

# The Case of the Forged Note: Exploring Chromatography

## Lesson Overview

In this lesson, students transition from being observers to forensic chemists. They will explore the principles of mixtures, solubility, and molecular polarity through the lens of Paper Chromatography. By the end of the session, students will use scientific evidence to identify which "suspect" wrote a mysterious note.

## Learning Objectives

- **Identify** the difference between pure substances and mixtures.
- **Explain** the roles of the stationary phase and the mobile phase in chromatography.
- **Analyze** how molecular polarity and solubility determine the rate at which substances travel.
- **Apply** the scientific method to solve a simulated real-world forensic problem.

## Materials Needed

- White coffee filters or chromatography paper
- 3-4 different brands of black felt-tip pens/markers (e.g., Sharpie, Expo, Crayola, Papermate)
- Clear plastic cups or glasses
- Water (polar solvent)
- Isopropyl alcohol/Rubbing alcohol (less polar solvent)
- Pencils and tape
- Scissors and a ruler
- A "Crime Scene Note" (written by the instructor using one of the pens on a strip of filter paper)

## 1. Introduction: The Hook (10 Minutes)

**The Scenario:** A handwritten note was found at a high-security facility. It contains a secret code, but we need to know who wrote it. We have four suspects, each carrying a different brand of black pen. At first glance, all black ink looks the same. But is it?

**The Question:** How can we "unmask" the colors hidden inside a single drop of black ink to identify the culprit?

**The Science:** Briefly introduce *Chromatography*. Explain that most black inks are actually mixtures of many different colored pigments. Chromatography is a method used to separate these mixtures based on how they interact with a "stationary" surface (the paper) and a "mobile" solvent (the water or alcohol).

## 2. Instruction: "I Do" (15 Minutes)

Demonstrate the core concepts using the following talking points and a quick visual setup:

- **Mixtures vs. Pure Substances:** Explain that black ink is a mixture. If it were a pure substance, it wouldn't separate into different colors.
- **Solubility:** Explain that for chromatography to work, the substance must be able to dissolve in the liquid (solvent). If the ink is permanent (like a Sharpie), water won't move it; we need a different solvent like alcohol.
- **The Mechanism:** Use a "Race Track" analogy. The paper is the track. The solvent is the wind pushing the runners (pigments). Smaller, more soluble molecules move faster and farther, while larger, less soluble molecules lag behind.
- **Modeling the Setup:** Show how to cut a strip of filter paper, draw a "start line" in pencil (not pen!), and place a single dot of ink on that line.

## 3. Guided Practice: "We Do" (15 Minutes)

Work together to set up a control test to ensure the technique is mastered before "solving the crime."

1. Cut a strip of filter paper approximately 1 inch wide and 5 inches long.
2. Use a pencil to draw a horizontal line 1 inch from the bottom. (*Discuss: Why pencil? Because pencil lead/graphite is not soluble and won't interfere with the results.*)
3. Place a small, concentrated dot of "Suspect Pen #1" in the center of the pencil line.
4. Tape the top of the strip to a pencil and rest the pencil across the top of a cup.
5. Add just enough water to the cup so the bottom of the paper touches the liquid, but the **water level stays below the ink dot.**
6. Watch the water move up the paper (capillary action) and begin to pull the pigments apart.

## 4. Independent Investigation: "You Do" (30 Minutes)

The student now takes the lead as the Forensic Lead Scientist.

**The Task:** Create a "chromatogram library" for all suspect pens and compare them to the "Crime Scene Note."

1. **Prepare the Evidence:** Set up three more strips for the remaining suspect pens.
2. **The Variable:** If one pen is a "Permanent Marker," have the student predict what will happen in water vs. alcohol. Let them run one strip in water and one in alcohol to see the difference.
3. **Run the Crime Scene Sample:** Place the "Crime Scene Note" strip into the solvent.
4. **Data Collection:** Once the solvent reaches 1 inch from the top, remove the strips and let them dry.
5. **Analysis:** Measure the distance traveled by the solvent front and the distance traveled by the primary color bands. Calculate the *Rf Value* (Retention Factor) if advanced math application is desired:  $Rf = \text{Distance of Pigment} / \text{Distance of Solvent}$ .

## 5. Conclusion: Closure & Recap (10 Minutes)

- **Summary:** Have the student present their findings. "Which suspect wrote the note? How do you know?"

- **Recap:** Ask the student to define the *mobile phase* and *stationary phase* in their own words.
- **Real-World Application:** Explain that chromatography is used by the FDA to check for pesticides in food, by hospitals to check for toxins in blood, and by environmental scientists to test for pollutants in water.

## Assessment

**Formative Assessment (During the lesson):** Observe the student's setup. Are they keeping the ink dot above the water line? Ask: "Why is the blue color moving faster than the red color in this specific pen?"

**Summative Assessment (End of lesson):** The student completes a "Lab Report" including:

- A hypothesis: "I think Pen X is the culprit because..."
- A labeled diagram of their best chromatogram.
- A concluding statement explaining how polarity and solubility allowed them to identify the ink.

## Success Criteria

- Student successfully separates at least one black ink into two or more distinct colors.
- Student correctly identifies the suspect pen that matches the crime scene sample.
- Student can explain why water worked for some pens but not others (Polarity/Solubility).

## Differentiation & Adaptations

- **Scaffolding (Struggling Learners):** Provide a pre-drawn template on the filter paper. Focus strictly on the visual matching of color bands rather than Rf calculations.
- **Extension (Advanced Learners):** Challenge the student to calculate the Rf values for every color band. Introduce the concept of *Hydrophilic* vs. *Hydrophobic* molecules. Test different types of paper (paper towels, notebook paper) to see how the stationary phase affects the results.
- **Classroom/Group Setting:** Assign each "Suspect Pen" to a different small group and have them pool their data on a central whiteboard to find the match.