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# Hydrogen Balloons: Bright Colors but Hidden Fire Hazard

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**Abstract**

A party isn't really a party without balloons. Balloons aren't just for birthday parties, people used a plenty of ways to incorporate them into wedding decor, New Year's fest and graduation parties. Due to Archimedes' law, a gas for lifting is required to create buoyancy because density is lower than that of air. Hydrogen is the lightest gas (less dense than air about 14 times), for this reason it is the most appropriate lifting gas. However, hydrogen has several disadvantages, the most important that the gas is flammable. Helium consider as the second lightest gas, so, it is an attractive gas. A major advantage is that the gas is nonflammable, but it is expensive. Ignorance or sometimes disregard for safety rules, some simple craftsmen produce hydrogen from aluminum cans for soft drinks believing that it is helium. They fill the balloons with the produced gas which can cause an explosion if caught fire. The biggest danger is that people produce hydrogen gas in this way at homes. In January 2018 and during one of the celebrations, eleven university students were burned as a result of filling of balloons with hydrogen.

**Keywords:** Hydrogen; Helium; Balloons; Fire; Explosion

## Introduction

Attention to safety is a priority for preserving life and property. Specialized safety research is an important means of promoting a culture of safety [1-5]. Hydrogen is the lightest element on the periodic table [6]. Hydrogen gas is a colourless, odourless, and tasteless. It is non-toxic, non-metallic and highly combustible diatomic gas [7]. Industrial production is mainly from natural gas steam reforming [8]. The explosion of the Hindenburg airship was an example of hydrogen combustion and the cause is still dispute [9].

## Hindenburg Disaster

A balloon can fly when it is filled with lighter gas than air [10]. Due to Archimedes' law; A lifting gas is required to induce buoyancy. Hydrogen, considered the most suitable lifting gas, but it is flammable [11].

The textile balloon coating is responsible for spreading the fire and showing the colour of the combustion (Figure 1). The combustion of hydrogen gas is not usually visible to the human eye in daylight [12].

## Hydrogen Characteristics Related to Fire Safety

Hydrogen is lighter than gasoline vapor (Figure 2). It is lighter than air. This means that if it is spilled in an open environment, it will rise and disperse rapidly, so this is a safety advantage in an environment in case of outside gas spill.

Hydrogen gas forms explosive mixtures with air in concentrations

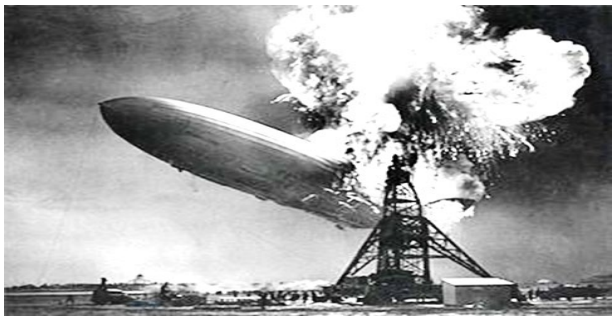

**Figure 1:** The stern of the Hindenburg begins to fall, with the mooring mast in the foreground.

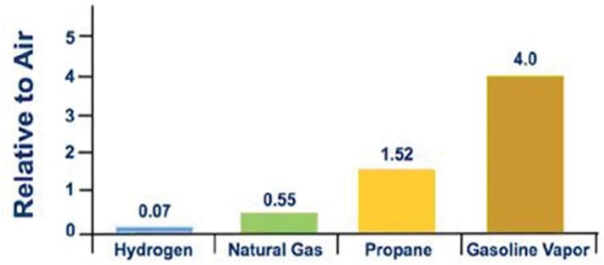


**Figure 2:** Hydrogen vapour density compared with other fuels.

(4-75%) with very wide flammability range compared to other fuels, as shown in Figure 3 [13]. Under the optimal combustion condition (a 29% hydrogen-to-air volume ratio), the explosive reactions may be initiated by spark, heat, or sunlight, 500°C is the temperature of spontaneous ignition in air [14].

The energy needed to ignite hydrogen gas is very low compared to other fuels as shown in Figure 4 [13].

A flame detector needed to detect of a burning hydrogen leak; such leaks can be very dangerous from fire safety stand point [15], as part of our own interest in the field in safety and security [16-25].

## Helium Hazards Identification

Helium as a gas does not threaten life but can be a suffocating substance in case of replacing the air in a closed place. Adverse Health Effects: Helium is non-toxic and inert. At low oxygen concentrations in air, unconsciousness and death may occur in seconds without warning.

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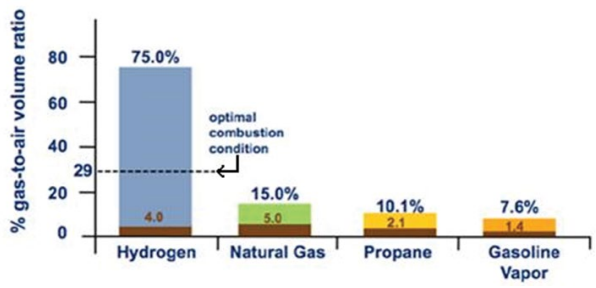


**Figure 3:** Flammability range.

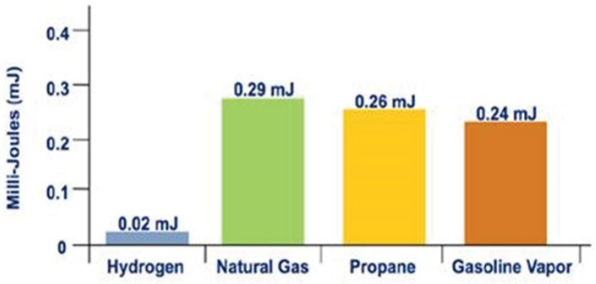


**Figure 4:** Minimum ignition energy.

Chemical Hazards: Helium is inert gas and forms no known chemical compounds. Biological Hazards: Helium is a light gas and soon appears in the air in an open space. Fire hazard: Non-flammable, It can explode if exposed to heating in confined place [26].

## Why Helium is Preferred to Hydrogen in Filling Balloons?

Helium and hydrogen are very important elements as; balloons need a light gas in other for it not to explode and loose shape although hydrogen is light as well as helium. Hydrogen is very reactive and flammable. Helium, on the other hand, is so inert that you can inhale it and all it would do is to make you sound like a chipmunk for a minute or so. Hydrogen is even used in weapons of mass destruction. Figures 5 and 6 shows the Hazard diamonds for hydrogen and helium according to NFPA (National Fire Protection Association)

Though oil wells are one of helium resources, helium gas is expensive because of its scarcity, as not all our oil wells have it the amount of helium that we can access cheaply. However, helium is preferable to being non-flammable.

## Hydrogen Production

There are several methods for producing hydrogen:

### Method 1

One of the easiest ways to obtain hydrogen is to get it from water, $H_2O$. This method employs electrolysis, which breaks water into hydrogen and oxygen gas.

### Method 2

Reacting of hydrochloric acid with zinc.

$Zn\ (solid)+2HCl\ (liquid) \rightarrow ZnCl_2\ (liquid)+H_2\ (gas)$

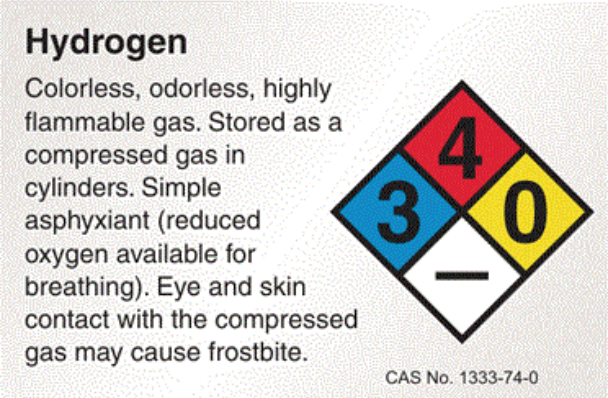


**Figure 5:** Hazards diamond for hydrogen according to NFPA.

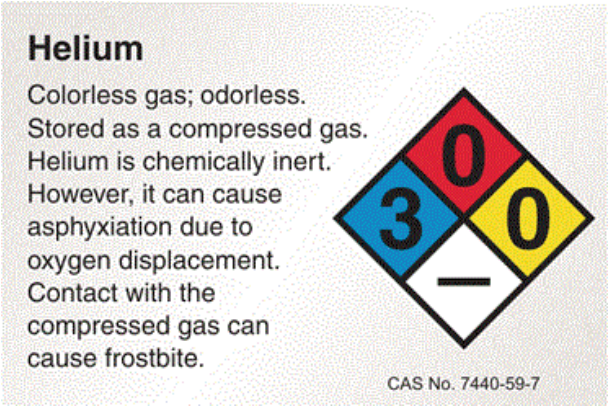


**Figure 6:** Hazards diamond for helium according to NFPA.

Iron filings or aluminum strips can be used instead of zinc granules.

As soon as the reaction between acid and zinc begin hydrogen gas bubbles will be released. Be very careful to avoid acid contact with the produced gas.

### Method 3

Homemade hydrogen gas.

Certain drain clog removers contain sodium hydroxide. Soft drink cans, can be used as aluminum metal.

$2Al\ (solid)+6NaOH\ (aqueous) \rightarrow 3H_2\ (gas)+2Na_3AlO_3\ (aqueous)$

This is an extremely easy method of making homemade hydrogen gas. The reaction is exothermic; the resulting gas preferably collected in glass bottle (Figures 7-10) [27]. The biggest danger is that people produce hydrogen gas in this way at homes.

Some simple craftsmen produce hydrogen from aluminum cans for soft drinks believing that it is helium (Figures 11-14). They fill the balloons with the produced gas which can cause an explosion if caught fire.

## Hydrogen and Helium Balloons when Exposed to A Flame

When hydrogen and oxygen gases mix in the range of 4-75% then ignited, the gaseous reaction is

**Figure 7:** Aluminium in soft drink bottle.


**Figure 8:** Tab water addition.


**Figure 9:** Sodium hydroxide addition.

**Figure 10:** Hydrogen gas production.

**Figure 11:** Sodium hydroxide addition.

**Figure 12:** Aluminium soft drink cans addition.

**Figure 13:** Lock the cylinder firmly.

**Figure 14:** Balloons filled with hydrogen gas.

$2\ H_2\ (gas) + O_2\ (gas) \rightarrow 2\ H_2O\ (vapor)$

This reaction is exothermic and yields 232 kJ/mol of water. The rapid release of energy causes the surrounding air to expand suddenly, resulting violent explosion. The explosion will be less rapid when hydrogen is ignited using surrounding air as oxidizer and a significantly larger flame is produced according to this reaction. The mild sounds emitted when the helium balloons are ignited. The explosions occur by a sudden pressure effect through the action of heat and gas expansion [28].

The experiment can be conducted with great caution by bringing a torch to the hydrogen and helium balloons and the result is as shown in the Figures 15-18.

## Hydrogen Gas Explosion Color

Hydrogen gases can forms explosive mixtures when combined with air in concentrations about (4-75%), (Figure 3). When the mixed ratio is about (29% hydrogen to air as volume ratio) an optimal combustion condition can be obtained. The color of the flame resulting from combustion depends on the ratio of hydrogen gas to air. Figure 19 shows the color produced from hydrogen combustion.

**Figure 15:** Hydrogen balloon when exposed to flame.

**Figure 16:** Hydrogen balloon explosion.

**Figure 17:** Helium balloon when exposed to flame.

## A Realistic Incident Caused by the Explosion of Hydrogen Balloons

A party isn't really a party without balloons. Balloons aren't just for birthday parties, people used a plenty of ways to incorporate them into wedding decor, New Year's fest and graduation parties. In January 2018 and during one of the celebrations, eleven university students were burned as a result of filling of balloons with hydrogen as shown in Figures 20 and 21.

It is clear from Figure 20 that the color of the fire resulting from the explosion matches what is stated in Figure 19.

## Helium Balloons

It is more appropriate to use helium gas to fill balloons in order

**Figure 18:** Helium balloon explosion (No fire appears).

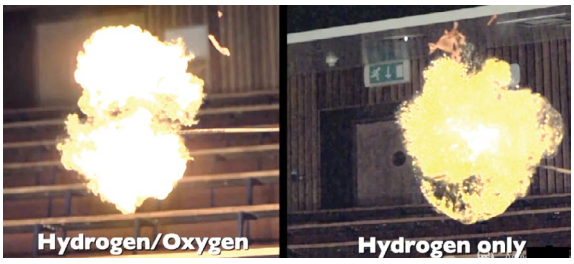


**Figure 19:** Hydrogen balloon explosion colour.

**Figure 20:** Hydrogen balloon explosion during student's celebration.

**Figure 21:** Injuries of students with first and second degree burns.


**Figure 22:** Helium cylinder with balloons.


**Figure 23:** Helium balloons kit.

to prevent fires. Helium kits are available in the markets containing helium gas cylinder and balloons as shown in Figures 22 and 23.

## Conclusion

Most people use balloons in their various celebrations especially those that fly in the air. Hydrogen gas or helium can be used as lifting gases because its density lowers than that of air. Hydrogen has several disadvantages, the most important of which is that the gas is flammable. Helium can be used as an alternative gas; a major advantage is that the gas is non-combustible. The major disadvantage is that the gas is expensive. Simple craftsmen produce hydrogen from aluminum cans for soft drinks believing that it is helium. They fill the balloons with the produced gas which can cause an explosion if caught fire. The subject is very dangerous considering that there is a belief by people that the gas produced by the methods described in this research is helium but hydrogen which is a very dangerous gas in terms of fire.

### Conflicts of Interests

The authors declare that they have no conflicts of interest.

### Recommendations

- Increase awareness in the culture of safety through the media in its various ways.
- Requires the state to set strict controls to limit industrial production that is incompatible with safety instructions.
- Purchase materials from reliable and approved places.
- Do not rely on publications on the Internet for dangerous experiments.
- Do not conduct dangerous experiments or manufacture hazardous materials at home.
- Consult specialists when there are doubts about the use of unknown materials.

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