

Color Change Challenge

Problem Solving by Trial and Error



Introduction

Scientists use many different strategies to solve problems. One such strategy is known as *trial and error*. The term may lead some to believe that when a test (the trial) leads to an incorrect solution (the error), then the experiment has failed. This activity will help students discover that learning what does not work is just as valuable in science as discovering what does work.

Concepts

- Chemical change
- Problem solving
- Nature of science
- Trial and error



Background

The nature of scientific inquiry is not a rigid path, but a dynamic process of discovery. Discovery includes observations, asking questions, and designing experiments to test possible answers to these questions. Some experiments involve trial and error. The purpose of trial and error is to test multiple possibilities for solving a problem, but not necessarily to find out why the solution works. Trial and error is often used to discover new medicines and is a great strategy for producing new inventions. Thomas Edison (1847–1931), the famous inventor, once said, “I have not failed. I’ve just found 10,000 ways that won’t work.”

This activity uses the problem-solving strategy of trial and error to identify a series of chemical changes that will result in specific color changes. A chemical change is defined as a change in the composition and properties of a substance. The transformation of original substances (reactants) into new substances (products) as a result of a chemical change is called a chemical reaction. Both in the natural world and in the laboratory we recognize that a chemical reaction has occurred by observing the appearance of products with physical and chemical properties different from the reactants from which they were made. Many types of observations may be used to determine that a chemical change has occurred, one of which is a color change that does not result from dilution or color mixing.

The purpose of this experiment is to mix four solutions labeled A, B, C, and D in the correct sequence to produce a series of color changes—from colorless to orange, then to bluish-black, and finally back to colorless again. See the *Pre-Lab Preparation* section for identification of the four solutions.

Materials (for 15 groups of students)

Bleach solution (sodium hypochlorite, 5%), 20 mL	Labels, adhesive, 60
Potassium iodide solution, KI, 0.1 M, 30 mL	Paper towels
Sodium thiosulfate solution, $\text{Na}_2\text{S}_2\text{O}_3$, 1 M, 40 mL	Pipet holders, 15
Starch, 1 g	Spot plates, 12- or 15-well, 15
Disposable pipets, thin stem, 60	Toothpicks

Additional Materials Needed (for *Pre-Lab Preparation*)

Water, distilled or deionized	Hot plate or laboratory microwave oven
Beakers, 100-mL, 3	Stirring rods, 3
Beaker, borosilicate glass, 100-mL	Wax pencil
Graduated cylinder, 50- or 100-mL	

Pre-Lab Preparation

Bleach solution, 50%: Add 20 mL of 5% sodium hypochlorite solution to a 100-mL beaker. Stir in 20 mL of distilled water. Label the beaker.

Starch solution, 2%: (Best prepared no earlier than three days before the lab.) Heat 50 mL of distilled water to boiling in a 100-mL borosilicate glass beaker. Add 1 g of starch to a clean 100-mL beaker. Add a few milliliters of the hot water to the starch in the beaker. Stir. Continue to add the remaining hot water slowly to the beaker, stirring until the mixture appears uniform. Allow the colloidal starch solution to cool slowly to room temperature before using. Label the beaker.

Sodium thiosulfate solution, 1 M: Add 10 g of sodium thiosulfate pentahydrate to 40 mL of distilled water. Stir with a stirring rod. Label the beaker.

1. Obtain 60 thin-stem disposable pipets and adhesive labels. Fold one label around the stem of each pipet (see Figure 1). Label each set of four pipets A, B, C, and D.
2. Open each pipet holder (cassette case) as in Figure 1.
3. Fill each pipet with approximately 2 mL of the appropriate solution, using the chart below.
4. Place the pipets stem side up in the pipet cases for storage.

Label	Solution
A	Starch, 2%
B	Potassium iodide, 0.1 M
C	Bleach, 50%
D	Sodium thiosulfate, 1 M

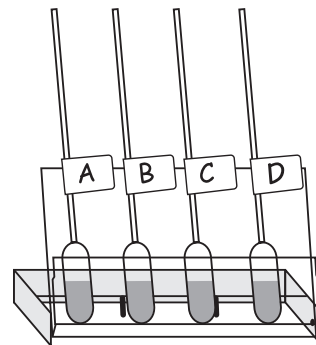


Figure 1.

Safety Precautions

Sodium hypochlorite solution (bleach) is a corrosive liquid, reacts with acid to evolve poisonous chlorine gas, and is moderately toxic by ingestion and inhalation. Avoid contact with organic material. Sodium thiosulfate pentahydrate is slightly toxic by ingestion and a body tissue irritant. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Remind students to wash their hands thoroughly with soap and water before leaving the laboratory. Please review current Safety Data Sheets for additional safety, handling, and disposal information.

Procedure

1. Explain the purpose of the experiment to the students as described in the *Background* section.
2. Instruct students to write an “action plan” to test the possible combinations of solutions. Included in the action plan should be a way to clearly communicate observations and results.
3. Once the action plans have been approved by the instructor, allow students to test their plans using the prepared unknown solutions.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures, and review all federal, state and local regulations that may apply, before proceeding. All solutions used in this activity may be disposed of down the drain with plenty of excess water according to Flinn Suggested Disposal Method #26b. The small amounts of liquid in the spot plates may be blotted up with several thicknesses of paper towel and disposed of according to Flinn Suggested Disposal Method #26a.

NGSS Alignment

This laboratory activity relates to the following Next Generation Science Standards (2013):

Disciplinary Core Ideas: Middle School

MS-PS1 Matter and Its Interactions
PS1.B: Chemical Reactions

Disciplinary Core Ideas: High School

HS-PS1 Matter and Its Interactions
PS1.B: Chemical Reactions

Science and Engineering Practices

Planning and carrying out investigations

Crosscutting Concepts

Stability and change

Tips

- This is a great activity for experiencing the nature of scientific inquiry and problem-solving as well as to introduce chemical reactions.
- Only one sequence will yield the correct results—B + C + A + D (or C + B + A + D). Avoid telling students this, however, so they will test all possible combinations.
- The solutions used in this activity have a poor shelf life and should be prepared no earlier than three days before the lab. A 0.1 M potassium iodide solution and starch solution will grow mold. A 1 M sodium thiosulfate solution is subject to bacterial decomposition. The 50% bleach solution will keep for seven to ten days.
- Five drops of each solution is recommended for the necessary color change. When adding the 50% bleach solution to the 0.1 M potassium iodide solution, a yellow color will appear first. If five drops of each are used, the solution will turn orange.
- Students may prepare their own pipets of each solution. Have identical beakers of each solution labeled A–D available in a central area. Advise students to fill the pipet bulbs only halfway.
- Assure students that even though the solutions are unknown to them, the instructor knows what they are, and mixing them according to the teacher's instructions is safe. Using trial and error to mix completely unknown solutions of course is not safe!
- The following is an explanation for the reactions taking place.
Iodine ions, I^- , from the potassium iodide solution react with the bleach to produce elemental neutral iodine, I_2 , and chloride ions. Iodine is an amber color.
Iodine reacts with starch to form the familiar dark blue starch–iodine complex.
Sodium thiosulfate reduces the iodine in the starch–iodine complex to regenerate colorless iodide ions, I^- .
- Adding sodium thiosulfate solution to the starch–iodine complex may not reduce all of the iodine immediately. A few dark “flecks” may remain momentarily, but with stirring the solution should become completely clear.
- Offer a slightly greater challenge by adding a fifth mystery liquid, distilled or deionized water. The addition of a few drops of water will have no effect on the color of the solutions, other than a slight dilution in intensity (a physical change). The instructions for the challenge would be to determine which four out of the five solutions will product the correct sequence of color changes.

Materials for *Color Change Challenge* are available from Flinn Scientific, Inc.

This activity is also available as a student laboratory kit, with enough materials for 15 groups of students, except spot plates, which may be purchased separately.

Catalog No.	Description
AP7209	Color Change Challenge—Student Laboratory Kit
S0079	Sodium Hypochlorite Solution, 500 mL
P0172	Potassium Iodide Solution, 0.1 M, 500 mL
S0114	Sodium Thiosulfate, pentahydrate, 500 g
S0125	Starch, Potato, 500 g
AP6399	Spot Plate, Polystyrene, 12-well
AP1519	Pipet Holder

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