Technological Intervention to Produce Green Hydrogen

Surbhi Dahiya

With the increasing amount of Greenhouse Gases (GHGs), especially carbon dioxide, efforts are being made to abide by the Paris Agreement to limit the increase in the global temperature to 1.5°C above pre-industrial levels. According to the National Oceanic and Atmospheric Administration (NOAA) Global Monitoring Lab study, the concentration of carbon dioxide in the atmosphere is 413.3 ppm, 50% higher than it was before the Industrial Revolution. Using fossil fuels to satisfy energy demands has led to harmful emissions such as sulfur dioxide, nitrous oxide, carbon dioxide, carbon monoxide, and particulate matter, increasing pollution as well as the high amount of greenhouse gases in the atmosphere. Academia, industry, government, NGOs, etc. are raising their voice to bring in the technology in the energy sector that can satisfy the needs of society in a clean and cost-effective manner fulfilling the SDG goal 7 (Clean and Affordable energy to all).

It is seen that "Green Hydrogen," has the potential to fulfil the growing energy demand in a sustainable way. It is the future fuel where the scientific community is looking forward to bringing newer ways to synthesise it leading to a "Green Revolution" in the energy sector. Before understanding the concept of green hydrogen, let us understand how many types of hydrogen as a fuel are there and why green hydrogen is expected to outperform all the others.

Hydrogen as a fuel is categorised through "spectra of colours" differentiating each of them by their method of production. Though hydrogen is colourless there is no visible difference between the hydrogen produced and it is only their method of production by which this differentiation is coded. Hydrogen is classified mainly into blue hydrogen, grey hydrogen, black and brown hydrogen, pink hydrogen, yellow hydrogen, white hydrogen, and green hydrogen.

The process of production of hydrogen from natural gas using the process of steam reforming gives blue hydrogen, however emitting carbon dioxide as the by-product. This method employs the technology to Carbon Capture Utilisation and Storage (CCUS), therefore the hydrogen generated is clean. CCUS involves a set of processes for reducing carbon emissions through its capture, transport as well as storage. Since the complete removal of carbon dioxide is not reported in the literature for this setup, this is also a "low-carbon hydrogen." During its preparation, the basic feedstocks used are natural gas, implying high pressure and temperature in the process. Grey hydrogen is also produced through a similar procedure using steam reforming of hydrocarbons, especially methane, without the implementation of carbon capture and utilisation technology. Hydrogen developed through using black or brown coal generates black and brown hydrogen. In Pink hydrogen generation, the technology of electrolysis is used powered by nuclear energy. If solar energy is used for electrolysis, the hydrogen produced is termed yellow hydrogen. White hydrogen is naturally present in geological deposits and is very clean, it requires higher technology to exploit its potential.

Green hydrogen is synthesised using a clean source of electricity for the process of electrolysis that splits water into hydrogen and oxygen. This is considered the purest form of hydrogen as no harmful emissions are involved in the process. Several studies and experiments are being carried out to produce green hydrogen making it cost-effective, and environmentally friendly. To carry out the process of electrolysis, the power generation should be from clean sources such as wind, solar, tides, hydraulics, etc. to produce hydrogen. However, these sources depend on factors such as location and geography which means not all the places are perfect for carrying out this process.

To overcome this problem, the thought of storage and supply of hydrogen from the place of generation can be implied. However, this leads to expensive incurrence in the utilisation of this type of hydrogen. Therefore, despite the basic definition of green hydrogen, the understanding is broadened by including hydrogen formed from the sources making the entire process carbon neutral into the category of clean and green hydrogen. Therefore, if the production is happening from the biomass source, the process can be termed as the green hydrogen process, even if the carbon capture is not taken during the synthesis as the carbon dioxide generation in the final step of hydrogen production comes out from the previous capture operated by the plant. This makes the entire process carbon neutral and brings the concept of circular economy.

There are various technologies that have come up to generate, store and utilise green hydrogen. Biomass gasification employs carbon-rich biomass like forest residue, animal wastes, organic municipal solid waste, etc., in partial-oxygen conditions converting it into syn-gas containing carbon-monoxide, hydrogen and other gases. In this process, high temperatures are employed normally above 700°C with less amount of oxygen, releasing carbon monoxide, carbon dioxide, and hydrogen. After this, there occurs a water-shift gas reaction in which carbon monoxide reacts with water to produce more hydrogen and carbon dioxide. The separation of hydrogen occurs through the implication of absorbers or membranes. Another important technology that has been known for a long time is electrolysis, which splits water into hydrogen and oxygen making this process the cleanest. Through this technology, a chemical reaction takes place using Direct Electricity (DC), along a non-spontaneous path. It is important to know that if this electricity is generated from