Wacky Waxy Watercolors

Section **PROPERTIES OF MATTER** *Topic* **SOLUBILITY**

Estimated Time Setup: 5 minutes; Procedure: 10 minutes

OVERVIEW

Students draw designs with wax on paper and paint over them with watercolors to watch the interaction between wax and water.

In this activity, students explore whether waxy substances are soluble in water. They draw a design on paper using wax crayons or candles, then paint over their design with watercolors, and notice that the watercolors appear to roll off or be repelled by the wax. The watercolors are only absorbed by portions of the paper without wax, creating fun designs in the process.

MATERIALS

For one setup:

- White paper
- White wax crayons or candles
- Watercolor paints
- Paintbrushes
- Water
- Cups

INQUIRY QUESTIONS

Getting Started:

- What are the physical properties of waxes?

Learning More:

- How does solubility explain why wax and water don't mix?

Diving Deeper:

- How does the molecular structure of wax molecules explain why they are insoluble in water?

ACTIVITY NOTES

This activity is good for:

- Individuals
- Small groups
- Concept introduction

Safety Tips & Reminders:

- Be sure to do this activity over a waterproof or protected surface and let each paper dry completely before moving it.
- Review the Safety First section in the Resource Guide for additional information.

CONTENT TOPICS

This activity covers the following content topics: solubility, properties of matter, polarity, crystalline versus amorphous solids

This activity can be extended to discuss: colloids, sols, waxy material production in plants and animals, human use of waxy products

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards:

- **2-PS1-1:** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **5-PS1-3:** Make observations and measurements to identify materials based on their properties.
- **MS-PS1-1:** Develop models to describe the atomic composition of simple molecules and extended structures.

ENGAGE

Use the following ideas to engage your students in learning about solubility:

- Start the activity by telling students that you have a secret message to share with them. Can they find a way to reveal the secret message? You can distribute different parts of the message to different groups, and after the messages are revealed they can be fit together!
- Brainstorm a list of substances that are soluble in water. Based on their experiences, can students order them from most to least soluble? What causes these distinctions between substances? Why do they interact differently with water?

See more ideas for engagement in the Solubility Background section! You can also look at the Elaborate section of this activity for other ideas to engage your students.

Fun Fact #1

Paraffin comes from the Latin words for parum, which means "barely," and affins, which means "lacking reactivity." The name comes from the fact that paraffin is unreactive in nature.!

EXPLORE

Procedure:

1. Pressing firmly, use the crayon or candle to draw designs or a message on a white piece of paper.
2. Wet the paintbrush in a cup of water and then in a watercolor.
3. Lightly paint the entire sheet of paper. Observe and record what happens.

Notes

DATA COLLECTION & ANALYSIS

Analyze and discuss the results of this activity using the following questions:

- Look closely: What do you see after writing with the wax on the paper?
- What happens when the watercolors touch the wax? Why do you think this happens?
- What about on the parts of the paper without the wax? Why do you think this happens?

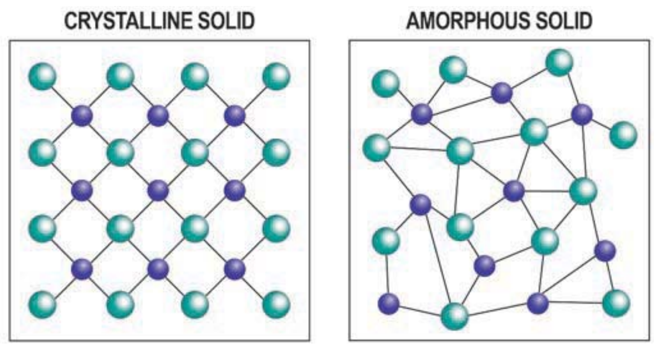
EXPLAIN

What's happening in this Activity?

First review the Solubility Background section to gain a deeper understanding of the scientific principles behind this activity.

Matter is commonly described and categorized by an important physical property: its **state**. There are three major states of matter: solid, liquid and gas. There are many different ways to categorize matter in each of the states. For example, there are two main types of solids: amorphous solids and crystalline solids.

- **Crystalline solids** are made up of atoms or molecules that are organized in specific repeating patterns, which form crystals. Examples include ice, sugar, salt, and diamonds.
- **Amorphous solids** are made up of atoms or molecules that are locked in place, but are not arranged in a specific repeating pattern or structure. Examples include cotton candy, glass, rubber, and plastic.



The same compound can take different shapes a solid. For example, sugar is found as a crystalline solid as sugar cubes or as granulated sugar. However, sugar is also the main ingredient of cotton candy. Cotton candy is made by melting down sugar, then solidifying it in a different form. Although sugar cubes and cotton candy are both created from sugar ($C_{12}H_{22}O_{11}$), it exhibits different properties as each type of solid.

Waxes are amorphous solids, and have molecules that are not arranged in a specific pattern. Both crayons and candles are made of Paraffin wax, a type of wax that is a white or colorless soft solid obtained from crude oil and is composed of a mixture of hydrocarbon molecules (i.e. molecules containing hydrogen and carbon atoms). Waxes tend to have similar **physical properties** because they are composed of hydrocarbon molecules: they have low melting points and melt at moderate temperatures, can be buffed or polished under slight pressure to produce a glossy appearance, and are **hydrophobic**—meaning they repel water.

Crayons and candles both exhibit these properties of waxes. For example, if you place water on a wax candle—or on a wax drawing—you might notice that the water forms a "bead" or droplet which sits on the surface of the candle or rolls off. Wax and water do not mix, and are **insoluble** in one another.

Solubility is a physical property that describes the ability of one substance (the solute) to dissolve in another substance (the solvent) to create a uniform solution. A substance that dissolves in another substance is **soluble** in that substance. If a substance does not dissolve in another substance, it is **insoluble**.

In this activity, the crayons or candles are not soluble in water, but the dyes in watercolor paints are soluble in water and easily mix to form a colorful solution. Because the dyes in

EXPLAIN continued

the watercolor paints mix with the water, they can be transferred and applied to the paper. However, when the water and dye solutions move over the wax, the wax does not mix with the water, causing the water roll off the area from the wax and preventing the paint form being applied to the paper underneath.

As the water evaporates from the watercolor paint mixture, the paint is left behind on the paper where the water was absorbed. In the places where the wax form the candle or crayon was used to draw on the paper, none of the watercolor paint mixture was absorbed by the paper, and remains colorless.

Diving deeper into solubility, we may wonder why dyes are soluble in water but waxes are not. The reason for this is based on polarity, which describes how charges are distributed throughout a molecule. If a molecule is polar, there are slight positive and negative charges on opposite ends of the molecule. (Think of it like the North and South Poles of the Earth!) This is because electrons are shared unequally throughout the molecule. An example is a water molecule (H_2O) where the oxygen has more electrons than the hydrogen atoms, so the molecule has slight charges on each end: negative near the oxygen, and positive near the hydrogens. Conversely, paraffin ($C_{20}H_{42}$ or $C_{30}H_{62}$) has charges evenly distributed throughout. This makes it nonpolar, or not charged. In chemistry, "like dissolves like," meaning that nonpolar solutes can be dissolved by nonpolar solvents, and polar solutes can be dissolved by polar solvents. A nonpolar solute cannot be dissolved by a polar solute, and vice versa. Paraffin wax is nonpolar and therefore cannot be dissolved by water, which is polar. This is why they are insoluble.

Differentiation for Younger or More Advanced Students

You can differentiate this activity for students of different grade levels by focusing on the concepts outlined below.

GETTING STARTED	DIVING DEEPER
For younger students, emphasize the following concepts: • States of matter - solids, liquids, gases • Types of solids – crystalline and amorphous • Solutions and mixtures • Basics of solubility	**For more advanced students, emphasize the following concepts:** • Molecular differences between crystalline and amorphous solids • Solubility – dissolving solutes in solvents • Factors affecting solubility, including polarity of solutes and solvents • Polarity and molecular structures of molecules

ELABORATE

Elaborate on your students' new ideas and encourage them to apply them to different situations. The section below provides some alternative methods, modifications, and extensions for this activity.

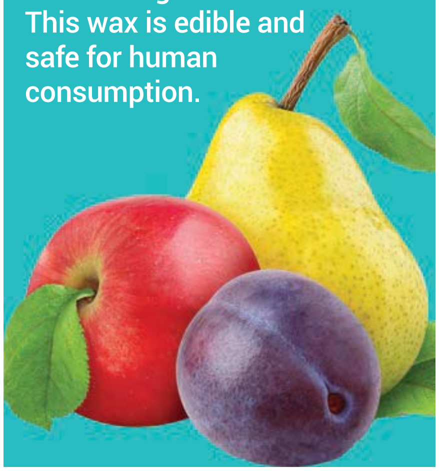
- Have students write secret messages to one another, and use the watercolor paint to reveal the work!
- Repeat the procedure using a white colored pencil or pastel instead of a crayon or candle. Ask students to compare and contrast the results.
- There are many types of waxes students might have encountered with physical properties that make them especially useful. Ask students to find other waxy substances in the classroom, at home, or through research. Describe their physical properties, uses, and some fun facts.
- For some added science art, sprinkle salt on the picture while it is still wet. You will see the salt particles dissolve in water and repel the color pigments, which creates an interesting effect in the picture.
- There are dozens of techniques to make interesting designs using watercolors, many of which can be used in the classroom! Research and see if students can figure out the science behind each technique.
- Do this activity in conjunction with a book the students are reading. Can they make a wax picture to depict a certain part of the story?
- Try the activity with colored and fluorescent crayons to create more vibrant designs.

CHEMISTRY IN ACTION

Share the following real-world connections with your students to demonstrate how chemistry is all around us.

Real-World Applications

Many products are covered in a waxy coating to make them waterproof or look shiny while on display. Next time you go to your local grocery store, take a close look at some of the produce. Apples, plums, pears, and many other fruits produce their own wax to help keep moisture in, retain firmness, protect the fruit, and slow the natural degradation. Sometimes food-grade wax is added to fruits and vegetables (think of a cucumber!) so they have a longer shelf life. This wax is edible and safe for human consumption.



Some animals and plants produce waxes: bees create beeswax, and sheep create lanolin wax in their wool. Waxes can also be derived from plants. An example of this is carnauba wax, which comes from the Brazilian palm. This wax creates a glossy finish and is used in car and surfboard waxes, shoe polish, dental floss, food products (think of the glossy coating on your favorite sweets!), cosmetics, and paper coatings.

Careers in Chemistry

- Chemists use hydrophobic materials for a variety of purposes! Hydrophobic coatings, which repel water, are often used on ships and large vessels to make them more fuel efficient. As large ships sail through water, the hydrophobic coatings allow the water to glide off the surface off the ship, increasing its fuel efficiency.

EVALUATE

- Ask students to journal throughout their day: Where do they notice waxy coatings on things? Why might that be? Can students find examples at home, at school, and outside? They can report their findings in small groups the next day.
- Students can write or draw out the takeaways from the activity in wax, then pass to a partner to reveal with watercolor and add comments as a form of peer evaluation.

Fun Fact #2

Watercolor is one of the oldest painting techniques. Starting in 15,000 BCE, artists made cave paintings by mixing natural pigments with animal fat or spit. Today, the pigments are dissolved in water and dried into a powder or disc.