Come Shine with Us: Utilizing Floor Polish Testing and Industrial Science To Teach Critical Thinking

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Grade Level:

Middle School (6-7-8)

Discipline:

Household Chemistry, Scientific Method, Problem Solving

Goals:

1. To understand how science relates to everyday life
2. To build in students a natural curiosity about products in the world around them
3. To develop basic scientific problem solving skills through experimentation

Specific Objectives:

- To learn testing procedures used in an industrial laboratory.
- To compare various brands of household and industrial floor polishes based on testing for durability (water, soil, scratch, detergent, and black heel resistance) and appearance (gloss, tack, slip)
- To alter the formulation of a floor polish and to check its performance.

Background:

Floor polish is an easily accessible material and a common household product. It is used both to protect as well as to beautify a floor. A polish's durability or resistance to scratches, detergents, soil, water, and black heel marks as well as its gloss, tack and slip resistance are all important properties for consumers.

A floor polish formulation or recipe consists mainly of a polymer (the main film forming component) and water (the carrier for the emulsion). In addition, there are a variety of "salt and pepper" ingredients that appear in very small amounts but which are essential for the overall performance of the product. They include such things as wax, wetting agents, defoamers, preservatives, solvents, leveling agents and stabilizers. In Part 2 of this experiment, students will have the opportunity to alter the formulation of a floor polish by adding small amounts of other ingredients and observing the effects of these additives on the properties of the floor polish.

Manufacturers produce both household and industrial strength floor polishes. Household polishes tend to be lower in cost, have poorer water and detergent resistance, but have extremely high gloss and removability. In comparison, industrial polishes have higher durability and are more useful in heavy traffic areas such as school halls. Household polishes can also be identified as redispersable and non-redispersable. Redispersable polishes, such as Perk® or Brite® dissolve the base coat when a new coat is added. Any solids on the polish are dispersed with the new coat, resulting in a new, clean single coating of polish. In Part 1 of this experiment, students will have the opportunity to compare and measure the different properties of household and industrial floor polishes.

Suggested Timeline:

The following experiments were developed to be used in conjunction with one another. However, if time constraints make that difficult, Part 1 and Part 2 could be done independent of one another. The teacher would need to introduce the testing procedures developed in Part 1, possibly as classroom demonstrations, in order for the students to be successful in Part 2.

The following is a suggested timeline for the use of all experiments in Parts 1 and 2. A class period of 50 minutes is assumed for each day.

Day 1: **Tile Preparation**

a. Discuss floor polish background, testing, and hypotheses
b. Teacher preparation — Tiles for Parts 1 and 2

Day 2: **Performance testing (Part 1)**

a. Polish application and wet appearance
b. Test #1: Tack
c. Test #2: Water Resistance

Day 3: **Performance Testing (Part 1)**

a. Test #3: Gloss
b. Test #4: Fingernail Scratch
c. Test #5: Detergent Resistance
d. Test #6: Soil Resistance

Day 4: **Performance Testing (Part 1)**

a. Teacher Demonstrations
   (1) Test #7: Black Heel Resistance
   (2) Test #8: Slip Resistance
b. Discuss results and conclusions of Part 1
c. Teacher Preparation of solutions for Part 2:

Discuss choice of additives and hypotheses

Day 5: **Repeat Day 2 testing with Part 2 solutions**

Day 6: **Repeat Day 3 testing with Part 2 solutions**

Day 7: **Wrap up**

a. Discuss results and conclusions for Part 2
b. Discuss extension activities.

Management Suggestions:

1. Group Roles: These experiments can best be done with teams of 5 students, each student being assigned a specific role.

   Group Leader: monitors the group's progress and their attention to task; communicates difficulties to the supervisor (the teacher); encourages full group participation

   Senior Scientist: main experimenter

   Junior Scientist: assists senior scientist in active experimentation

   Technician A: takes care of all equipment needs

   Technician B: reads directions and records data

2. Each team of students will need 4 black tiles and 4 white tiles to complete all of Part 1 and Part 2 testing. The best tiles to purchase for testing are unfinished, vinyl composition tiles with no urethane coating. Kentile® solid black and white tiles can be used, as well as Armstrong feature tiles which are available from Color Tile® stores or from the factory:

Armstrong World Industries
Customer Response Center
P.O. Box 3001
Lancaster, PA 17604
1-800-233-3823

3. Lining the table tops with newspaper or paper towels will help with cleanup after the tile preparation and polish application.
4. Labeling of the tiles is important to assure good interpretation of results. The teacher might discuss how incorrect labeling could lead to faulty conclusions by the scientist.
5. Test #1 and #2 are performed immediately or shortly (a few minutes) after polish application. Therefore, it is important for the students to know the testing procedures before the polish application.
6. At the end of the experiments, tiles may be stripped with a solution of Spic and Span® and household ammonia. They can then be reused for the same set of experiments.

Materials:

Part 1 Testing:

1 black floor tile
1 white floor tile
ruler
straws or popsicle sticks
Scotch® tape
thick black marker
sponge
water
gauze pads (2" x 2")
3M® cleaning pads
4 brands Household floor polish
(Possibly: Mop & Glo®, Future®, Perk®, Klear®)
1 brand of Industrial Floor Polish
(Check the Janitor's supply closet; Possibly: Brite 'N Easy® or Mannington®)
Spic & Span® (liquid)
index cards
masking tape
rubber gloves
potting soil
spoon
eye droppers
paper towels
china marker

Part 2 Testing:

All materials from Part 1
3 black tiles
3 white tiles
graduated cylinder
small glass jars with lids
liquid hand soap (unthickened)
glycerine (available from drug store)
sugar
salt
stirrers
labels
teaspoon

Teacher Demonstrations:

box with lid (sweater box size)
3 white tiles
piece of white paper
3 black rubber heels

Procedure:

Title Preparation: Part 1 & 2 (Teacher Preparation)

1. Prepare a double concentration solution of Spic & Span® according to the directions on the container.
2. Wearing rubber gloves and using a 3M® cleaning pad, scrub each black and white tile clean using the concentrated solution. (This will remove the factory

protective coating from the tile.) Use long up and down strokes. Turn the tile 90 degrees and repeat the scrub procedure. Rinse tiles with water and a clean sponge. Wash gloves to be reused for polish application.

3. Divide each black tile into six test sections using scotch tape. These sections will later become 5 test areas for polishes A through E in Part 1 and test areas for new test solutions 1 through 4 in Part 2. Each tile will also include a control area. (See Figure 1)

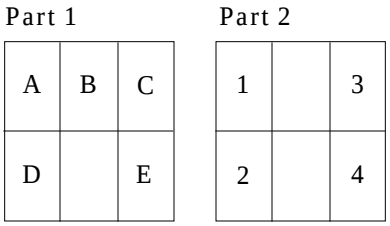

Figure 1
(Front of Tiles)

4. Using a china marker, label the back, top righthand corner of one of the black tiles with the letter "A" for Part 1 testing. Label the back, top righthand corner of the other black tile with the number "l" for Part 2 testing. This will assure correct location of the test sections when applying the polish. See Figure 2.

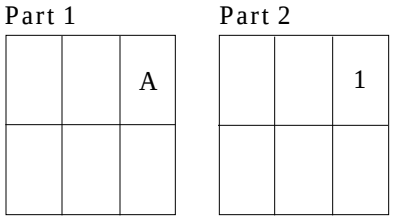

Figure 2
(Back of Tiles)

5. Divide each white tile in a similar manner using masking tape. Label the back of the tile. See steps 3 and 4.

6. Identify by letter the polishes to be used and record.
   Polish A - _____
   Polish B - _____
   Polish C - _____
   Polish D - _____
   Polish E - _____

Polish Application:

Part 1

1. Using gloves, apply 30 drops or 1.5 mL of the appropriate polish to the assigned section of each black and white tile. Be sure to check the labeling position on the back to assure the correct placement of polish. Puddle the polish in the center of the areas to be coated. Use a 2"x2" gauze pad to absorb as much polish as possible. Then disperse the polish evenly over the surface with up and down and then crosswise strokes. (Note: Use a clean gauze pad for each polish application.)
2. Note the wet appearance and record on the data chart.
3. Perform Test #1 for Tack and Test #2 for Water Resistance as described in procedure below.
4. Allow tiles to dry for at least 24 hours before further testing.
5. When tiles are dry, letter identifications of test sections may be placed on the front of the tiles for easier identification of test areas.

Questions:

(Set #1)

1. Why do people polish floors? As a consumer, what would your family look for in a good floor polish? What would the janitor in your school look for in a good industrial floor polish?
2. What controls are used in setting up comparison testing of products? Why do scientists use controls?
3. What are the variables that may affect the results?
4. How is labeling an important part of experimentation?
5. What do you hypothesize will be the difference between various household floor polishes? Between household and industrial floor polish?

Part 1:

Performance Testing of Floor Polish

Testing Location Diagram – (Figure 3 below shows possible sites for Tests #1 through #5 which are all performed on a black tile.)

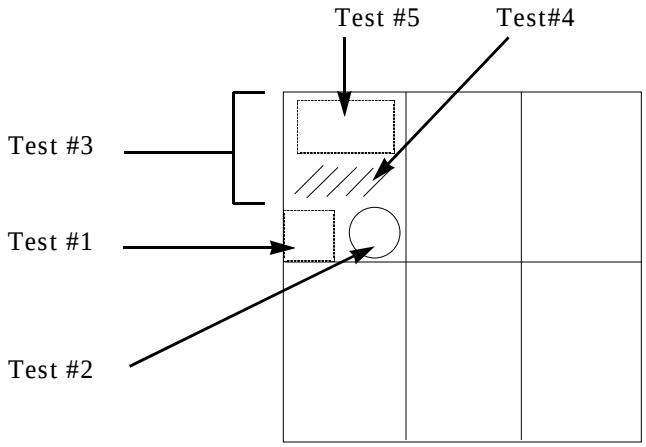

Figure 3

Test #1: Tack
This test rates how fast the polish film dries. Polishes need time for the film to build hardness in order for the maximum strength of the polish to be reached. Many consumers want a fast drying polish.

1. Apply floor polish to the appropriate section and allow it to dry for 7 minutes.
2. Touch your finger to the lower corner of each test section. Determine and record the rate of drying or tack using the following scale:

   5 – Excellent; completely dry
   4 – Very good; slightly tacky
   3 – Good; fingerprint mark is left when touched
   2 – Fair; fingerprint mark is left and tile is wet to touch
   1 – Poor; completely wet, polish did not dry

Test #2: Water Resistance
This test determines what would happen if water was spilled on a freshly polished surface. The longer a film is allowed to harden or dry, the greater should be its water resistance.

1. After applying the floor polish, wait 5 to 10 minutes until the film is dry. This timing can happen simultaneously with Test #1 for Tack.
2. Using a china marker, draw a circle about the size of a quarter on the bottom of each test section.
3. Place 8 drops of water inside the circle and allow it to remain undisturbed for 20 minutes.
4. Afterwards, blot the water with a paper towel and examine the film in the circle for whitening. Determine and record a rating using the following scale:

   5 – excellent; no change from the original appearance
   4 – very good; faint water outline and film lightening
   3 – Good; some white dots throughout the area
   2 – Fair; numerous white dots throughout area
   1 – Poor, complete film failure with gross whitening

Test #3: Gloss
This test rates how shiny the polished surface is. Many consumers want a high gloss product.

1. Prepare a gloss standard title as follows (This should be done ahead of time by the teacher):
   a. On a prepared black tile, coat each section, according to the diagram (See Figure 4):

5 – 100% Mop & Glo®

4 – 75% Mop & Glo®; 25% water

3 – 50% Mop & Glo®; 50% water

2 – 25% Mop & Glo®; 75% water

1 – 0% Mop & Glo®; 100% water

5 100%	4 75%	3 50%
2 25%	1 0%	

Figure 4

   b. Allow dry time of 24 hours and apply a second coat. Again allow 24 hours to dry.

2. On an index card, print your name in bold, black letters. At the center bottom edge of the card, tape a 3 inch piece of a straw or a popsicle stick to the card as shown. (See Figure 5)

3. Place the stick against each section of the gloss standard and observe the reflection of the letters. Then using the standard as a basis for comparison, rate and record the gloss of each test polish:

5 – Excellent gloss
4 – Very good
3 – Good
2 – Fair
1 – Poor

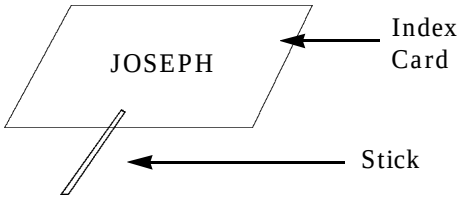

Figure 5

Test #4: Fingernail Scratch
This test gives some indication of the hardness of the polish film by determining its resistance to scratches. This is particularly important in heavy traffic areas.

1. Using the side of you fingernail, wack the test area 3 or 4 times. Try to be uniform in pressure.
2. Examine the polish film and using direct comparison between the polishes, rate and record the results using the following scale:

5 – Excellent, no scratches
4 – Very good
3 – Good
2 – Fair
1 – Poor

Test #5: Detergent Resistance
This test gives some indication of how well a polish film will hold up to floor washing between polish applications. Most consumers want the polish to last.

1. Prepare a 10% solution of Spic & Span® using 10 mL of concentrate to 90 mL of water.
2. Place 5 mL of solution on a 2" x 2" piece of sponge. Wearing gloves, scrub 3 test areas at a time across the tile with 5 cycles. (Each cycle consists of a back and forth stroke. Try to be uniform in pressure.) Wipe with a damp sponge or paper towel and wave tile for 30 seconds to air dry. Observe closely and record film appearance.
3. Repeat step #2.
4. Rate the performance using the following scale:

    5 – Excellent; no film removed after 10 cycles
    4 – Very good; no film removed after 5 cycles, but haze after 10 cycles
    3 – Good; some film removed after 5 cycles and more removed after 10 cycles
    2 – Fair; most film removed after 5 cycles
    1 – Poor; all film removed after 5 cycles

Test #6: Soil Resistance
This test, done on a white tile, gives some indication of how a polish will hold up to dirt marks.

1. Place a half-teaspoon of potting soil on each test area. Using a 2" x 2" gauze pad rub the soil on the tile for 10 cycles. (Each cycle consists of a back and forth stroke.) After cycle 3 and 6, scrape loose soil into the test area and continue cycles. Try to be uniform in pressure.
2. With a paper towel, wipe away loose soil to observe tile.
3. Using direct comparison between the polishes, rate and record the soil resistance using the following scale:

    5 – Excellent; no soil marks
    4 – Very good
    3 – Good
    2 – Fair
    1 – Poor

Test #7: Black Heel Resistance
Teacher Demonstration – This test will give some indication of a polish's resistance to heel marks.

1. Scrub a white tile and divide it in half using masking tape. On one side apply 3 mL of household polish (ex. Future®) and on the other side 3 mL of industrial polish. Allow 24 hours to dry.
2. Use masking tape to secure the corners of the tile to the bottom of a box. Add 3 black heels and secure the lid.
3. Pass the box around the room. Each student is asked to shake the box for 1 minute and then pass it to the next student to do the same. (Hint: Recess might be a good time to pass the box around!) For best results at least 15 students need to shake the box.
4. When completed, remove the tile and examine it closely. A noticeable difference should be observed.

Test #8: Slip Resistance
Teacher Demonstration – All manufactured floor polishes must pass a certain minimum standard for slip resistance in order to comply with government safety regulations. A qualitative "paper under foot" slip resistance test will help students understand this property.

1. Two full white tiles will be needed for this demonstration. Leave one tile unscrubbed, with the factory coating still on it. Scrub and prepare the other tile and coat it with 5 mL of any brand of floor polish. Allow 24 hours to dry.
2. Place both tiles on the floor against the wall. Put a piece of paper under your shoe and on top of the tile and slide the paper across the surface. Compare the polished surface to the factory coated surface.
3. Demonstrate the procedure and allow each student to test it for themselves.

Questions:

(Set #2)

1. What controls are used in each test? What variables have to be kept constant?
2. What properties would you use to determine the "best" floor polish? Examining the data from Part 1, which polish would you consider the "best"?
3. Describe how you might quantify the test for black heel resistance?
4. Can you see any differences in performance between household and industrial floor polishes? If so, what are they?
5. What polish would you suggest using in your home? Why? What polish would you suggest using on the school floor? Why?
6. Why are some tests done on black tiles and some on white tiles? Could colored tiles be used?

Part 2:

Adjusting Properties of Floor Polish

Preparation of Test Solutions

(Three sets of altered polish solutions are made for Part 2 experimentation. One set uses a household floor polish as a base...Future® is suggested...another uses an industrial polish as a base, and the last set uses a "Combo" as a base...50% household and 50% industrial. If material or time is a concern, the teacher may decide to omit the "Combo" set of solutions.) Preparation of solutions may be done ahead of class by the teacher.

1. **Household Base Test Solutions:**
   Each solution is prepared in a glass jar. Contents are stirred vigorously and then covered with a lid. Contents of the jars are labeled.

   Test Solution #1:
   Prepare a 2% solution of liquid hand soap by adding 10 drops of soap to 25 mL of Future®. (Soap is used during the process of making a polymer. However, too much soap will negatively affect the properties of the polish.)

   Test Solution #2:
   Prepare a 20% salt water solution by adding 10 g of salt to 40 g of water. Slowly add a total of 10 drops of this solution to 25 mL of Future®. Add 3 drops, and then 4 drops at a time, stirring vigorously until dissolved. (Salt has an ionic character. Although it is not directly added to a polish formulation, other ionic materials are added to help interlock the polymer chains.)

   Test Solution #3:
   Prepare a 10% sugar solution by adding a quarter teaspoon or 2 g of sugar to 25 mL of Future®. (Sugar will directly improve the gloss of a polish. However, it also has a negative affect on other properties, besides the fact it is very attractive to the ant population!)

   Test Solution #4:
   Prepare a 2% solution of glycerine by adding 10 drops of glycerine to 25 mL of Future®. (Glycerine slows down the dry time of a polish. It is similar to propylene glycol, used as a polish stabilizer, but is more readily available to teachers.)

2. **Industrial Base Test Solutions:**
   Prepare these test solutions in the same way as described for the household base solutions, but substitute 25 mL of Industrial polish.

3. **"Combo" Base Test Solutions:**
   Mix 100 mL of Industrial polish with 100 mL of Future® floor polish to make the "Combo" polish solution base. (Note: the teacher may choose to do this in a larger quantity ahead of time.) Prepare the test solutions in the same way as described for the household base solutions, but substitute 25 mL of "Combo".

Polish Application:

(Part 2)

1. Follow the same procedure as in Part 1. Be careful to place test solutions in correct areas of tile. (See Figure 6)

2. The top middle section is polished with the base polish used in each set of test solutions (ex.: Future®, Industrial, "Combo").The bottom middle section is left unpolished. Both of these areas will serve as controls for comparison.

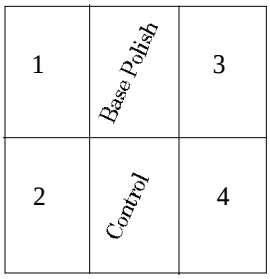

Figure 6

3. Perform Tests #1 and #2. Record wet appearance of polish.

4. When tiles have dried after 24 hours, carefully label sections for identification. Also label both black and white tiles as Household, Industrial, or "Combo".

Performance Testing (Part 2)
Follow all procedures outlined in Part 1.

Questions:

(Set #3)

1. How did each of the following additives affect the performance of the floor polish...liquid hand soap?...salt?...sugar?...glycerine?
2. Which of the above additives would you want to add to a floor polish formulation? Why?
3. Which additives would you not add? Why?
4. Sugar improves the gloss of a floor polish but is not likely to be added? Can you think of a reason why you would not want something with sugar on your floor?

Extensions:

1. After examining all data from Parts 1 & 2, each team of students can develop their own polish formulation to create the "best" polish. Each team is asked to:
   a. Reassign group roles to include a Marketing Manager, Advertising Manager, Technical Adviser, Sales Manager, and Assistant Sales Manager
   b. Market their product and present supporting data to back their statements
   c. Propose a company and product name
   d. Prepare a commercial to sell their product
   e. Create a magazine and/or newspaper advertisement to sell their new product.

2. Invite an industrial scientist to your classroom to talk about what he or she does. Contact a local industry and ask to tour their research laboratories.

Data Chart

(Part I) Performance Tests

	Wet Appearance	#1	#2	#3	#4	#5	#6
Polish							
A							
B							
C							
D							
E							

(Part 2) Performance Tests

		Wet Appearance	#1	#2	#3	#4	#5	#6
Test Solutions								
Household	#1							
	#2							
	#3							
	#4							
	Control							
Industrial	#1							
	#2							
	#3							
	#4							
	Control							
Combo	#1							
	#2							
	#3							
	#4							
	Control							

Student Assessment:

To assess students' growth in understanding and application of what they have learned, assign the following as team or individual projects:

1. Write written responses to each set of questions.
2. Prepare a written report or orally present an analysis and interpretation of your results and findings.
3. Design an experiment to test another commercial product. Be sure to identify various properties of interest to the consumer. Devise controlled tests for evaluating the performance of the product and qualifying the results.

Glossary:

Polymer – A chemical with very large molecules. Floor polishes, paints, glue, plastics, nylon and chewing gum are all polymers. In floor polishes, polymers make up at least 50% of the formulation.

Emulsion – A mixture of very small polymer particles dispersed and suspended in water.

"Salt and Pepper" Ingredients – Relatively small amounts of additives which make up the recipe of a floor polish. They are essential for the overall performance of the polish. Too much of any one additive, however, will have a negative affect on the properties of the polish.

a. **Wetting Agents** – These are generally soap-like materials which will allow the polish to wet out over the floor title. However, because they are like soaps, they will tend to lead to foam production in the polish bucket or on the floor.

b. **Defoamer** – This is an oil-like material which serves to break down foam bubbles in the polish.

c. **Preservatives** – These materials protect the wet polish from bacteria and fungal microbes.

d. **Leveling Agents** – These are used to achieve a smooth polish film surface and prevent mop application ridge marks after multiple coatings.

e. **Stabilizers** – These are added to help protect a wet polish from freeze/thaw instability and/or some viscosity or sedimentation instability on prolonged storage.

f. **Wax** – This is added to favorably change the polish's scuff, black heel, and slip resistance.

g. **Solvents** – These are organic materials added to help in film formation.

References:

1. Literature on floor care and testing is available through Rohm and Haas Company. Write for information to:

   Marketing Services
   Rohm and Haas Company
   Independence Mall West
   Philadelphia, PA 19105

   When writing for information ask for the following:

   Floor Care Polymers: Test Methods for Evaluation of Floor Polishes, Rohm and Haas: May, 1990. #83B4

   Polymers, Resins and Monomers: Duraplus, Rohm and Haas: April, 1989, #83B39

2. Additional literature may be obtained by calling or writing to the manufacturer of each floor polish used.

3. Technical references – See Project LABS Publications, 1989, 1990, 1991. Rohm and Haas Company, 727 Norristown Road, Spring House, PA 19477.