Hydrogen | H_2

The economic, ecological, social and health consequences of climate change and environmental pollution pose a serious threat to our quality of life. The energy revolution and the hydrogen economy offer a sustainable solution with the full decarbonization of our energy system by completely replacing the currently predominant fossil energy carriers with green electricity and green hydrogen. The energy revolution in the direction of sustainable power generation and the hydrogen economy represents the next major industrial revolution, offering not only the prospect of a healthy and liveable environment for future generations, but also the economic opportunity for innovative know-how and technological leadership.

Hydrogen can be used in many ways. In addition to the already established fields of application in industry and the energy sector, which are described in more detail below, hydrogen can also be used as a fuel for stationary fuel cells for power generation or for mobile systems in vehicles. The overall efficiency from energy generation to traction on the road is about twice as high as that of petrol vehicles. The strengths of fuel-cell technology lie in its long ranges, fast refuelling times of three to five minutes, local zero emissions and the decoupling of electricity production and demand. The fuel cell is the technology of the future for public transport, heavy goods traffic, shipping and trains. In the case of passenger cars, battery electric vehicles and electric vehicles with fuel-cell drive will complement each other in the future.

Hydrogen can be burnt in internal combustion engines largely without pollutants, neither carbon monoxide, carbon dioxide nor hydrocarbons are produced, and the emission of nitrogen oxides can be kept low. If hydrogen is used in a fuel cell, it supplies electrical energy in a "cold combustion" process without emitting pollutants or noise. However, a number of economic and technical issues still need to be resolved in order to make hydrogen industrially usable as an energy carrier for power generation in fuel cells or as vehicle propulsion in fuel cells or internal combustion engines.

Properties

Hydrogen is a colourless, odorless and non-toxic gas. It is the element with the lowest density, so hydrogen diffuses easily through porous partitions as well as through metals such as platinum. As a rule, hydrogen occurs in a diatomic molecular form (H_2). Hydrogen atoms occur in bound form in numerous compounds, e.g. in water or in organic compounds such as hydrocarbons (methane, ethane, benzene), alcohols (methanol, ethanol), aldehydes, acids, fats, carbohydrates and proteins. Hydrogen atoms are very common in the human body and are involved in many important metabolic processes such as digestion.

As with any other flammable gas, hydrogen can become a hazard if it is present in a certain mixing ratio with an oxidant and meets an ignition source at the same location. If these three factors are separated, there is no danger. From a technical point of view, hydrogen is therefore as safe to use as petrol, diesel or electrical energy in batteries. Hydrogen has been used on a large scale for decades. The handling of hydrogen and its associated safety risk is well proven. As long as the state of the art is used and known safety measures are observed, the residual risk can be reduced to a minimum.

Production and use

A number of processes are used to produce hydrogen. Since hydrogen occurs in nature only in bound form, its production requires the use of primary energy. Worldwide, around 600 billion Nm^3 (normal cubic metres) of hydrogen are currently produced and consumed each year. This corresponds to approximately 1 per cent of total global energy consumption or six exajoules. Almost 40 per cent of this is a by-product of industrial processes, such as the chloralkali process. The remaining 60 per cent is generated independently with 95 per cent of this coming from hydrocarbons and the remaining 5 per cent from electricity.

The vast majority of the hydrogen produced comes from fossil energy sources, from catalytic steam methane reforming (natural gas reforming), the partial oxidation of heavy oil (diesel) and the gasification of coal. These manufacturing processes, which are based on carbonaceous starting components, produce CO_2. The production of hydrogen by electrolysis of water, which has been made electrically conductive with caustic soda or sulphuric acid, allows a regenerable emission-free energy chain when using wind, water or solar energy. Just as emission-free but expensive, hydrogen can be obtained from a series of chemical reactions with water, for example from the reaction of alkali metals and water. Other production processes are at the research and development stage, such as autothermal reforming, the Kværner process, gasification of biomass and organic waste as well as high-pressure electrolysis. Research is also being carried out into methods of hydrogen production using biological processes.

Half of the hydrogen produced is used in the Haber-Bosch process to produce ammonia, which is used as a starting material for nitrogen fertilizers, while half of the remaining hydrogen is used in refinery processes for processing crude oil, such as hydrorefining and hydrocracking. The remaining hydrogen is used in the semiconductor industry, analytical and food chemistry, water treatment and metallurgy. The use of hydrogen in the energy industry and transport technology only accounts for a small part of global use so far.

Storage

Hydrogen is a chemical energy storage medium. Particularly with renewable energy sources, the energy produced often cannot be used directly. For this reason, the increased use of environmentally friendly renewable energy sources requires the intermediate storage of energy. Hydrogen enables the storage of otherwise unused energy and can be converted back into electricity when electricity demand increases or used as an energy source for vehicles. If hydrogen is produced by electrolysis, the emissions from the electricity generation have to be taken into account. Hydrogen from renewable energy sources is completely emission-free.

Due to the low density of hydrogen, storage with sufficient energy density presents technical and economic challenges. Typical processes include the storage of compressed gaseous hydrogen, cryogenic liquid hydrogen and the storage of hydrogen in chemical or physical compounds. Gaseous hydrogen is highly compressed to pressures of 200 bar to 900 bar and stored as CGH_2 (compressed gaseous hydrogen) in pressure vessels. There are four types of pressure vessels, ranging from simple steel cylinders to full composite cylinders. In addition, hydrogen can also be stored in the natural gas network and thus be stored in large quantities and transported via pipelines. In Austria, up to 4 vol. per cent hydrogen can already be fed into the natural gas grid today.

In order to achieve higher energy densities, hydrogen is liquefied and stored as LH_2 (liquid hydrogen) at low temperatures. Since the condensation of hydrogen at ambient pressure only occurs at -252.85 degrees Celsius, the effort required for liquefaction is high and must be optimized in terms of energy.

Further information about the element hydrogen can also be found at www.hycenta.at/wasserstoff.

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