammonia	1 250 mL beaker

10 cm piece of white undyed wool yarn Hot plate

On Lab bench: ruler, red litmus paper, Deionized water, capillary tubes

Safety Hazards – Caution should be exercised when working with boiling water baths and ammonia. Hot test tubes should be handled with test tube holders.

A. Removing the coating from the candy

1. Obtain a hot plate from the shelf on the wall, plug it in and turn it on to around 300 °C. Fill the 250 mL beaker ~ 2/3 full of tap water. Put the beaker with the tap water on the hot plate to heat up. This is your boiling water bath.

2. Obtain five M&Ms or Skittles (all of the same color and type, ex: five green Skittles). Record the type of candy and the color. Put the 5 candies into a test tube. Add just enough vinegar to cover the candies completely. Tap the side of the test tube to stir. As soon as you see the white of the inside of the candy, go onto step 3.

3. Carefully decant (pour the liquid off the solids) the solution into a clean test tube. Avoid transferring the candies or any solid. The solution contains mostly FD&C dyes and sugar.

4. Dispose the candies in the trash can immediately to prevent sticking. Clean the test tube and return it.

B. Separating the dyes from the dissolved sugar

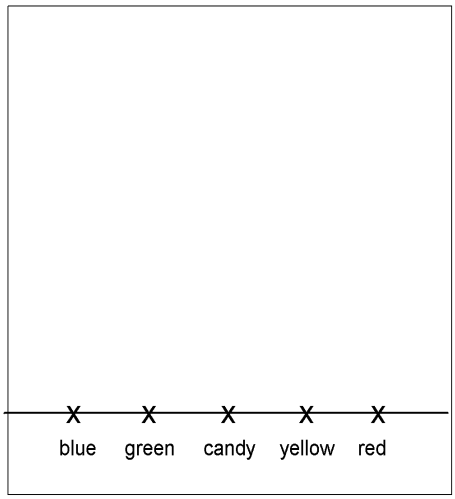
1. Completely submerge a piece of woolen yarn in the test tube containing the dye solution (use a stirring rod to push it down). Heat the test tube in a boiling water bath for 5 minutes; stir occasionally with a stirring rod.
2. Remove the now colored yarn from the test tube and rinse the yarn with deionized water. The dyes are now chemically attached to the yarn, while the sugar remains in the solution.
3. Dispose of the remaining vinegar solution in the sink.

While the yarn is cooking in the vinegar dye solution, go onto step C. Preparing the Chromatography papers.

C. Preparing the chromatography papers

You will be preparing 2 identical chromatography papers.

Practice spotting the food coloring on a piece of paper towel before you put the spots on the chromatography paper.



1. Obtain two pre-cut 6 x 8 cm pieces of chromatography paper. With a pencil draw a line 1 cm from the short edge on each paper.
2. Mark 5 x's along the pencil line and label them blue, green, candy, yellow, red, as in the diagram below.
3. Using a capillary tube, spot each of the food coloring solutions on the appropriate x, as well as some of the candy solution once you are done with Part D. Practice making small spots on a paper towel before using chromatography paper. You may need to spot the candy dye more than once to get it dark enough.
4. Fold the papers so that it will stand up in your beaker without touching the edges of the beaker. Test it before you add solvent.

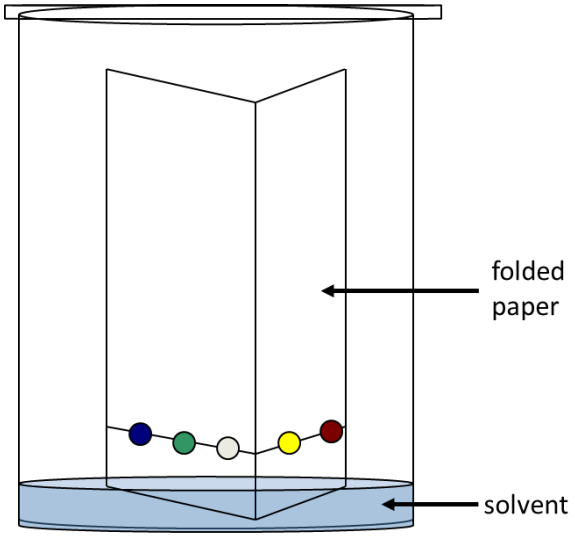
D. Re-dissolving and concentrating the dye solution

1. Add about 2 mL of ammonia to a clean test tube. Completely submerge the colored yarn.
2. Verify that the solution is basic: dip the end of a glass stirring rod in the solution, then touch the rod to red litmus paper. If the paper turns blue, the solution is basic. If it does not turn blue, add an additional 1 mL of ammonia and retest.

3. Heat the tube with the yarn and ammonia in a boiling water bath for 5 minutes, stirring occasionally with a glass rod. Most of the dye will come off of the yarn and dissolve in the ammonia.
4. Concentrate the dye solution by pouring the solution from the test tube onto a watch glass, then placing the watch glass on top of the hot water bath beaker. The solution on the watch glass should reduce to almost half its original volume. Do not allow the solution to completely evaporate. Add a drop or two of water if the dish has dried out.

5. Dispose of the yarn in regular waste.

E. Separating the dyes



1. Obtain two 1000 mL beakers. Place enough vinegar to just cover the bottom in one beaker. Place enough ammonia to just cover the bottom of the other beaker.
2. Put the prepared chromatography papers in each of the beakers, being careful that the folded chromatography papers do not touch the sides of the beaker. Cover the top of the beakers with plastic wrap or a watch glass.
3. As the solvent rises up the paper, it will separate the dyes in the food coloring. When the solvent front is approximately 1 cm from the top of the paper, remove the paper from the beaker and set the chromatography papers on a piece of paper towel.
4. Sketch your results (the colors and approximate locations of each spot) on your lab report.
5. **Read the instructions on calculating the R_f carefully.** Calculate the R_f for all dyes (each separate color in each food coloring) in the food coloring and in the candy. Some spots will be long streaks – approximate the center of the spot and use that point for the R_f calculation.
6. When finished measuring spots, measure the distance from the pencil line to the solvent front.
7. After you have noted down all the measurements, the chromatography papers can be thrown into the regular waste.

Waste Disposal

- liquids – sink
- candy, string, litmus paper, chromatography paper – regular waste
- capillary tubes – glass waste box

Name_____

Team Name _____

CHM111 Lab – Physical Separations – Grading Rubric

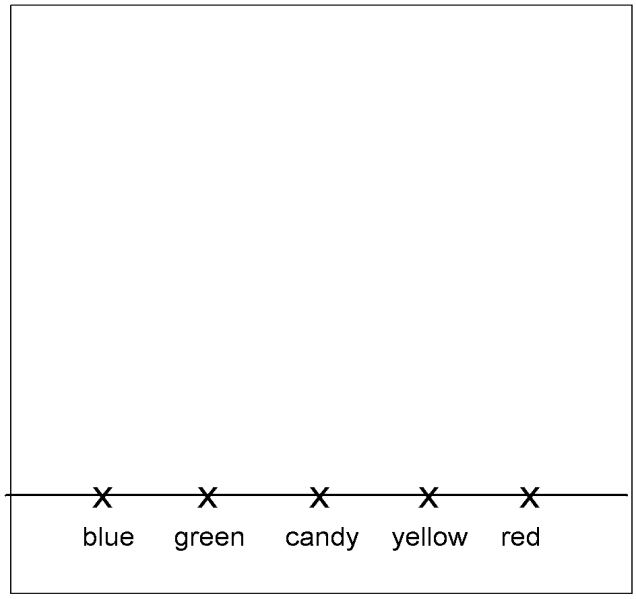
Criteria	Points possible	Points earned
Lab work performed correctly. Proper safety procedures followed and waste disposed of correctly. Work space and glassware cleaned up. Participated actively in performing the experiment.	4	
Q1 Plates sketched and colors indicated.	2	
Q2. Distances correctly measured. Rfs correctly calculated	8	
Q3.	2	
Q4 - CER format used, complete sentences. Specific colors and Rf values cited.	4	
Total	20	

Subject to additional penalties at the discretion of the instructor

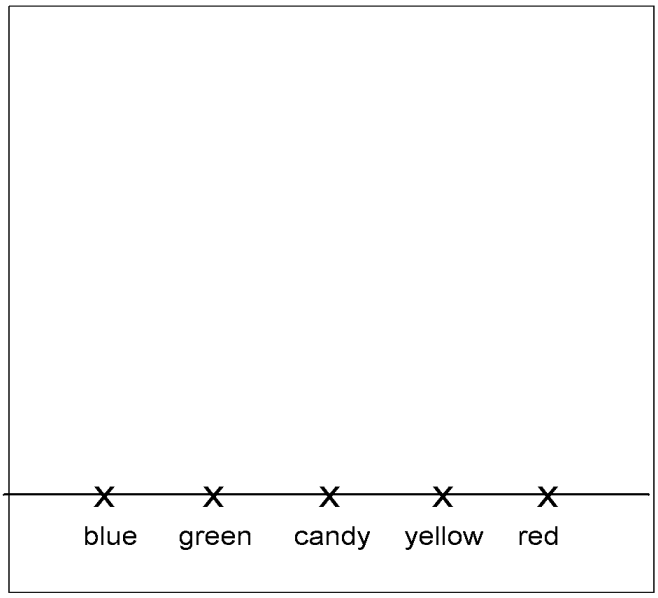
Lab Report - Physical Separations **Name: _____ Team name: _____**

Type of candy used:		**Color of candy used:**	

1. Sketch your chromatography papers and label the color of each developed spot.



Vinegar



Ammonia

2. Fill in the tables. Write a separate entry for each spot on the paper. If the source only contained one dye, leave one line blank.

Chromatography paper in Vinegar Results			
Dye Source	**Color of Spot**	**Distance spot traveled**	**R_f**
Blue Food Coloring			
Green Food Coloring			
Candy			
Yellow Food Coloring			
Red Food Coloring			
Distance from pencil line to solvent front			

Chromatography paper in Ammonia Results			
Dye Source	**Color of Spot**	**Distance spot traveled**	**R_f**
Blue Food Coloring			
Green Food Coloring			
Candy			
Yellow Food Coloring			
Red Food Coloring			
Distance from pencil line to solvent front			

3. Classify your food coloring as mixtures (M) or pure substances (PS). (Did they contain one dye or more than one dye?)

blue food coloring _____ green food coloring _____ candy spot _____

yellow food coloring _____ red food coloring _____

4. Dye spots with the same color and similar R_fs (± 0.1) are likely to be the same substance. Find two spots that you think are the same substance (preferably one in your candy and one in a food coloring). Write your argument in CER format:

Claim State which two spots are the same dye. (ex: The red spot in the candy and the red spot in green food coloring are the same substance).
Evidence - Write your evidence in complete sentences. This should state the <u>color</u> of each spot and state the <u>specific Rf</u> of each spot.
Reasoning - Write a sentence explaining how the evidence supports your claim.