Hydrogen Combustion OSPREY

the human energy company™ Chevron

AUSTRALIAN EARTH SCIENCE EDUCATION

Hydrogen Combustion OSPREY – Teacher Resource

Powering Careers in Energy Link:

Unit 3: Demonstrate an understanding of Behaviour Based Safety in the workplace through the use of school-based OSPREYs

Background Information:

Hydrogen stores 140 MJ/kg of energy which is released when it reacts with oxygen. The explosive combustion of hydrogen led to the end of the airship era in 1937 when the Hindenburg exploded while docking in New Jersey. Hydrogen combustion fueled space exploration, powering NASA's Centaur, Apollo and Space shuttle programs.

The 'pop test' for hydrogen is commonly carried out in high school science classes. Hydrogen is generated by reacting acid and metal. A match ignites the collected gas, producing a 'pop' noise. Larger volumes of hydrogen can be generated and collected in a balloon. Combustion of larger volumes of hydrogen is more dangerous and should only be carried out in tightly controlled environments.

Hydrogen fuel cells are a solution to the safety concerns with combustion. In a fuel cell, hydrogen and oxygen combine to release electrical energy without explosive combustion.

Aim

To create OSPREYs for the pop test and combustion of a hydrogen-filled balloon.

Materials

Per student or small group

- 2 OSPREY forms
- Hazard Wheel

Option:

If carrying out the pop test and balloon combustion, you will need appropriate equipment and PPE, as per a formal science risk assessment and the student OSPREYs.

Safety Notes

Hydrogen ignites easily and is flammable at low (4%) concentrations. Extreme care must be taken in collecting larger (>10 mL) amounts of hydrogen and in performing balloon combustion. Formal school risk assessments must be in place for these activities.

Method

1. Watch a video of the hydrogen pop test.
2. As a class, identify ways that the demonstrator has protected themselves and the environment.
3. Identify any improvements that could be incorporated in the OSPREY.
4. Complete an OSPREY for the hydrogen pop test.
5. Watch two videos showing combustion of a hydrogen-filled balloon on a retort stand and on the ceiling.

6. Identify the safety issues in these videos using the Hazard Wheel.
7. Complete an OSPREY for safe combustion of a hydrogen-filled balloon.

Results

Hydrogen pop test video

The experimentor is wearing a lab coat to protect clothing and safety glasses to protect eyes. They tell the concentration and type of acid (1 M HCl), which is considered a very safe concentration to use in the high school classroom (Year 7+). The hydrogen gas accumulates in the stoppered test tube before being tested with the lit splint. The gas is allowed to dissipate into the atmosphere of the room, decreasing the concentration. This results in the positive pop test sound, without a visible explosion. These factors combine to make this a safe experiment. Students may identify improvements such as placing the reaction test tube in a rack to avoid burns. The experimentor mentions that the tube gets hot because of the exothermic (heat-producing) reaction.

Hydrogen balloon videos

There are many causes for concern in these videos, including:

- *Only one of these experimentors (balloon on ceiling) is wearing safety glasses. Normal glasses do not protect the sides of the eyes and are not made of safety glass that can withstand sudden changes in pressure.*
- *The experimenter who put acid in the balloon to start the reaction, notes that the flask is very hot and appears to set it in the sink. This may lead to cracking of the flask and certainly allowed the escape of large amounts of hydrogen gas.*
- *The balloon explosions are loud. No one is wearing hearing protection. One experimenter tells viewers to cover their ears.*
- *The balloon on the ceiling risks setting the ceiling on fire. In this case, there are heatproof tiles, but there is a large stain on them. If the stain was caused by a flammable substance, a hazardous fire may have resulted.*
- *The experimenter ignites the balloon in the retort stand while standing very nearby (without safety glasses), thus placing themselves at risk.*
- *After the balloon on the ceiling explodes, you can see particles floating to the ground. It is unclear what these are and whether they represent a safety hazard to people in the room (probable hazard).*
- *Neither video shows a safety barrier between viewers and the explosion.*

Discussion

1. What are the standard safety procedures you would use in the school science lab for working with chemicals and flame?

   Safety glasses, long hair tied back and clear workspace are standard precautions.

2. How does the scale of the hydrogen combustion reaction (pop test vs balloon) affect your OSPREY?

   There is less danger with a smaller combustion reaction (pop test), so more standard safety precautions can be used. When a greater volume of hydrogen is used, the reaction produces visible flame and all risks (noise, heat) are greater. Thus, the safety controls need to be proportional to the risk.

Evaluation:

1. The industrial production and use of hydrogen involve tonnes of hydrogen gas created and stored at a single site. Would the OSPREY for industrial hydrogen use be similar to those you have written? Explain your answer.

   In an industrial setting where tonnes of hydrogen are being generated and used, different safety procedures and equipment are needed. Equipment must be much stronger to contain the hydrogen. Storage would need to be outdoors because accumulation in a building could lead to a catastrophic explosion.

References:

Learn about a safety incident involving ignition of hydrogen-oxygen filled balloons here:

https://h2tools.org/lessons/hydrogen-oxygen-balloon-hazards

A formal risk assessment for hydrogen balloons is available here:

https://www.sserc.org.uk/subject-areas/chemistry/chemistry-resources/hydrogen-balloons/

Worksheet: Hydrogen Combustion OSPREY

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Operating Safely to Protect Resources, the Environment and You (OSPREY)

Activity: Hydrogen pop test

Resources used:

Potential impact on the environment (built and natural environment):

Potential impact on people:

Actions to minimise impact on:

Environment:

People:

Labelled diagram of safe method:

Operating Safely to Protect Resources, the Environment and You (OSPREY)

Activity: Combustion of a hydrogen-filled balloon

Resources used:

Potential impact on the environment (built and natural environment):

Potential impact on people:

Actions to minimise impact on:

Environment:

People:

Labelled diagram of safe method: