Student Sheet

In this practical I will be:

- Writing messages with a variety of substances which can be used as invisible inks.
- Changing the conditions of the invisible inks to see if messages become visible.
- Using my scientific knowledge to explain how changing the conditions the inks are under affects their visibility.

Introduction:

It is 410BCE and the Ionian or Decelean war, between Athens and Sparta has been raging for four years. You have been tasked by King Agis of Sparta to develop a way of delivering secret messages to his armies, which would be unreadable if they fell into the enemies' hands. You wonder if there is a way of writing with an ink that is only visible under certain conditions. Like all good science-artists, you decide to investigate further…

Wear eye protection.

Wear disposable plastic gloves.

Use one of the methods below to write a question on a piece of white paper. Pass the message to another group who will write an answer to the question and pass it back to you to develop. It would be good to use different types of ink as advised by your teacher.

How you reveal the message depends on the ink you used.

Heat-activated invisible inks

Equipment:

Any of the following for your invisible inks:

- Any acidic fruit juice (e.g. lemon, apple, or orange juice)
- Onion juice
- Baking soda (sodium bicarbonate) (or 1 M sodium hydrogen carbonate)
- Vinegar (or 1 M ethanoic acid)
- Dilute cola
- Diluted honey
- Milk
- Soapy water (or 0.1 M sodium carbonate)
- Sucrose (table sugar) solution (1 tsp in 10 cm^3 water)

Other Equipment:

- Iron or oven at 230 °C or hotplate
- Hairdryer
- A4 paper or filter paper
- Paintbrushes (and/or straws, cotton buds, spills)
- White tiles (For using on the hotplate. The tiles heat up but protect the paper from burning.)

Method:

1. Use the ink by writing your message with it using a paintbrush, spill, cotton bud, straw with a cut end to make a nib, or toothpick with cloth wrapped around it. Let the message dry in the air or use a hairdryer.
2. Write another (not secret) message on the paper with ballpoint pen, pencil or crayon, so it doesn't appear to be blank and meaningless. Do not use a fountain pen since this ink could run into your invisible ink and make it visible. Avoid using lined paper to write your invisible message, for the same reason.

Most invisible inks are made visible by heating the paper. Take extra care when heating the paper. An easy way to reveal these types of messages is to iron the paper gently. The paper containing the message can be placed onto a white (ceramic) tile and the white tile can then be placed onto a hotplate. This is a reasonably safe way to heat the paper without risk of burning and it works well to reveal the message.

The paper can also be placed directly onto the hotplate on a low heat but greater care must be taken because it is more likely to burn this way if not supervised carefully.

Going further:

Inks developed by chemical reactions:

Many of them work as pH indicators, so when in doubt, paint or spray a suspected message with a base (like sodium carbonate solution) or an acid (like lemon juice).

Equipment:

Any of the following for your invisible inks:

- Phenolphthalein (pH indicator) HIGHLY FLAMMABLE & HARMFUL, *developed by 0.1 M sodium carbonate (Solid is IRRITANT – solution is LOW HAZARD) (or another base).*

- Thymolphthalein HIGHLY FLAMMABLE & HARMFUL, *developed by 0.1M sodium carbonate (or another base)*
- Vinegar or 1 M acetic (ethanoic) acid, *developed by red cabbage water*
- Ammonia(1 M ammonium hydroxide) *developed by red cabbage water*
- 1 M sodium hydrogen carbonate sodium bicarbonate (baking soda), *developed by grape juice*
- 1 M sodium chloride (table salt), *developed by 0.1 M silver nitrate*
    - M copper sulfate, *developed by 1 M sodium iodide, 0.1 M sodium carbonate, or 1 M ammonium hydroxide*
- 0.005 M lead(II) nitrate TOXIC, *developed by 1 M sodium iodide*
- M iron sulfate IRRITANT, *developed by 0.1 M sodium carbonate, 1% starch solution (e.g. corn starch or potato starch), or by 0.1 M iodine solution*
- Lemon juice, *developed by 0.1 M iodine solution*

Other Equipment:

- Hairdryer
- A4 paper or filter paper
- Paintbrushes (and/or straws, cotton buds)

Method:

1. Use the ink by writing your message with it using a paintbrush, spill, cotton bud, straw with a cut end to make a nib, or toothpick with cloth wrapped around it. Let the message dry in the air or use a hairdryer.
2. Write another (not secret) message on the paper with ballpoint pen, pencil, or crayon, so it doesn't appear to be blank and meaningless. Do not use a fountain pen since this ink could run into your invisible ink and make it visible. Avoid using lined paper to write your invisible message, for the same reason.
3. Your message will be developed by spraying, wiping or painting the paper with a second chemical such as an acid.

Inks developed by ultra-violet light (black light)

Equipment:

Any of the following for your invisible inks:

- Dilute laundry detergent (the bluing agent glows) or 0.1 M sodium carbonate hydrated (Check packets for safety notes)
- Tonic water (quinine glows)

- Vitamin B-12 dissolved in vinegar

Other Equipment:

- Hairdryer
- A4 paper or filter paper
- Paintbrushes (and/or straws, cotton buds)

Method:

1. Use the ink by writing your message with it using a paintbrush, spill, cotton bud, straw with a cut end to make a nib, or toothpick with cloth wrapped around it. Let the message dry in the air or use a hairdryer or warm radiator.
2. Write another (not secret) message on the paper with ballpoint pen, pencil, or crayon, so it doesn't appear to be blank and meaningless. Do not use a fountain pen since this ink could run into your invisible ink and make it visible. Avoid using lined paper to write your invisible message, for the same reason.
3. Messages are revealed by shining an ultraviolet light on the paper.

Theory:

Heat-activated invisible inks

Some of these are organic substances that oxidize when heated, which usually turns them brown or black because the compounds break down. For this type of "heat fixed" ink, any acidic fluid will work in helping to develop the ink. The most secure way to use any of the following substances for invisible ink is by dilution, usually with water, close to the concentration point when they become difficult to develop. This can only be determined by trial and error.

Inks developed by chemical reactions

In most cases, the substance changes colour when mixed with an acid or base because the pH changes and the liquid acts like an indicator and changes colour.

In some cases specific indicators have to be used during which a chemical reaction takes place in which there is a colour change or a precipitate is formed.

Inks developed by ultra-violet light (black light)

Some inks glow faintly or **fluoresce** when under an **ultra-violet lamp**. This is a property of many substances, particularly organic substances and body fluids.

Other inks work in a near opposite way by **absorbing** ultra-violet light but without fluorescing. When these are used on fluorescent paper, the inked areas fluoresce less than the surrounding paper area when under an ultra-violet lamp. This is especially a property of inks with a yellow tint.

Some UV-visible inks may be detected on a photocopy, due to the relatively strong ultra-violet component in light from the photocopier scanning head.

Acknowledgement to Royal Society of Chemistry:

Classic Chemistry Demonstrations

In Search of Solutions

Classic Chemistry Experiments