Flash Paper

Classifying Matter and Physical vs. Chemical Changes

Introduction

A piece of paper quickly ignites into a brilliant flash. Compare physical and chemical changes using regular paper and flash paper.

Concepts

- Chemical change
- Physical change
- Organic composition
- Rates of combustion

Materials

Ethanol, C_2H_5OH, 500 mL*
Nitric acid, concentrated, HNO_3, 250 mL*
Sodium bicarbonate, $NaHCO_3$, 1 M, 500 mL*
Sulfuric acid, concentrated, H_2SO_4, 200 mL*
Water and water source*
Beakers, 1-L, 3*
Cotton*
Flash paper, 2 pieces (approximately 8 × 5 cm) may be prepared or bought
Flame source
Forceps (optional)
Paper towels*
Salts, various (if you want to add color to flame)*
Stirring rods*
Thermometer*
Tissue or toilet paper*

**Materials for preparation of flash paper.*

Safety Precautions

Flash paper is very flammable and a fire risk. Handle with care and keep it away from heat, open flame, or sparks until ready to use. Wear appropriate personal protective equipment including eye protection. Read all notes before attempting preparation of flash paper! Do not allow students to perform this preparation. The mixture of acids is extremely caustic and contains strong oxidizing agents. Do not get acid on skin or clothes. It is corrosive and can cause severe burns. Have a concentrated solution of sodium bicarbonate available for neutralization. Much heat will be generated upon mixing of the acids. Mix in a working fume hood. Keep the paper moist until needed. Allow plenty of time for the paper to dry. Keep the paper and ethanol away from heat or ignition sources. The ethanol is a flammable liquid. The paper will decompose if left out over a period of months. Avoid contact of all chemicals with eyes and skin. Follow all laboratory safety guidelines. Wear chemical splash goggles, chemical-resistant gloves, and a chemical resistant apron. Please review current Material Safety Data Sheets for additional safety, handling, and disposal information. Wash hands thoroughly with soap and water before leaving the laboratory.

Preparation

Note: There are many different procedures. The following is a compilation of both the Solomon and Shakhashiri methods with changes that have been found to work nicely.

1. Mix concentrated nitric acid and concentrated sulfuric acid in a 5 to 4 ratio in a 1-L beaker. Prepare enough to completely submerge the paper to be prepared. *Caution:* Use a fume hood!
2. Allow this mixture to cool to at least 40 °C.
3. Add tissue paper, toilet paper, or cotton to the liquid surface and submerge it with a stirring rod. You may do more than one sheet at a time. Please fluff the cotton if you are trying the cotton. *Note:* The paper will fall apart if the solution isn't cool enough.
4. Soak the paper in the mixture for 15–20 minutes. Tissue paper will have an off-white color and toilet paper will appear brownish.

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5. Gently remove the paper using forceps and allowing the acid mixture to drip off of the paper.
6. Place the pieces of paper in water in a 1-L beaker. Leave in the water for 5 minutes with occasional stirring. The color will change from brown to off-white if you are using toilet paper.
7. Pour off the water and refill the beaker. Let running water continuously fill the beaker.
8. Take the paper out of the water bath and let most of the water drip off.
9. Let the paper dry. This process can be sped up by using paper towels.
10. Place the paper in a 1 M solution of sodium bicarbonate. Rinse in water again if bubbling occurs. (From Shakhashiri) Allow the paper to thoroughly dry.
11. Place the paper in an ethanol bath.
12. Take out of ethanol and allow plenty of time to dry before use. Paper must be ***dry***.

Procedure

1. Display a piece of flash paper and ask the students to make observations (white, thin, rectangular, and translucent).
2. Tear the paper into two pieces and ask the students to again make observations (still white, thin, translucent, but now in two pieces of smaller size).
3. Ask the students if they think that the paper has been changed chemically into a new substance. The students easily recognize that the paper has not changed chemically, and the change can then be identified as a physical change.
4. Holding a second piece of flash paper with a forceps (or with your fingers) bring a lit match to the paper. The paper burns quickly with no residue. (You may wish to repeat this with the remaining pieces of paper because some students may miss the observation.)
5. Ask the students if they think that the paper has now been changed chemically into a new substance or substances. The students will identify the change as a chemical change.

Disposal

Please consult your current *Flinn Scientific Catalog/Reference Manual* for general guidelines and specific procedures governing the disposal of laboratory waste. The acid mixture may be disposed of by neutralizing with base and then flushing down the drain with plenty of excess water according to Flinn Suggested Disposal Method #24b. For disposal of the ethanol water bath please reference Flinn Suggested Disposal Method #26a.

Tips

- In a unit on reaction rates, flash paper can be used in two ways. The nature of the reactants in a combustion reaction affects the rate of the combustion, and this can be quickly demonstrated by burning first a piece of notebook paper fol lowed by a piece of flash paper. Flash paper can also be used as an assessment by having students determine the rate of combustion of the paper in appropriate units. Students can measure either the mass of the paper or the size of the paper and then determine the rate in units of grams/second or cubic centimeters/second.
- Flash paper can be purchased from magic stores, novelty stores, and Web sites, such as www.magical-tricks.com.

Discussion

Flash paper is paper that has been nitrated to form cellulose trinitrate. The compound contains sufficient oxygen for complete conversion to the gaseous products carbon monoxide, carbon dioxide, nitrogen, and water vapor when ignited.

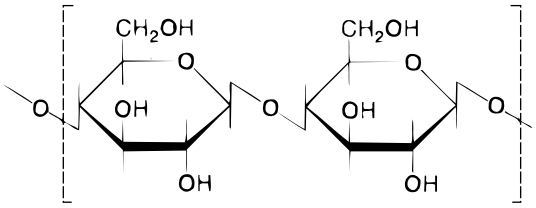
Flash paper, or cellulose nitrate, has been around for awhile. It was first created around the 1850s and became popular for magicians in the late 1800s. Its preparation was discussed in magic books dating back to 1912. A common name for flash paper is guncotton and it can be used for the manufacture of propellants, as a detonator or primer, and in the making of explosives.

Flash paper can be a great addition to a chemistry class. It can be used to get the students attention. It can also be used to

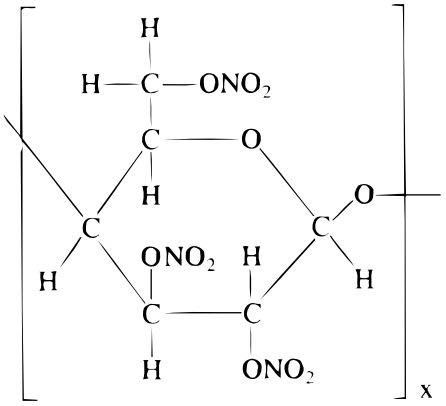
demonstrate that certain equipment is hot even though it doesn't look like it. Touching the flash paper to a ***hot*** stirring rod or a hot piece of metal can combust the material. One can also use a candle attached to a pole or a piezoelectric butane starter. Magic shops also offer many different devices that will ignite the paper. These combustions can happen in different devices offering both explosive and non explosive types of reactions.

Some methods have you mix the two acids in different concentrations and ask that you let the two acids settle for 24 hours. Neutralization of the acids can happen by water bath or some suggest the use of sodium bicarbonate or use of urea. The paper source can be either ordinary wrapping tissue paper or toilet paper. Cotton can also work if you have it so all areas of the cotton exposed to the chemicals. Magic shops can provide materials such as flash paper, flash bills, flash string, flash cord, and flash cotton.

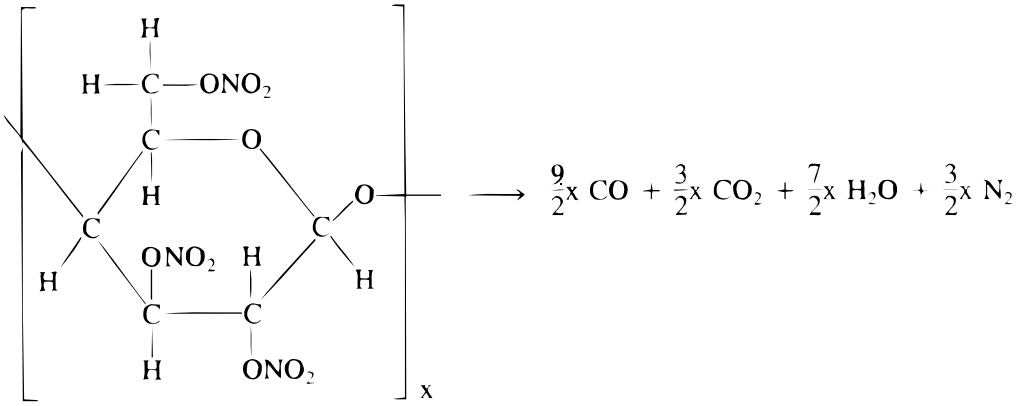
The reaction takes the basic form of cellulose and causes nitrates to attach. This is shown in the following diagram. The cellulose nitrate is then combusted by a high temperature and this forms the following products according to Shakhashiri.



Cellulose Example



Cellulose Nitrate



Reaction of the Cellulose Nitrate to form the following products.

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12

Constancy, change, and measurement

Content Standards: Grades 5–8

Content Standard B: Physical Science, properties and changes of properties in matter, motions and forces, transfer of energy

Content Standards: Grades 9–12

Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions, motions and forces, conservation of energy and increase in disorder, interactions of energy and matter

Reference

Grossman, J. H. Flash Paper, *Linking Ring Magazine*, June 1961.

Johnson, V. *Chemical Magic*, Pearson, 1920; pp 30–31.

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Solomon, S.; Hur, C.; Smith, K. *Journal of Chemical Education*, 1995, 72, pp 1133–1134.

Steele, Mark ed. *How to Make Flashes*, *Bangs and Puffs of Smoke*, Hades Publications, 1989, pp 13–14.

Zubay, Geoffrey. *Biochemistry*, Brown, Vol 4, 1998; p 288.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Flash Paper* activity, presented by Kathleen Dombrink, is available in *Classifying Matter and Physical vs. Chemical Changes*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Flash Paper* are available from Flinn Scientific, Inc.

Catalog No.	Description
N0016	Nitric Acid, 500 mL
S0143	Sulfuric Acid, 500 mL
S0042	Sodium Bicarbonate, 500 g
E0009	Ethanol, 500 mL

Consult your *Flinn Scientific Catalog/Reference Manual* for current prices.