

Paper chromatography of inks and dyes

Target audience: 9-12

Background and Notes:

Different molecules exert different forces of attraction on each other resulting in different solubilities within different solvents. These solubility differences make it possible to separate mixtures into their separate components.

Chromatography relies on two phases, stationary and mobile. The separation of a mixture is based on a difference in the degree of attraction between the components and the stationary and mobile phases. In paper chromatography, the stationary phase is the paper and the mobile phase is the solvent either water or alcohol.

In this activity, students will use two solvents to separate different water based and nonwater based inks into their different components.

Knowledge and skills:

- Students should be able to relate the polarity of molecules to their solubilities in different solvents.
- Students should be able to connect molecular motion in a solvent to polarity of molecules.
- Students should be able to distinguish between stationary and mobile phases and calculate the R_f values for the different components separated.
- Students should know the terms: polar, nonpolar, hydrophilic, hydrophobic, homogeneous, heterogeneous, solvents, and R_f

Fundamental understanding:

- Different molecules exert different forces of attraction on each other resulting in different solubilities within given solvents.

Essential Questions:

- How does molecular structure and polarity relate to the separation of molecules?

National standard:

National content standard B, students should develop an understanding of the structure of atoms and the structure and properties of matter.

Students should understand the motions and forces with Interactions of energy and matter.

State standard(s):

- 1.02 and 1.07 Objectives for North Carolina Standard Course of Study Objective: Bond Polarity and molecular polarity, including intermolecular forces in order to explain polarity.

Purpose: to separate components of inks or dyes by their different polarities.

Safety Precautions: Careful not to stain clothing or hands. Do not breathe solvent fumes.

Materials:

- **Equipment:**

1. Chromatography paper or white coffee filters (2/2 students)
2. Glass rods or pencils (2/2 students)
3. Tape
4. capillary tubes for the dyes
5. 2 Beakers (250 ml) or jars/ team of 2 students
6. Foil or watch glasses to cover beakers during activity
7. Ink pens to be tested waterproof and water based inks
8. Other possible liquids, food dyes, acid base indicators

- **Reagents:**

1. Water
2. Isopropyl alcohol
3. Other possible solvents to test: methanol or 50% water: acetone

Procedure: for one piece of paper into one beaker of one solvent

1. Cut appropriate size chromatography paper (~ 10.0 cm), handle by the edges
2. Mark a pencil (do not use ink) line (~2.0 cm) from the bottom, label a spot for each ink tested



3. Apply different inks or dyes (use capillary tubes for liquids) to the labeled spots on the pencil line. Record which liquid is at each spot into your lab book.
4. Tape the paper to the pencil or glass rod such that the line with the ink spots is not submerged in the solvent (or the ink will come out into the solvent rather than run up the paper).
5. Add solvent, water or alcohol to beaker, then place glass rod with taped, marked paper.
6. Run the solvent at least 6-7 cm up the paper.
7. Mark the solvent front with a pencil.
8. Measure the distance the solvent moved and the distance each component of the dyes moved.

Results:

- **Observations:** Draw the image of your chromatogram into your lab book and/or tape your chromatogram into the lab book
- **Data table: Determine the R_f values for each component in each ink.**

Calculations and Data Analysis:

1. Calculate R_f values for each ink or dye using the formula

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

Conclusion:

1. Restate Purpose.
2. Are all inks of the same color composed of the same substances? Explain.
3. Are all the inks you tested water-soluble? Explain.
4. If an ink is not water soluble, how could you determine if that ink were a mixture or a pure substance?
5. How would you change or improve this activity?

References and Resources:

High school or a college chemistry book

Teacher Notes:

Lab set up:

At each lab table for 4 students

1. 4 250 ml beakers or jars
2. 4 strips of chromatography paper (10.0 cm long)
3. 4 glass rods
4. Scotch tape
5. Water
6. Isopropyl alcohol – 1 bottle
7. Waterproof pen
8. Water based pen (black vis a vis work well)

Note: As an Inquiry activity, all supplies can be set out and students allowed to design a way to separate molecules in a mixture of ink or food dyes.

An unknown mixture of food dyes can be set up as long as the student can run the pure food dyes in the mixture are run on the same paper.