

Teacher's Preparatory Guide

Part 1 Properties of Fluids: Stationary Phase

Purpose: This lab is part 1 of 2 labs that will explore the properties of water flow. This inquiry-based lab consists of 2 sections: the *Guided Lab Activity* and the *Going Further* (research) portion. The guided lab activity, performed on the first day, is designed to help students observe and understand the way fluids interact with a stationary phase for example, chromatography paper. As the students do their guided lab activity, they will be responsible for generating a minimum of three questions related to the lab activity that would require further research. The *Going Further* (research) portion should be used on the second day as an inquiry-based follow-up to part 1. The purpose of this portion is for students to get some answers to their chromatography questions. Each student will choose one of their generated questions and research the answer to it. Students may end up researching the properties of liquids, the different types of liquids used in food, the body, the medical field, and in industry, as well as how chromatography and nanotechnology link together (for example, nano-liquid chromatography is used in “lab-on-a-chip” technology). From their research, students should be able to devise a new experiment that will allow a deeper understanding of the material; this exercise could be done for extra credit.

Level: Middle school or high school chemistry, physics, and physical science

Time required: Total: two to three 50-minute class periods, or two 90-minute block periods
Guided Lab Activity section: one 50-minute class or one 90-minute block period
Going Further section: one to two 50-minute class periods, or one 90-minute block period, during which students will use your school's library resources or computer lab

Teacher Background

Chromatography is the technique of passing a liquid or gaseous mixture over or through an adsorbent material that adsorbs the different components of the mixture at different rates in order to identify those components. Paper chromatography involves using chromatography paper (the *stationary phase*) through which a solvent (the *mobile phase*) passes using *capillary action*. In this lab, the marker ink is the solute, the alcohol is the solvent (*mobile phase* of the chromatography system), and the paper is the *stationary phase*. *Capillary action* occurs when the *adhesion force* of a substance is greater than the *cohesion force* of that substance; in other words and in this case, the attraction of the alcohol to the paper is greater than the attraction of the alcohol to itself causing the alcohol to move up the paper. The different colored marker inks and their components also have different attractions to the paper, themselves, and the alcohol; therefore, each component will move up the paper at different distances depending on each component's intensity of attraction to these different items.

The retention factor (Rf value) of a component is the ratio between the distance the component (ink) travels and the distance the solvent (alcohol) travels from a shared starting point (the center of the ink spot). In other words:

$$\text{Rf value} = \frac{\text{distance component travel}}{\text{distance solvent travels}}$$

An example is that the component travels 2.5 cm from the center of the ink spot and the solvent travels 5.0 cm from the center of the spot resulting in an Rf value of 0.5 for this component. This calculation would look like this:

$$\text{Rf value} = \frac{2.5 \text{ cm}}{5.0 \text{ cm}} = 0.5$$

When the conditions remain constant in paper chromatography, a compound will always move a set proportion of the distance traveled by the solvent. The Rf value is a constant for a particular compound and can be used (often with other properties) to identify compounds.

Chromatography is used in many occupational fields. Chemists and biologists use it to identify unknown substances in a sample by separating them into their individual components and comparing them to the profiles of known samples. Criminalists use a form of chromatography to identify components in a sample of blood, or drugs, and even in the ink on notes found at crime scenes in order to determine the specific ink used on the note. Many databases have been developed of different components creating profiles to which crime scene evidence can be compared, thereby narrowing the clues in the hopes of solving the crime.

Nanotechnology is linked to chromatography in several ways. First, chromatography is the separation of a complex mixture into its components at the molecular level. Recent developments have led to nano-liquid chromatography which allows for decreased inner diameters of the liquid chromatography column. This in turn allows for smaller samples and increased sensitivity. Another area of development with nano-liquid chromatography is with microfluidics and “lab-on-a-chip” devices. These require liquid chromatography separation as part of the chemical analysis occurring within these devices.

Materials per student:

- nitrile gloves
- goggles

Materials for each group of 2 students:

- 2 strips of white chromatography paper, cut into 25 cm strips (this lab used Whatman brand, basic weight 87 g/m² thickness 0.18mm medium flow rate)
- sheet protector (with artist’s tape as a label)
- colored markers (green, orange, purple, yellow, at least)
- ruler
- pencil
- 75 ml rubbing alcohol

National Nanotechnology Infrastructure Network

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Developed by Urenia Hernandez; edited by Angela Berenstein
Development and distribution partially funded by the National Science Foundation

NNIN Document: NNIN-1216

- graduated cylinder or plastic 150 ml measuring cup
- paper towels

Safety Information: Students should wear protective gloves and goggles to protect themselves from chemical splash. Instruct students not to inhale the alcohol fumes. Explain that students should wear gloves while handling the paper so that oils from their hands do not contaminate the paper and interfere with the experiment.

Advance Preparation:

1. Put a strip of artist's tape on each sheet protector to serve as a label so each group can write their names on it.
2. Cut chromatography paper into strips - While wearing gloves, cut the chromatography paper into 25 cm long strips. Only handle the paper with gloves so that oils from your hands do not contaminate it.
3. Schedule time to use school's library resource or computer lab. Reserve the computer lab or contact your school librarian and schedule one to two 50-minute class periods, or one 90-minute block period, immediately following the guided lab activity class so that students may use the resources available there. You may wish to have the contact information of the company who makes the markers or contact them beforehand (to use less class time) for information about what is inside their markers.

Directions for the Activity

Guided Lab Activity section

Teaching Strategies: This activity works best in student pairs. *Before* beginning the lab, ask the students the questions and review the terms in the *Guided Dialog* section below. Inform students that in the next section of this lab, they will be responsible for generating a minimum of three questions related to the activity today that would require further research, and then will choose one of their questions and research the answer to it. Demonstrate the materials and procedure before distributing them to the students.

Guided Dialog:

A. *Before* beginning the lab, ask students the following questions to provoke thought and review what they already know:

1. What colors are primary? *red, yellow, blue*
2. What colors are components of other colors? *blue & yellow are components of green, yellow and red are components of orange, red and blue are components of purple, etc.*
3. What does it mean when something is stationary? *it's still; not moving*

Remind students that they should be thinking of these questions as the activity is going on.

B. Review the meaning of the following terms:

Chromatography *the technique of passing a liquid or gaseous mixture over or through an adsorbent material that adsorbs the different components of the mixture at different rates in order to identify those components*

Stationary phase of paper chromatography *the paper that does not move during chromatography*

Mobile phase of paper chromatography *the solvent that passes over or through the paper*

Adhesion force *the attraction of the solvent to the paper*

Cohesion force *the attraction of the solvent to itself*

Capillary action *occurs when the adhesion force of a substance (the attraction of the solvent to the paper) is greater than its cohesion force (the attraction of the solvent to itself)*

Rf value *the ratio between the distance the component (ink) travels and the distance the solvent (alcohol) travels from a shared starting point (the center of the ink spot)*

Part 1 directions can be found in the Student Worksheet Part 1. Below is the Student Worksheet Part 2 with answers.

Name: _____ Date: _____ Class: _____

Student Worksheet

Part 2, Properties of Fluids: Stationary Phase

Going Further

Directions: Come up with at least three questions related to part 1 of this lab that you would like to research further.

1. Question: Example question: How far will the line travel up the paper?

Prediction: _____

Category: experiment (This student can simply wait to see how far the line will travel up the paper, and does not need to look up this answer on the web.)

2. Question: Example question: Is a chemical reaction taking place?

Prediction: _____

Category: research (This student would need to know the definition of chemical reaction to be able to decide whether one is taking place. So, this student will need to use the library resources to answer the question.)

3. Question: Example question: Why didn't the green dot move up the paper like the other colors did?

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Developed by Urenia Hernandez; edited by Angela Berenstein
Development and distribution partially funded by the National Science Foundation

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Prediction: _____

Category: research (This student may need to know something about what is inside the green marker. This student may need to contact the company for more information about the chemicals or ingredients that are used in the marker.

Procedure: Choose one of your questions from the previous page and research the answer. Use these websites as a starting point: www.ask.com; www.yahoo.com; www.altavista.com; www.google.com

Look for information that will help answer your questions. Look for about 3–5 articles and choose the one that is easiest to read from beginning to end. If you haven't found anything useful after 15 minutes, type any of the words below in the search box:

- paper chromatography
- dye speeds
- paper chromatography calculations
- alcohol as a solvent in paper chromatography
- rate of flow
- chromatography as a physical change
- chromatography as a chemical change

Draw Conclusions:

1. Which question did you end up researching?

2. Was your prediction correct? Explain.

3. What did you discover today about paper chromatography?

4. List your sources (where you got the information).

Extra Credit

From your research, can you devise a new experiment that will allow a deeper understanding of the properties of fluids? Describe it.

Cleanup: Students should label the sheet protector with the names of everyone in their group. Then they should put a paper towel into the sheet protector and put the chromatography paper strips inside without dripping any liquid. Have students gather materials into a bin and throw gloves in a plastic recycle bin or trash if a recycling bin is unavailable. Collect the fluid waste in a waste bottle from the students at the end of the lab. The alcohol is reusable. Never pour alcohol or chemical waste down a sink.

Going Further section

Teaching Strategies: For the first 5 minutes of class, ask students to predict the answers to their questions. Remind students that a prediction follows this format: I think _____ because _____.

Before going to the library or computer lab, lead a quick discussion on which types of questions students can answer by conducting an experiment and which questions would need research on the web. Ask students to take a few moments and sort their questions into two categories: experiment and research.

Invite a few students to share their questions with the class to use as an example. (*See Student Worksheet With Answer Key, Part 2, Going Further for some example questions.*) Instruct students to focus their research only on those questions that are labeled “research”. Ask: “Besides the Internet, what other resources are available in the library that you could use?” *dictionaries, encyclopedias, journals, books, articles*

When students arrive in the library/computer lab, tell them to focus on a question for 15 minutes. If they haven’t found anything within 15 minutes, to move on to the next question.

Ask students why they should be cautious about using Wikipedia as a source. *Anyone in the world can add to the Wikipedia article at any time, so some information may be incorrect.*

Students will end this research section of the lab by completing the *Draw Conclusions* section and, if they want, the *Extra Credit* section found on the last page of the Student Worksheet, Part 2.

Assessment

Guided Lab Activity section

Each student will turn in their completed worksheet for part 1 at the end of the lab so the teacher can assess the student’s understanding of the way fluids interact with a stationary phase. Points can be given for correctly:

- completing the activity and explaining observations during the activity
- measuring the distances needed to calculate the Rf value
- calculating the Rf value
- portraying his/her results on the diagram provided

Going Further section

Each student will turn in their completed worksheet for part 2 so the teacher can assess the student’s ability to do the research for an independent inquiry. Points can be given for correctly:

- generating 3 questions and predictions for those questions
- sorting his/her questions into the proper categories

- performing the research needed to correctly answer one of his/her questions
- listing the resources used

Extra credit points can be given for correctly:

- devising and describing a new experiment that will allow a deeper understanding of the properties of fluids

Resources: Background information and inspiration for this lab can be found at the following websites:

- Project: Paper Chromatography: Basic Version
<http://chemmaster.blogspot.com/2007/11/project-paper-chromatography-basic.html>
 Chromatography http://74.125.95.132/search?q=cache:yLOQMx4JuYEJ:www.clt.uwa.edu.au/__data/page/112506/fsp11_chromatography.pdf+Rf+value+of+each+component+of+ink+on+chromatography+paper&hl=en&ct=clnk&cd=3&gl=us
- Introduction to chromatography chromatography introduction <http://www.rpi.edu/dept/chem-eng/Biotech-Environ/CHROMO/chromintro.html>

National Science Education Standards (Grades 5–8)

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Properties and changes of properties in matter
- Motions and forces

Content Standard E: Science and Technology

- Abilities of technological design
- Understandings about science and technology

National Science Education Standards (Grades 9–12)

Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Content Standard B: Physical Science

- Structure and properties of matter
- Motions and forces

Content Standard E: Science and Technology

- Abilities of technological design
- Understandings about science and technology