To close the yellow note, click once to select it and then click the box in the upper left corner.
To open the note, double click (Mac OS) or right click (Windows) on the note icon.

Designer Colors, an Inquiry Approach to Flame Testing

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INTRODUCTION

Description

In place of traditional flame test procedures, the students will make lances (small tubes that hold the materials for color testing), make a spectroscope to observe the flames from the burning lances, and create a specific, reproducible color.

Student Audience

This activity is appropriate for chemistry students in the eleventh and twelfth grades.

Goals for the Activity

The students will be able to

- follow a detailed schematic to produce a spectroscope to be used in the testing;
- explain and demonstrate the science of spectroscopes and the uses of spectroscopes in both the classroom and industry;
- understand the role of test lances in determining the colors produced;
- perform an experiment with an array of variables and multiple trials;
- extrapolate from the testing data in order to design additional lances of designated colors;
- work safely in the laboratory setting;
- evaluate testing results and plan new trials;
- improve and fine-tune their lance designs;
- share the formulae with peers in order to determine the reproducibility of their creations;
- validate the work of their peers by testing the formulae invented by these classmates;
- predict the components of the lances of their peers based on their own observations and experimentation; and
- create a chart to reflect the experimental results.

Recommended Placement in the Curriculum

Chemistry—atomic structure
Physics (with access to a hood)—light

STUDENT HANDOUT
Designer Colors, an Inquiry Approach to Flame Testing

Purpose

To investigate the spectroscopic colors unique to elements, and to use this information to create a specific color.

Scenario

While an understanding of color and spectra are important in the study of chemistry, physical science, and physics, applications include the production of pyrotechnics, stage effects, identification of unknown materials (forensics, patent research), astronomical observations, and an appreciation of natural light phenomena.

Materials

Per group

- dark green hanging file folder
- scissors or utility knife
- CD-ROM
- 50–75 small Post-it® Notes
- roll of transparent tape
- 2, 1/4-inch wooden dowels, 6 inches long
- 2, 3/16-inch wooden dowels, 6 inches long
- 12 lance test bases (1-inch-square pieces of particle board with a hole in the center 75% of the way through)
- paper to make funnels

Per class

- collection of nitrates and chlorides (strontium, copper, barium, potassium, aluminum, etc.) that have been finely ground by the instructor and are quite dry
- propane blowtorch for use in the fume hood
- matches
- waste container and hand broom to clean the area between groups
- fire extinguisher

Safety, Handling, and Disposal

It is your responsibility to specifically follow your institution's standard operating procedures (SOPs) and all local, state, and national guidelines on safe handling and storage of all chemicals and equipment you may use in this activity. This includes determining and using the appropriate personal protective equipment (e.g., goggles, gloves, apron). If you are at any time unsure about an SOP or other regulation, check with your instructor.

Ignition of lances must occur ONLY in a functioning fume hood. Only one group may work under the hood at a time. Students with acrylic nails may not ignite the lances.

Chemicals are to be handled using the tools provided. Use only the chemicals that have been provided by your instructor. If you find lumps in your chemicals that interfere with the filling of the lances, see the instructor. Record everything you do as it is done so that in an emergency the instructor will know what you have been working with.

Dispose of used reagents according to your instructor's directions.

Procedure to Learn the Process

I. Making a spectroscope

1. Follow the directions from the Wakabayashi, F.; Hamada, K.; Sone, K. "CD-ROM Spectroscope: A Simple and Inexpensive Tool for Classroom Demonstrations on Chemical Spectroscopy," *Journal of Chemical Education.* 1998, *75*(12), 1569–1570.

II. Making the test lances

1. Wrap a small Post-it Note around the larger-diameter dowel so that the sticky part is last and will hold the little tube together. (See Figure 1.)

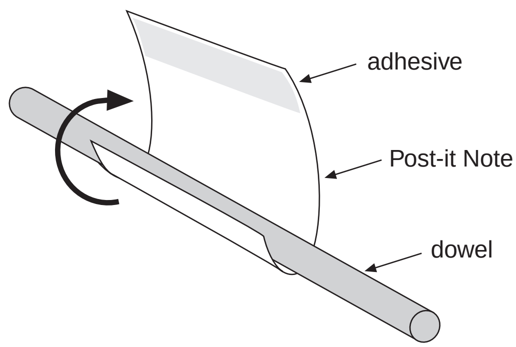

Figure 1: Wrapping the Post-it Note

2. Use a small piece of tape to reinforce the seam. (See Figure 2.)

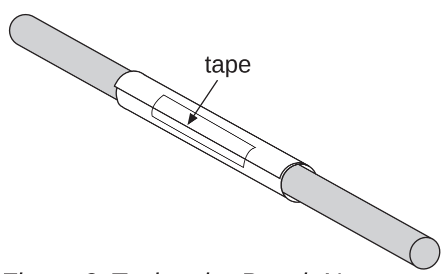

Figure 2: Taping the Post-it Note

3. Move the dowel so that the paper overhangs the dowel by almost 1/4 inch. (See Figure 3.)

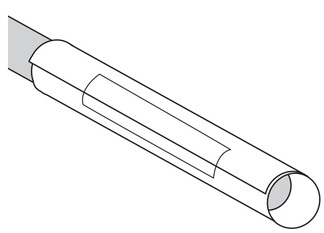

Figure 3: Post-it Note overhanging the dowel

4. Bend this 1/4 inch of paper over to form a base, creasing the paper over the dowel end. (See Figure 4.)

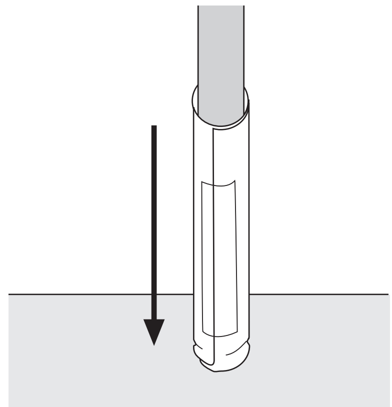

Figure 4: Creasing the paper

III. <u>Filling the lances</u>

1. Select one of the chemicals provided and weigh out three 1-gram samples.
   Do NOT use larger samples.

2. Making a funnel out of paper, fill one of the lances with the material. Filling is easier if the lance is standing in the base. Use the compacting (smaller-diameter) dowel to help fill the lance and to gingerly tamp the materials down. (See Figure 5.)

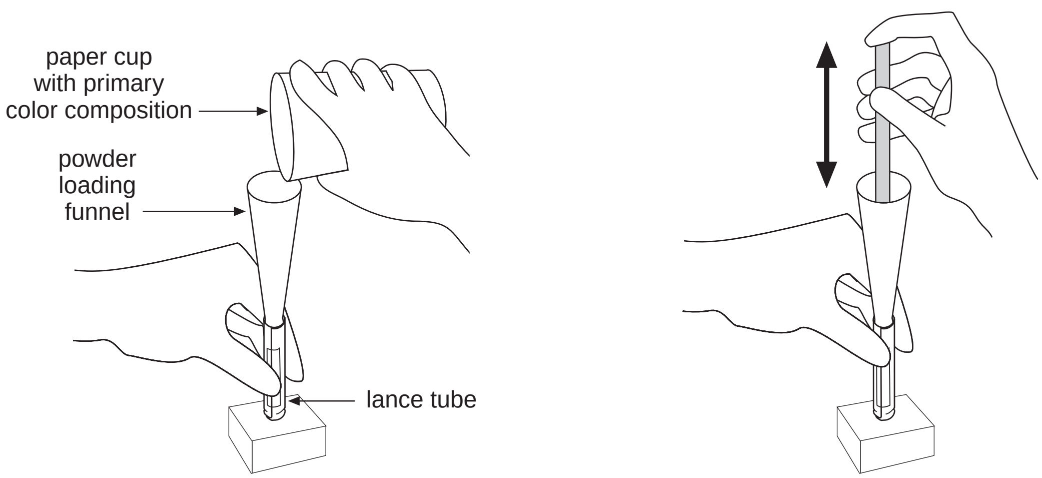

Figure 5: Adding and compacting the material

3. Remove the funnel and the compacting dowel. Cut off the excess paper 1/8 inch above the tamped-down chemical. (See Figure 6.)

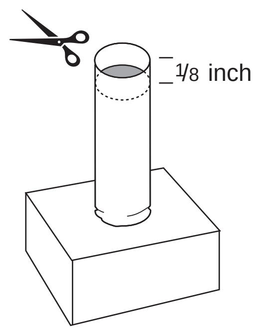

Figure 6: Cutting the excess paper

4. Repeat for the two other samples of the same material.

IV. <u>Igniting the lances, making observations</u>

Do this part of the activity only under the immediate supervision of the instructor.

1. Take the three samples to the hood.

2. Place one sample in the center of the hood.

3. Using the propane torch, ignite the lance (See Figure 7.)
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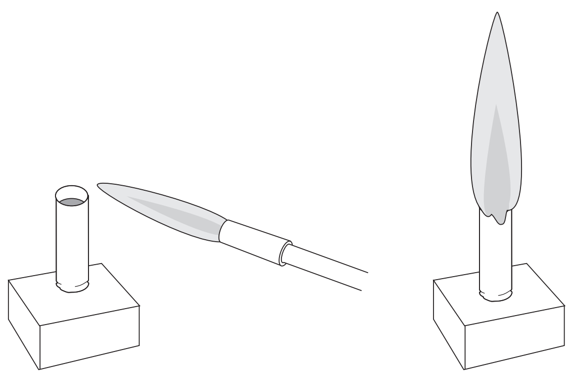

Figure 7: Igniting the lance

4. Observe the burning lance; record your observations as follows:
    a. Use your eyes to determine
        1. color
        2. purity
        3. uniformity
    b. Use your spectroscope to determine
        1. color
        2. spectra

5. After sample 1 has stopped burning, repeat steps 1–4 with the other two samples of this chemical.

6. Repeat Part III and steps 1–5 of Part IV for all the chemicals provided by the instructor.

Inquiry Procedure

1. Each group will receive a color sample (paint chip—an opportunity to contrast light colors and pigments).

2. Keeping copious records, use procedural steps from Parts II–IV of the Procedure section above to find a way to create this color by mixing the chemicals. It does not necessarily follow that because the chemicals had specific colors individually, they will stay the same color when mixed with others. The number of trials with each combination may be reduced to two. Safety is of paramount importance.

3. Once your group has decided that it has attained the best possible match of the color, write down the proportions and names of the chemicals. This information will be given to another group (selected by the instructor) to replicate the results.

4. Make a set of four lances containing this formulation for demonstration and evaluation by the class and instructor.

Questions

1. Describe the events at the atomic level that are reflected by the spectroscopic observations.

2. How would you design a control for this experiment?

3. Why do laboratory results need to be reproducible? What are the ethical implications of this?

4. List all the possible procedural, technical, equipment, and human sources of error in this experiment.

INSTRUCTOR NOTES
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Time Required
This activity requires 4 hours (3 hours if making the spectroscope is a take-home project or if commercial products are used).

Group Size
Dividing 24 students into groups of three worked well.

Materials
Per group
- dark green hanging file folder
- scissors or utility knife
- CD-ROM
- 50–75 small Post-it® Notes
- roll of transparent tape
- 2, 1/4-inch wooden dowels, 6 inches long
- 2, 3/16-inch wooden dowels, 6 inches long
- 12 lance test bases (1-inch-square pieces of particle board with a hole in the center 75% of the way through)
- paper to make funnels

Per class
- collection of nitrates, chlorides, and perchlorates (strontium, copper, barium, potassium, aluminum, etc.) that have been finely ground by the instructor and are quite dry
- propane blowtorch for use in the fume hood
- matches
- waste container and hand broom to clean the area between groups
- fire extinguisher

Safety, Handling, and Disposal
As the instructor, you are expected to provide students with access to SOPs , MSDSs, and other resources they need to safely work in the laboratory while meeting all regulatory requirements. Before doing this activity or activities form other sources, you should regularly review special handling issues with students, allow time for questions, and then assess student understanding of these issues.

Ignition of lances must only occur in a functioning fume hood. Only one group may work under the hood at a time. Students with acrylic nails may not ignite the lances.

Dispose of used reagents according to the local ordinances.

Points to Cover in the Pre-Lab Discussion
During the pre-lab, focus on safety, procedure for directed component, and the format for the inquiry component. The electromagnetic spectrum should be reviewed.

Procedural Tips and Suggestions

- **Do not rush!**
- For the inquiry component, give students attainable colors—like shades of red, green, and orange.
- The procedure works well if copious notes are taken by the students.
- Students need to be aware of what they are doing at all times and to document this in their notes.
- Safety must be at the forefront of this activity.
- Determine any precautions that must be taken with the salts you use and make sure your students understand them.
- Remain near the hood at any time that a student is using the propane torch.
- Students are not to crowd the group working at the hood.
- Emphasize to the students that there are no shortcuts.
- Make sure you grind the chemicals to create a collection of similarly sized particles. Some salts are unstable to grinding. Check in advance.
- For the inquiry component, students found that using no more than two or three compounds gave them better results. Also nitrates provided colors of greater purity than did the chlorides.

Plausible Answers to Questions

1. Describe the events at the atomic level that are reflected by the spectroscopic observations.
   Samples of all elements emit a light when they are vaporized. The atoms absorb the energy and give off light in specific wavelengths (color). Each element has a specific spectrum that can be viewed as an atomic fingerprint for that element.

2. How would you design a control for this experiment?
   An empty lance containing a relatively inert substance like sand could be burned and the spectrum of the paper recorded.

3. Why do laboratory results need to be reproducible? What are the ethical implications of this?
   Answers determined in lab need to be more than a fluke or mistake. There is no intrinsic or long-term value in a result that represents chance or malfeasance. Academic dishonesty creates false hopes and misinformation.

4. List all the possible procedural, technical, equipment, and human sources of error in this experiment.
   Answers may include impure chemicals, inaccurate measurements, inconsistent flame from the torch, insufficient trials, etc.

References

A Collection of Pyrotechnic Compositions. http://huizen.dds.nl/~gdewit/compoDB.html (accessed May 18, 2000).

Kosanke, B.J.; Kosanke, J.L. “Lecture Notes for Fireworks Display Practices.” *Journal of Pyrotechnics*, 1998.

Kosanke, B.J.; Kosanke, J.L. “Lecture Notes for Pyrotechnic Chemistry.” *Journal of Pyrotechnics*, 1998.

Nova Online: Kaboom! *Pyrotechnics: It’s Elemental.* http://www.pbs.org/wgbh/nova/kaboom/elemental University of Oulu, Finland (accessed May 18, 2000).

Pihko, P. *The Secrets of Pyrotechnic Light and Colour Production.* http://cc.oulu.fi/~kempmp/colours.html (accessed May 18, 2000).

Wakabayashi, F.; Hamada, K.; Sone, K. "CD-ROM Spectroscope: A Simple and Inexpensive Tool for Classroom Demonstrations on Chemical Spectroscopy," *Journal of Chemical Education.* 1998, *75*(12), 1569–1570.