

# Food Dye Chromatography

## Introduction

Food dyes have been used extensively for more than 100 years. Would you eat maraschino cherries if they were their natural color of beige instead of red? Explore the properties of artificial food dyes with this chromatography activity.

## Concepts

- Chromatography
- Polarity
- Food chemistry

## Background

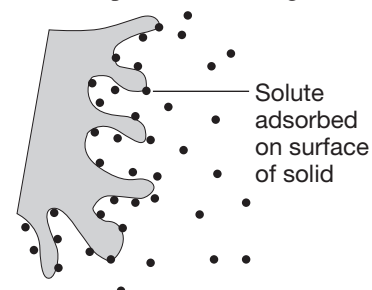
The use of color additives increased dramatically in the United States in the second half of the nineteenth century. As the economy became more industrial, fewer people lived on farms, city populations grew, and people became more dependent on mass produced foods.

Food dyes were initially used to make food more visually appealing to the consumer and, in some cases, to mask poor-quality, inferior, or imitation foods. For example, meat was colored to appear fresh long after it would have naturally turned brown. Jams and jellies were colored to give the impression of higher fruit content than they actually contained. Some food was colored to look like something else—imitation crab meat, for example. Many food colorings and additives were later discovered to be harmful or toxic.

Food colorants were initially added to food with little or no health testing. In 1907, the USDA reduced the number of synthetic food dyes approved for use from 695 to just seven. Only two of the original dyes from 1907 are still accepted for use today. Five others have been added between 1907 and 1971. Only seven dyes are approved for use in the United States today. All of the FD&C approved food dyes are charged, water-soluble organic compounds that bind to natural ionic and polar sites in large food molecules, including proteins and carbohydrates.

Food dyes can be separated and identified by paper chromatography. Paper chromatography is an example of a more general type of chromatography called *adsorption chromatography*. The paper acts as an adsorbent, a solid which is capable of attracting and binding the components in a mixture (see Figure 1). The mixture to be separated is "spotted" onto the surface of the paper and a solvent is allowed to seep or flow through the paper by capillary action. If one of the components in the mixture is more strongly adsorbed onto the paper than another, it will move up the paper more slowly than the solvent. Components that are not strongly adsorbed onto the paper will move up the paper at a faster rate. This "partitioning" of the components of a mixture between the paper and the solvent separates the components and gives rise to different bands or spots. If the components of the mixture are colored, like food dyes or pigments in an ink, the colored bands are easily distinguished.

The distance a sample moves along the chromatography paper is compared to the overall distance the solvent travels—this ratio is called the  $R_f$  or rate of flow. In general, food dye molecules that are more highly charged, that is, have more ionic binding sites and are more polar, will be attracted to the paper more strongly and will have lower  $R_f$  values.



**Figure 1.** Adsorption of solute particles onto the surface of a solid.

## Materials

Food dye mixtures (Kool-Aid<sup>®</sup>, candy, etc.)  
Food Dye FD&C Blue No. 1, 0.5%, 1 mL  
Food Dye FD&C Blue No. 2, 0.5%, 1 mL  
Food Dye FD&C Green No. 3, 0.5%, 1 mL  
Food Dye FD&C Red No. 3, 0.5%, 1 mL  
Food Dye FD&C Red No. 40, 0.5%, 1 mL  
Food Dye FD&C Yellow No. 5, 0.5%, 1 mL  
Food Dye FD&C Yellow No. 6, 0.5%, 1 mL  
Sodium chloride solution, NaCl, 0.1%, 50 mL\*

Beaker, tall-form, 1000-mL or Mason jar  
Chromatography paper, 20 cm × 20 cm  
Pencil  
Ruler  
Scissors  
Stapler  
Toothpicks, 8  
Watch glass that fits on beaker or jar

\*Dissolve 0.1 g of sodium chloride per 100 mL of distilled or deionized water.

## Safety Precautions

The FD&C dyes are slightly hazardous by ingestion, inhalation, eye and skin contact. Red No. 40 may be absorbed through skin and Yellow No. 5 may be a skin contact sensitizer. All are irritating to skin and eyes. Avoid contact with eyes, skin, and clothing. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Please follow all laboratory safety guidelines.

## Procedure

1. Cut a 20 cm × 18 cm piece of chromatography paper (see Figure 2). Handle the paper by the edges.
2. Using a ruler and pencil, draw a faint line 1.5 cm from the bottom across the entire width of the paper (see Figure 3).
3. Using the same ruler and pencil, draw eight small dots. Measure 2 cm from one edge for the first dot and then add a dot every 2 cm across the line. Label the dots (see Figure 3).
4. Obtain the seven pure dye solutions and an “unknown” food dye mixture.
5. Using a clean toothpick for each dye sample, spot the chromatography paper by putting the toothpick into the dye sample solution and then touching the tip of the toothpick gently onto a pencil dot. Repeat the procedure as necessary to increase the concentration of the sample but do not increase the size of the dot.
6. Wait 1–2 minutes for the samples on the chromatography paper to completely dry.
7. While the sample is drying obtain a tall-form beaker or Mason jar and a watch glass that will fit over the container.
8. Pour 50 mL of 0.1% NaCl solution into the beaker and cover the top with a watch glass. This is the chromatography chamber. The 0.1% NaCl is the developing solvent.
9. Wrap the chromatography paper into a cylinder, and slightly overlap the blank ends. Staple, being careful not to disrupt the samples (see Figure 4).
10. Remove the watch glass from the beaker and carefully place the paper cylinder into the chamber with the sample end down (as shown in Figure 5). Do not get any solvent on the upper portion of the chromatography paper. The sample spots must remain above the level of the solvent. If the solvent level is too high, the samples will dissolve into the solvent.
11. Place the watch glass back on the beaker and allow the chromatogram to develop— 15–25 minutes.

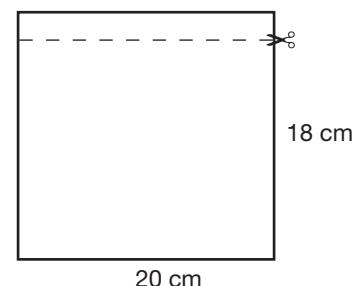


Figure 2.

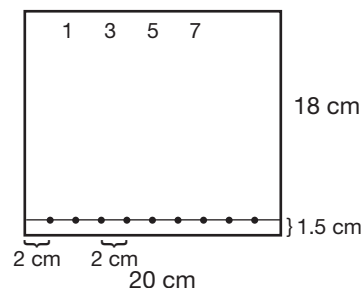


Figure 3.

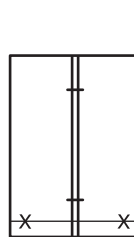


Figure 4.

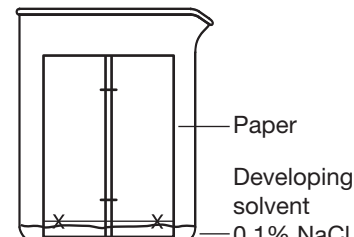


Figure 5.

12. When the solvent is within 1–2 cm of the top of the paper, remove it from the beaker.
13. With a pencil, lightly draw a line to mark the distance the *solvent* traveled to the top of the chromatography paper. This is called the *solvent front*.
14. Gently remove the staples and lay the paper flat.
15. Measure the distance from the pencil line at the bottom of the chromatography paper to the solvent front. Record this distance in cm.
16. In pencil, trace the shape of each dye band or spot to mark the location of each separated band. This should be done immediately because the color and brightness of some spots may fade over time.
17. Measure the distance traveled in cm by each dye in each pure solution or mixture. Measure from the line at the bottom of the paper to the *center* of each band.

## Tips

- Make sure the initial sample spots are as small as possible. If the spots are too large or if there is too much material (dye) on the initial spot, the students may only see streaks of color.
- The chromatography paper must be left in the solvent chamber long enough for the solvent to be drawn up near the top of the strip. Underdevelopment will lead to poor separation. Do not allow the solvent front to move off the paper, however.
- Other size beakers or mason jars will also work for chromatography chambers—the taller the better. The chambers can be covered with plastic wrap, Petri dishes, or Parafilm.
- Students can design experiments to identify the dyes in colored food products such as M&Ms or Skittles. Candy may be placed in 5–6 drops of water. Stir the candy until the color dissolves. Repeat with two more candies.

## Sample Results *(Student data will vary.)*

Location	Dye	Color	$R_f$
1	<i>Yellow No. 5</i>	<i>Yellow</i>	<i>0.71</i>
2	<i>Blue No.2</i>	<i>Dark navy blue</i>	<i>0.35</i>
3	<i>Green No.3</i>	<i>Dark blue-green</i>	<i>0.90</i>
4	<i>Red No.3</i>	<i>Red</i>	<i>0.10</i>
5	<i>Blue No.1</i>	<i>Dark turquoise blue</i>	<i>0.88</i>
6	<i>Red No.40</i>	<i>Dark red</i>	<i>0.31</i>
7	<i>Yellow No.6</i>	<i>Dark orange</i>	<i>0.52</i>

## Materials for *Food Dye Chromatography* is available from Flinn Scientific, Inc.

Catalog No.	Description
AP7375	FD&C Food Dyes, Set of 7
AP7394	Food Dye Chromatography—Student Laboratory Kit
AP4299	Chromatography Paper
AP7418	Exploring Chemical Reactions with Food Dyes
AP7428	Quantitative Determination of Food Dyes

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.