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Invisible Ink

An engaging science activity involving chemistry, great movies, and lots of intrigue!

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Known throughout the country for motivating and engaging teachers and students, Brad has co-authored over a dozen books that provide easy-to-teach yet mathematically rich activities for busy teachers while teaching full time for over 30 years. In addition, he has co-authored over 40 teacher training manuals full of activities and ideas that help teachers who believe mathematics must be both meaningful and powerful.

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*References available upon request*
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Brad 😊
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0 b) Affordable staff development
0 c) Ongoing staff development
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Invisible Ink
An engaging science activity involving chemistry, great movies, and lots of intrigue!

Procedure:

Before the students arrive:

1. Decide if you want to demonstrate heat-released inks, chemically released inks, fluorescing inks, or any combination of them.

2. Gather the necessary materials for each station:
   a. Heat-released inks:
      i. Sugar water
      ii. Milk
      iii. Sugar and milk
      iv. Vinegar
      v. Soda pop (clear is best)
   b. Chemically released inks:
      i. Vinegar
      ii. Lemon juice
      iii. Ammonia
      iv. Phenolphthalein
      v. Potato or bread mashed in water
   c. Fluorescing inks:
      i. Sunscreen
      ii. Liquid dish soap
      iii. Bar soap

For the chemically released inks you will also need the releasing agents. Vinegar, lemon juice, and the potato or bread mixtures can be released with a diluted iodine solution. Phenolphthalein can be released with ammonia and vice versa.

3. Set up each station with the following materials:
   a. A beaker or glass containing the ink.
   b. A paintbrush or cotton swab
   I cover the ammonia container to decrease the fumes.

4. Phenolphthalein is available from a chemical supply company. It is a severe laxative; so if you do not want to use this with younger children, skip this ingredient.

5. I have been told that you can also show the heat-released inks using the heat of a strong incandescent light bulb, however, I have not been able to do this. Apparently you need about a 100-watt bulb, and those are becoming harder to find. I use an

Required Materials:

- Student Lab Sheet
- Paintbrushes or cotton swabs
- Milk, sugar, vinegar, soda pop, lemon juice, phenolphthalein, ammonia, potato, bread, sunscreen, liquid dish soap, bar soap, and iodine as needed from the lists on the left.
- A fluorescent bulb (black light)
- Student Activity Sheet
- An electric skillet

Optional Materials

- Other chemicals as listed in the lesson
- A copy of the movie National Treasure
electric skillet on medium heat and remove the papers with tongs. I would not suggest letting students do this for safety reasons. Also do not leave the skillet unattended as a fire could start.

**Class Lesson, First Day:**

1. I like to begin this lesson by talking to students about the science that is portrayed in movies. The television show *Mythbusters* often tries to recreate movie scenes to demonstrate if they are scientifically plausible, and your students may have seen some episodes that will help them engage in this lesson. I then talk about the movie *National Treasure* in which Nicholas Cage’s character discovers that a secret message is hidden on the back of the Declaration of Independence. After “borrowing” the document, he uses lemon juice and the heat from a hair dryer to expose the concealed message that eventually leads him to the discovery of hidden treasure. I ask the students how much of that seems realistic to them and how much is fiction?

2. You may wish to show the movie *National Treasure* or at least the pertinent scenes to pique their interest.

3. I then pass out the Student Lab Sheet and they put their name on all pages. They should then separate the pages if they have been stapled. **Do not print the pages in the Student Lab Activity** back to back as the inks will be released by separate processes.

4. Explain that the students will visit each station and write a simple message in each scroll using the appropriate ink. This should only take about five to ten minutes. Have them return to their seats to take notes.

5. Display the notes for them to copy. These will help them fill out the Student Activity Master and also will show them how to reveal their inks the following day. I like to discuss the notes as they write them down to make the lesson more interactive. This activity and these notes tend to generate a lot of questions in my students. This should take the entire period. If you showed part of *National Treasure*, you are already well into day 2. In that case, this will be at least a three-day lesson.

**Class Activity, Following Day:**

1. Set up stations for students to release their inks. I set up stations with the appropriate chemicals and ask them to consult their notes to know which station to use.

2. First they bring their heat-released page to me, and I set them all in the skillet. I check the bottom one every few moments and remove it when the inks have turned dark, calling out each student to come get their papers.

3. The students should take their chemically released inks to each station and swab them with the releasing agents.
4. I set up a third station with a fluorescent light (black light) source. Black light bulbs can get very hot, so I mount mine on a stand with a reflector.

5. After they finish, I ask them to return to their seats. I then lead a discussion incorporating these questions:
   a. Which of the inks are easiest to read?
   b. Which inks are permanently revealed and which ones fade away after being revealed?
   c. What do you think of the scene in *National Treasure*? Based on what we know, is it plausible that an ink was released using lemon juice and a hair dryer and then faded away? Why or why not?
   d. If you were a government agent trying to pass a message, which method would you use? Why?
   e. What steps could you take to ensure only your agent would find your message?
   f. How might you encode your message to make it even more difficult to intercept?

6. You may also wish to assign the Student Activity Sheet for classwork or homework.

**Answer Key for Student Lab Sheet**

What is the release agent for the chemicals you used for this lab?

**Ink:**

- Milk [heat]
- Vinegar [heat or chemical (iodine)]
- Phenolphthalein [ammonia]
- Sunscreen [fluorescent light]
- Sugar [heat]
- Potato [chemical (iodine)]
- Soap [fluorescent light]

**1.** Which of the inks permanently reveal—that is, once exposed, they are permanently visible?

Heat released inks are permanently revealed because you are oxidizing (burning) the chemical, and you can’t reverse that. Iodine also permanently stains the paper.

**2.** In the movie Nicholas Cage used lemon juice and a hair dryer to reveal the message and then it faded away. Why was that unrealistic?

A hair dryer doesn’t provide enough heat to oxidize the chemical, and heat-released chemicals don’t fade away.
Lab Notes

Here are the notes that explain this lab. You should first decide if you need students to have the full set of notes or only the parts that pertain to the types of inks they used. You should also decide whether you want older students to copy all of these notes, or whether you will have them use the fill-in-the-blank Student Lab Notes sheet that accompany this lesson.

If you wish, you can purchase the PowerPoint file of these notes from my store at the Teachers Pay Teachers website. Please remember that each purchase is a single-user file. Making alterations or sharing this file would be a copyright infringement.

Invisible Ink Notes
I. A substance that is invisible upon application and can be restored later
   A. Types of invisible ink
      1. Heat-released inks
      2. Chemically released inks
      3. Fluorescing inks
   B. Some inks are permanently revealed while others fade away again
II. Heat-released inks
   A. Any acidic liquid will turn dark when it is exposed to heat. The acid oxidizes (burns) more quickly than the paper.
   B. Lemon juice and vinegar are examples.
   C. Sugary liquids such as sugar water and soda pop will also oxidize at low temperatures.
   D. Milk also burns well.
III. Chemically released inks
   A. Certain chemicals seem clear until mixed with other chemicals.
   B. Vinegar, lemon juice and starches such as potatoes and bread will turn colors when exposed to a diluted iodine solution.
   C. Phenolphthalein turns bright pink when exposed to ammonia.
IV. Fluorescing inks
   A. Certain chemicals react differently to black light (ultraviolet light).
   B. Sunscreen, liquid dish soap, and bar soap will fluoresce.
V. Invisible ink is the opposite of “disappearing ink” used in pranks. Disappearing ink is visible until exposed to the moisture in the air which makes it invisible.
VI. Invisible inks have been used in espionage. A seemingly blank paper can be passed from one agent to another who knows how to reveal the secret message.
VII. The science of invisible inks is called *steganography*. It is often used in conjunction with *cryptography* – the science of codes.
I. A substance that is __________________________ upon application and can be restored later

A. Types of invisible ink
   1. __________________________
   2. __________________________
   3. __________________________

B. Some inks are permanently revealed while others fade away again

II. __________________________

A. Any __________________________ liquid will turn dark when it is exposed to heat. The acid __________________________ (burns) more quickly than the paper.

B. __________________________ and __________________________ are examples.

C. Sugary liquids such as sugar water and __________________________ will also oxidize at low temperatures.

D. __________________________ also burns well.

III. __________________________

A. Certain chemicals seem clear until mixed with other chemicals.

B. __________________________, lemon juice and __________________________ such as potatoes and bread will turn colors when exposed to a diluted iodine solution.

C. __________________________ turns bright pink when exposed to __________________________.
IV. 

A. Certain chemicals react differently to black light  
_________________________ light).

B. ______________________, liquid dish soap, and bar soap will fluoresce.

V. Invisible ink is the opposite of “_________________________” used in pranks. That ink is visible until the chemical are exposed to the  
_________________________ in the air which makes them invisible

VI. Invisible inks have been used in ________________________. A seemingly blank paper can be passed from one agent to another who knows how to reveal the secret message.

VII. The science of invisible inks is called ________________________. It is often used in conjunction with _________________________ – the science of codes.
Samples:

- Sugar water released with heat
- Soda pop released with heat
- Lemon juice released with iodine
  - Phenolphthalein released with ammonia immediately and after 1 minute
- Sunscreen under black light
- Liquid dish soap under black light
- Bar soap under black light

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Name___________________________  Invisible Ink

Date ________________ Class _____

Heat released inks

Write in each region using a toothpick and the substance indicated. Allow the paper to dry. Reveal the invisible ink using the appropriate chemical or method.

Milk

Sugar

Vinegar

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Phenolphthalein:

Wash your hands after using phenolphthalein.

Vinegar:

Potato:
Fluorescing inks

Sunscreen:

Liquid dish soap:

Bar soap:

Wash your hands after using these chemicals.

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Answer these questions after completing the invisible ink lab.

What is the release agent for the chemicals you used for this lab?

<table>
<thead>
<tr>
<th>Ink</th>
<th>Release agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Milk</td>
<td>_______________________</td>
</tr>
<tr>
<td>b) Vinegar</td>
<td>_______________________</td>
</tr>
<tr>
<td>c) Phenolphthalein</td>
<td>___________________</td>
</tr>
<tr>
<td>d) Sunscreen</td>
<td>_______________________</td>
</tr>
<tr>
<td>e) Sugar</td>
<td>_______________________</td>
</tr>
<tr>
<td>f) Potato</td>
<td>_______________________</td>
</tr>
<tr>
<td>g) Soap</td>
<td>_______________________</td>
</tr>
</tbody>
</table>

3. Which of the inks permanently reveal—that is, once exposed, they are permanently visible?

__________________________________________________________________________

__________________________________________________________________________

4. In the movie Nicholas Cage used lemon juice and a hair dryer to reveal the message and then it faded away. Why was that unrealistic?

__________________________________________________________________________

__________________________________________________________________________

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