Student Sheet

In this practical I will be:

- Writing messages using an invisible ink.
- Changing the conditions of the invisible ink to see if messages become visible.
- Using my knowledge of metal salts to explain how changing the conditions the ink is under affects its visibility.

Introduction:

You have been working for King Agis of Sparta, developing invisible inks for writing secret messages. You know some of his armies are running low on supplies, including the chemicals used to make some inks visible. It can also be difficult to find enough firewood to heat the entire paper in order to read the message. You therefore need to develop an invisible ink that reveals its image with only a small amount of heat. Like all good science-artists, you decide to investigate further…

Wear eye protection.

Wear disposable gloves.

Tie back long hair.

Equipment:

- Filter or blotting paper sheets – as large as possible
- Wooden taper (spill)
- Matches
- Bunsen burner or hairdryer
- Small paint brush
- Tongs

Or

- 1 large piece of filter paper or blotting paper
- 1 wooden spill
- 1 small paint brush
- 1 pencil
- 1 paperclip
- Access to a hair dryer or warm radiator

- Access to a washing line
- Sodium nitrate saturated solution

Method:

Using a small paintbrush (or wooden taper or spill), write a message on the filter paper with the saturated sodium nitrate solution. It is important to use joined up writing.Mark the start of your message with a light pencil mark.

Dry the message using a hair dryer or by holding the paper on a warm radiator. When dry the message will be almost invisible.

Use a paper clip to hang the filter paper from a washing line above the bench or hold the paper with tongs over a sink. Turn on the tap to run some water gently.

Light the spill and then blow it out leaving the end glowing hot. Apply the glowing taper/spill against the start of the message until the treated paper starts to glow and char.

Remove the taper/spill and watch as the glow and charring works its way along the message, leaving the untreated paper untouched.

If the paper begins to burn too much it can be dropped into the sink with running water to put it out safely.

Going further:

Try other metal nitrates such as potassium nitrate or lithium nitrate.

What type of chemical is a metal nitrate?

Why does the solution have to be saturated?

Theory:

The reaction is **thermal decomposition**, a chemical decomposition caused by heat.

For a chemical to decompose the temperature must be just right. Metal salts decompose at different temperatures. When the metal is near the bottom of the reactivity series the salts generally decompose at low temperatures, and when the metal is near the top of the reactivity series the salts generally decompose at high temperatures. This is because stronger bonds form between the ions of salts of metals towards the top of the reactivity series. Strong bonds break less easily so the temperatures need to be high.

The temperature at which a substance chemically decomposes is known as the **decomposition temperature**.

When the reaction takes place it is usually endothermic. Heat is required to break the chemical bonds in the compound undergoing decomposition. If decomposition is exothermic, the reaction will occur very fast and possibly result in an explosion.

The reaction for the thermal decomposition of sodium nitrate is:

$$2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$$

The oxygen produced is sufficient to keep the treated paper smouldering while the untreated paper does not burn.

Potassium nitrate works in the same way as sodium nitrate.

Lithium nitrate also works in a similar way but decomposes slightly differently due to the higher charge density on the lithium ion:

$$4LiNO_3(s) \rightarrow 2Li_2O(s) + 4NO_2(g) + O_2(g)$$

Lead nitrate will work and the reaction is:

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

Ammonium nitrate does not work because it does not give off oxygen when it decomposes:

$$NH_4NO_3(s) \rightarrow N_2O(g) + 2H_2O(l)$$

Nitrogen(I) oxide (N_2O) does not work. It will decompose to give oxygen, but there is presumably either insufficient N_2O to keep the paper smouldering or the temperature is too low to bring about decomposition.

Forensic scientists have used information about the thermal decomposition of paints by fire to identify the original paint.