3s

Paper Chromatography

OBJECTIVES

- To demonstrate the separation of components of a mixture using Chromatography
- To study the affects on a chromatogram of changing the mobile phase.
- To use a chromatogram to identify similar mixtures.

INTRODUCTION

In order to study the chemical properties of materials, it is important to establish whether they are pure substances or mixtures. Often heterogeneous mixtures can be identified easily because different regions are easily identified by the naked eye. The sample of sand pictured in Figure 3.1a consists of several solid pieces with different appearance and composition. It is easily identified as a heterogeneous mixture.

Distinguishing homogenous mixtures, also called solutions, from pure substances can be more difficult. An aqueous solution of blue food coloring, pictured in Figure 3.1b, has the same appearance throughout. Homogenous mixtures have uniform physical characteristics such as density, color and boiling point.

One of the most effective techniques for both identifying and separating mixtures is chromatography. The word chromatography literally means "color writing". Chromatography typically involves the use of two "phases", one moving (the mobile phase) through or past the other (the stationary phase). The technique takes advantage of the fact that different components of the mixture interact differently with the two phases. Some will be more strongly attracted to (adsorbed onto) the stationary phase, while others will be more attracted to (soluble in) the mobile phase. As the mobile phase moves through the stationary phase,
those components more strongly adsorbed to the stationary phase will lag behind their more mobile counterparts, thereby effecting a separation.

If the same mobile and stationary phases are used, the distance that a component moves through the stationary phase is proportional to how far the solvent moves. Thus, for each component we can define a proportionality factor, called the Rf factor:

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

Components with the same color and Rf value are likely to be the same or very similar compounds. Figure 3.2 demonstrates that Rf values are calculated as the distance from the initial spots to the end of a spot divided by the distance from the initial spots to the solvent front. In this case, the Rf value for spot A is \( \frac{a}{s} \).

**EXPERIMENTAL**

- 8” Aluminum pie plate
- Toothpicks
- Food coloring
- Coffee filters
- Pencil
- 70% Isopropyl Alcohol
- "Expresso" ink pens
- Measuring cup
- Ruler

1) Measure approximately 1 cm from the edge of the coffee filter and mark eight evenly spaced lines around the filter lightly with a pencil (do not use ink).

2) Use a toothpick to spot the four food coloring dyes on one-half of the coffee filter along the pencil mark. On the other half, spot the filter using the pens. Allow each spot to dry and then re-spot two or three more times, see Figure 3.3.
3) After the coffee filter has been spotted, mark the top of each spot with your pencil. Below each spot, in pencil, label the color and if it is pen or food coloring. (Due to the small space below the spot, it may be easier to label "p" for pen, "g" for green, etc.)

4) Place the spotted coffee filter "upside down" in the aluminum pie plate.

5) Fill the pie plate (the chromatographic chamber) with rubbing alcohol to a level just below the spots on the filter. Click here to view a video of the developing chromatogram.

6) Once the chromatogram has developed and the alcohol travels to the "top" of the coffee filter, remove the filter from the plate. Using a pencil, mark the final position of the solvent. Click here to view a video of this procedure.

7) Next place a pencil mark at the end of each color. Note that some of the initial spots separated into multiple colors- be sure to mark each color (see Figure 4).

8) Allow the filter to air dry.

9) Determine and record the distance traveled by the mobile phase by measuring the distance (in mm) from the top of each of the initial spots (original pencil marks) to the final position of the solvent (Figure 3.4).

10) Determine and record the distance traveled by each color by measuring the distance (in mm) from the pencil mark at the top of each of the initial spots to the mark indicating the end of each color it produced (Figure 3.4).
Determine the $R_f$ (ratio of fronts) value for each component of every spot using the formula presented in the *Introduction*.

** Trials 2 & 3: 
- Repeat the experiment using a mixture of 1/4 cup H2O and 1/4 cup IPA (50:50 H2O: IPA). Note: You do not have to add the entire 1/2 cup of 50:50 H2O: IPA to the pie plate.
- Repeat the experiment using H2O only. Note: The water moves quickly up the coffee filter and continues "upward" even after you remove the coffee filter from the pie pan. Mark the solvent front quickly after removing the filter to reduce experimental error.

**RESULTS & DISCUSSION**

1) Based on your data, determine if any of the food colors or inks are mixtures of dyes. Explain your reasoning.

2) Describe the appearance of a chromatograph for a mixture.

3) Based on your data, determine if any of the food colors or inks contain only one type of dye molecule. Explain your decision.

4) Describe the appearance of a chromatograph for a substance with only one dye component.
5) Trials 1, 2, and 3 utilized different substances for the mobile phases. Which mobile phase was best at separating the components of the dye mixtures (i.e., showed the greatest difference in $R_f$ for the two components).

Using the data for the blue pen, blue food coloring, red pen, and red food coloring answer the following questions

6) Comparing pen spots to food coloring spots, what can you conclude about the make-up of the dyes that produce the colors? (i.e., are they similar for both media)

7) Comparing color fronts for the blue pen and blue food coloring, what can you conclude about the make-up of the dyes that produce the colors? (i.e., are they similar for both media)

8) To complete the laboratory, provide your data sheet and the answers to these questions to your instructor.