Exploring the Chemistry of Oil and Acrylic Paints

Background
Beginning painters are faced with the decision between purchasing oil or acrylic paints. Both paint types have advantages and disadvantages.

Oil paints consist of pigment particles suspended in a drying oil, like flax seed oil. A drying oil hardens when the oil molecules react with oxygen in the air and link together to form a tough solid. Oil paints do not change color when they dry, and can provide rich, deep colors. Solvents, like turpentine or mineral spirits, are required to clean dried oil paint off brushes once the oil has dried.

Acrylic paints consist of pigment particles suspended in a water-based acrylic polymer mixture. Polymers are large molecules made up of many repeating subunits. An acrylic polymer is a type of plastic. Acrylic paints dry as the water evaporates from the mixture. While acrylic paints remain wet, they can be washed away with water, allowing for simple cleanup. Latex house paint is one type of acrylic paint.

The pigment chosen for this activity is ultramarine blue, a deep blue pigment. It was originally obtained by grinding the rock lapis lazuli into powder. At one time it was the most expensive blue pigment, and painters reserved it for the most precious parts of their paintings. In the early 1800s, scientists devised a way to produce the same color artificially. Synthetic ultramarine is inexpensive and nontoxic. It is now used in many types of artist’s paints and wall paints, makeup, and even in laundry detergent as a “bluing” agent that brightens up faded whites.

Pre-lab Questions
1. List several situations where you have used paint. What surfaces were you painting? What type of paint did you use?

2. Both oil and acrylic paint are mixtures. Use the word bank to “fill” the paint cans with the correct components. Some words are used twice.

Word Bank:
- Water
- oil
- Pigment
- acrylic polymer

Oil Paint

Acrylic Paint
Objective
In this activity you will:
• Learn about the chemistry of two types of paints.
• Make your own paints.
• Complete an experiment to compare the drying time of the two types of paint.

Materials
• Safety and Housekeeping:
  o Sealable, metal disposal can for all oil containing waste
  o Table covers to prevent paint stains
  o Gloves (optional)
  o Aprons or old clothing
• Making paint:
  o Ultramarine blue pigment
  o Refined flax seed oil
  o Acrylic binder
  o Plastic forks or knives
  o Plastic teaspoon
  o Surface for mixing paint (glass surface or clear packing tape on a paper plate)
  o Scale (optional)
• Testing the paint:
  o Paint brushes of the same size
  o Cotton swabs
  o Canvas Paper
  o Clock or stopwatch

Safety
• Always wear safety goggles when handling chemicals in the lab.
• Wash your hands thoroughly before leaving the lab.
• Follow the teacher’s instructions for cleanup of materials and disposal of chemicals.
  The flax seed oil in this activity is flammable, and any materials that absorb the oil
  must be placed in a water-filled container.

Procedure
Making Paint:
1. You will create your paints on mixing surfaces made of glass, or paper plates
   covered in packing tape or plastic wrap. Obtain two mixing surfaces from your
   teacher. Label one “oil” and the other “acrylic”.
2. Transfer approximately half a teaspoon of pigment powder to each mixing surface.
   For increased accuracy, a scale can also be used to measure about 1.5 grams of
   pigment powder for each paint type. Use a plastic knife or fork to break up any
   pigment clumps. Make the pigment powder as fine as possible with the equipment
   available.
3. Make the oil paint by adding oil, drop by drop, on top of the pigment pile. Keep
   track of how many drops of oil you use. Start by adding 20 drops of oil on to the
   pile, then mix the oil and paint together using a plastic fork/knife. Use the utensils
   to grind the pigments into the oil. Continue to add drops of oil, 5-10 drops at a time
   as needed, to achieve a smooth consistency, mixing and grinding well after each
   addition of oil. The paint should be a fluid, and apply smoothly on a brush.
4. Make the acrylic paint by adding a small amount of the white acrylic binder to the pigment powder labeled “acrylic.” Start with about half a teaspoon of the acrylic binder. Mix together using the plastic fork/knife. Grind the binder and pigment together. Add a little more acrylic binder if needed, and mix until a smooth paint is made.

Comparing the Drying Time of the Paint:
1. Cut one sheet of canvas paper into four rectangles.
2. Obtain two identical brushes from your teacher. Use one brush for the acrylic paint, and another for the oil paint. Do not mix brushes. Label the brushes with masking tape if necessary.
3. Your first goal is to qualitatively compare different properties of the two paint types. Using the brushes and one of the pieces of canvas paper, paint a few different shapes with oil and acrylic. Paint lines, circles, and words. Try to create areas that are darker and lighter. What do you notice about the two paints? In what ways are they the same and in what ways do they differ? How do they adhere to the paper? Do they look different? Record your observations below.
4. The second goal is to *quantitatively compare* the drying time of the two paints. Take the second piece of canvas paper. Label one side “oil”, and the other “acrylic”. On one side label “1 minute” and “2 minutes”, as shown in the data table below.

5. Under “Oil” and across from “1 minute” quickly paint a smooth line of even thickness. Switch to the acrylic paint and brush and do the same next to “1 minute.” Begin timing 1 minute with your stopwatch ready as soon as the second line is painted.

6. After one minute has passed, use one side of a cotton swab and press firmly onto the page near the oil line. Apply strong and even pressure and push the cotton swab through the oil line, and going back and forth down the line in an “S” or zigzag pattern. Repeat for the acrylic line, using the clean side of the cotton swab.

7. Repeat these steps for the 2 minute trial. Use a clean cotton swab for each test.

8. After you complete the experiment, record your observations below.

<table>
<thead>
<tr>
<th>Data: Quantitative Comparison of Paint Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td><strong>1 minute</strong></td>
</tr>
<tr>
<td><strong>2 minutes</strong></td>
</tr>
</tbody>
</table>

9. On the third piece of canvas paper create labels for “5 minutes” and “10 minutes” much like you did previously.

10. For these longer test times, create multiple oil lines and multiple acrylic lines and then start the clock.

11. Complete the cotton swab test after 5 minutes and 10 minutes is reached.

12. After you complete the experiment, record your observations below.

<table>
<thead>
<tr>
<th>Data: Quantitative Comparison of Paint Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td><strong>5 minutes</strong></td>
</tr>
<tr>
<td><strong>10 minutes</strong></td>
</tr>
</tbody>
</table>
13. On the final piece of canvas paper create labels for “1 day” and “2 days” much like you did for the previous tests.
14. Again, create multiple oil lines and multiple acrylic lines. Note the day and time this test started in the data table below.
15. Put the paper at a safe location in the classroom, and repeat the cotton swab test again roughly 1 day and 2 days later.
16. After you complete the experiment, record your observations below.

<table>
<thead>
<tr>
<th>Data: Quantitative Comparison of Paint Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date/Time started:</td>
</tr>
<tr>
<td>Date &amp; Time for “1 day” test:</td>
</tr>
<tr>
<td>Date/Time started:</td>
</tr>
<tr>
<td>Date &amp; Time for “2 day” test:</td>
</tr>
</tbody>
</table>

**Data Analysis**
Summarize drying time results from each of your comparison tests below. Also include your observations. For example, how much did each paint smear on the page?

**Analysis Questions**
1. As each group presents their results to the class, take notes on drying times and other observations discussed.
2. Complete this chart describing the advantages and disadvantages of each type of paint. Include examples where oil paints are advantageous, where acrylic paints are advantageous, and the opposite.

<table>
<thead>
<tr>
<th>Paint Type</th>
<th>Property</th>
<th>Oil</th>
<th>Acrylic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drying Time: Advantages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drying Time: Disadvantages</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clean-Up</td>
<td></td>
<td></td>
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</tbody>
</table>

3. Acrylic and oil paints dry through two very different processes, as described below. Draw models below each description to represent each process. Use images, labels, symbols, arrows as needed.

**Acrylic paints dry as water evaporates from the pigment-polymer-water mixture:**

**Oil paints dry as molecules of oil react with oxygen in the air and form longer chains that turn into a hard solid:**
4. Physical changes occur when the form of a chemical substance changes, but the chemical composition (the molecules involved) remain the same. Which drying process is a physical change? How do you know?

5. Chemical changes, or chemical reactions, occur when existing atoms and molecules rearrange in new ways to form different molecules. Which drying process is a chemical change? How do you know?

Conclusion
Your teacher read you a scenario of two students trying to decide on what paint to buy. Write a letter recommending one type of paint. Use the data collected by the class on drying time, as well as your qualitative observations to explain your choice.