The Separations Lab: Candy Colors
Student Advanced Version

In this lab you will separate a mixture of unknown composition using several common household items. You will then perform a more specific separation, thin layer chromatography, in which you separate the dyes in Skittles and M&M's, and the differing colors used in making black ink.

Key Concepts:

- In chemistry and engineering, a **separation** refers to a process in which components of a mixture are separated from one another.
- A **basis of separation** is a property which differs among the components of a mixture that we take advantage of in order to separate those components.
- **Chromatography** is a general type of separation method in which a mixture of compounds passes through a **stationary phase**. Different compounds have different relative affinities for the mixture traveling along the stationary phase, or the **mobile phase**, and the stationary phase, causing these compounds to separate from one another.
- **Thin layer chromatography (TLC)** is a chromatography technique that separates components of liquid mixtures based on the polarity of the individual components.
- **Polarity** refers to the separation of charge in a molecule – in other words, how unequally the electrons in a molecule are shared among the different atoms.
- **Capillary action** occurs when liquids are able to move uphill against the force of gravity due to interactions between the stationary and mobile phases.

Part 1 – Separations Puzzle

In this first part, you will separate a mixture of unidentified items into seven individual components using the tools provided.

1. Take a few minutes with your group members to examine the mixture of unknown composition which you have been provided. **For the purposes of this lab, consider all the substances in this mixture radioactive, meaning that you cannot touch any of them with your hands.**

Q1. Do you recognize any of the components of the mixture? If so, which ones?

Q2. How many distinct items can you see in the mixture? If you are unsure what some of the items are, describe them briefly.

2. It is typically a good idea to separate out the components which seem most unlike the others first. **Among your group, determine which item seems the most different from the others.** Devise a strategy for separating this item from the rest.

Q3. Which item seems most different from the others? What will be the basis of separation that you will use to remove this item from the mixture?

3. Go ahead and try your strategy for removing the first component of the mixture.

Q4. Which tool did you use to try to separate your first item of choice? Why did you choose that item? Were you successful?

4. Among your group, agree on a strategy for isolating another compound from the mixture. If your first plan resulted in a mixture of two items that is separate from the rest, you may also choose to separate those two items from one another.

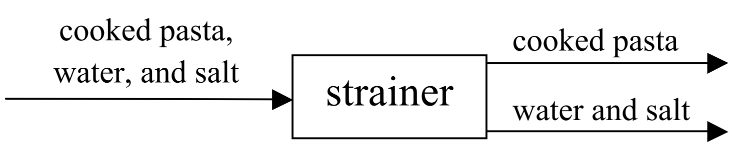
5. Continue separating items by finding relevant bases of separation and using appropriate tools to take advantage of those properties that differ among the items. **Try not to ask your teacher for hints unless your group is truly stumped!**

Concept Questions

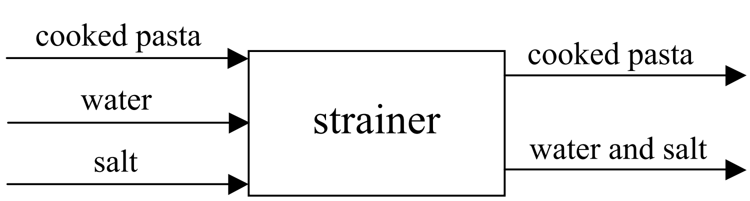
Q5. Fill in the following table with all the items you separated from the mixture, in order from the first item you separated to the last. In the columns on the right, note the basis of separation for each item and the tool you used to take advantage of that basis(es) of separation.

Order	Item	Basis of Separation	Tool
1			
2			
3			
4			
5			
6			
7			

A **process flow diagram** is a tool commonly used by engineers to keep track of the general flow of a process and the equipment used in that process. We can use this type of diagram to track a mixture as it is being separated into its various components. Below is an example of a process flow diagram for using a strainer to separate cooked pasta from salt and water:



Any equipment we use to separate the mixture is shown in a box, while the components coming into and out of that equipment are represented by labeled arrows. **We only show components as separate arrows if they are truly separate.** Thus, it would be incorrect to represent the pasta straining process as shown below, because the cooked pasta, water, and salt enter the strainer as one mixture, not as three separate parts:



Q6. With this background, work as a group to construct a process flow diagram for the separation puzzle that you just completed.

Q7. Now that you are able to visualize your separation strategy using a process flow diagram, can you suggest any ways in which you could have separated the mixture more efficiently?

Q8. Let's say that you're given a mixture of salt dissolved in water. Can you think of any basis of separation you could exploit to separate the salt from the water?

Q9. Name two real-life examples of separation processes and the basis of separation for each.

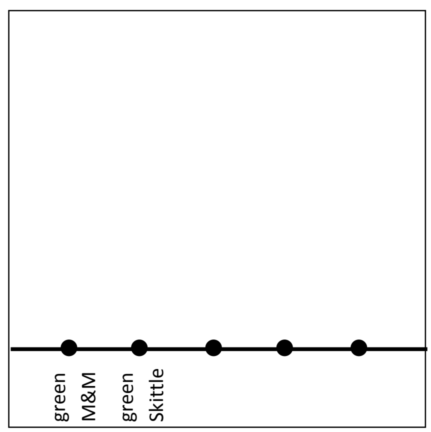
Part 2 – Candy Chromatography

In this part of the lab, you will use thin layer chromatography (TLC) to separate the individual dyes from M&M's and/or Skittles, as well as observing the different colors that make up black ink. In this experiment, coffee filter paper will be the stationary phase, while a solution of rubbing alcohol will serve as the mobile phase.

1. Cut the coffee filter paper into two 3 inch x 3 inch squares, one for candy and one for ink.

2. For each square, lightly draw a pencil line ½ inch from the edge of one side of the paper.

3. For the candy filter square, make a pencil dot for each color to be used along the line about ¼ inch apart and label each dot (see diagram below).



4. Remove the color (dyes) off the candies you choose to analyze by placing each candy in a piece of foil and adding 6 drops of water. Try to select pairs of candies of the same color (e.g., green M&M's and green Skittles, orange M&Ms and orange Skittles, etc.)

5. While you are waiting for the candy dye to dissolve, prepare your ink filter square. Make a small dot (approx. 2mm diameter) with each marker along the pencil line about ½ inch apart and label each dot.

6. For the candy filter square, dip a toothpick into each colored mixture left behind in the foil and dab the color on the corresponding pencil dot on the filter paper. Allow the filter paper to dry and add more color to each dot. Repeat so that you have added color to the dot three times.

7. When the papers are dry, fold in half so that they stands up on their own. **Make sure that the fold is vertical, leaving the line with the dots near the bottom edge of the paper.**

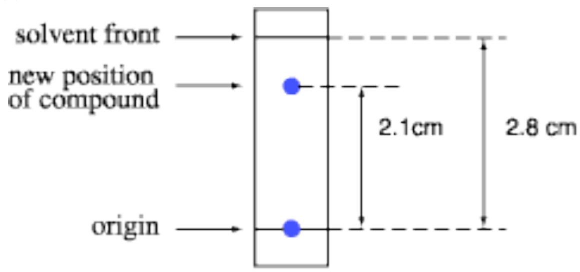
8. For each filter, pour rubbing alcohol (isopropyl alcohol) into a clean tall glass to a liquid level of 1/4 in. Then stand the filter paper inside the glass with the sample side down and the edge of paper wetted by the developing solution. **Make sure that the alcohol level is below the line of the samples.**

9. Observe as the rubbing alcohol progresses up the paper by capillary action. When the rubbing alcohol is ¼ inch from the top edge of the paper, remove the paper from the glass and let dry.

The retardation factor (R_f) is the distance traveled by the compound divided by the distance traveled by the solvent front:

$$R_f = \frac{distance\ traveled\ by\ the\ compound}{distance\ traveled\ by\ the\ solvent\ front}$$

See the following example:



$$R_f = \frac{2.1}{2.8} = 0.75$$

If you could repeat this experiment under exactly the same conditions, the R_f values for each sample would always be the same!

Concept Questions

Q10. Which are the stationary and mobile phases in this experiment?

Q11. Why did the dyes travel different distances?

Q12. Why did we use rubbing alcohol as the mobile phase?

Q13. What does coffee filter paper consist of and why would it be used as the stationary phase?

Q14. What do you think would happen if we varied the solvent (for example, if we used water instead)? Would the dyes travel the same distances as when we used rubbing alcohol?

Q16. Why might we want to cover the glass in which TLC is taking place?

SKITTLES: Yellow 6 Lake, Red 40 Lake, Yellow 5 Lake, Blue 2 Lake, **Yellow 5, Red 40**, **Yellow 6**, Blue 1 Lake, **Blue 1**
M&Ms: Blue 1 Lake, Blue 2 Lake, Red 40 Lake, Yellow 5 Lake, Yellow 6 Lake, **Blue 1, Blue 2, Red 40, Yellow 5, Yellow 6**