

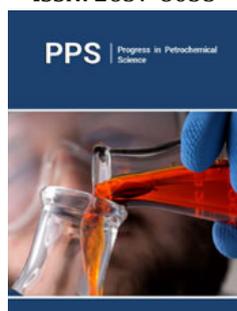
The Fuel of Future: Hydrogen and Reduction Products of Carbon Dioxide

Suresh C Ameta^{1*} and Rakshit Ameta²

¹Faculty of Science, PAHER University, India

²Faculty of Science, J R N Rajasthan Vidyapeeth (Deemed to be University), India

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***Corresponding author:** Suresh C Ameta,
Faculty of Science, PAHER University,
Udaipur, India

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Opinion

World is facing a problem of energy crises and air pollution because of industrialization, increasing populations, transportation, etc. and this has become a burning problem for today and it will continue to become graver in future. It is all because of over-exploitation of natural resources of energy like wood, coal, kerosene, petrol, diesel, etc. being supported by deforestation due to construction activities like buildings, roads, etc. We have reached an alarming situation and if proper action is not taken at this stage, we are bound to face many unwanted situations like rising of sea level due to melting of glaciers, rising temperature of atmosphere, ozone layer depletion, etc. This is all because of global warming caused by all these anthropogenic activities. This will result into natural catastrophes such as flood in many areas while draught in the other areas, hot summer, and chilling winter. One has to find solution to these undesired problems and therefore, efforts are to be made to search an alternate fuel, which will resolve the scarcity of fuels as well as control the global warming. Here, hydrogen enters the scene. Hydrogen has been predicted as fuel of future, because burning of any natural fuel will increase the amount of carbon dioxide in atmosphere causing global warming and its side effects. On the other hand, hydrogen will produce water as its oxidation product (which is harmless as compared to carbon dioxide), when burnt in a fuel cell. Hydrogen has a very high energy storage capacity, and it can be easily transported to long distances in filled cylinders just like LPG cylinders. Source of hydrogen will be water, which is covering almost three-fourth of our planet Earth. It is abundantly available. Water can be electrolytically reduced, but that is a costly affair. Therefore, photosplitting of water can be considered as a prime source of hydrogen, the fuel of future. Hydrogen is an energy carrier, and it can be used in internal combustion engines or fuel cells producing electricity and on combustion with oxygen virtually no greenhouse gases are produced.

Oxidation is a down-hill reaction, because when any source of carbon is burnt to carbon dioxide, it releases energy in the form of heat, while the reduction is an up-hill process, where one can store the energy in the form of energy rich products (reduced products). Hence, any suitable reduction reaction can be selected as energy storage reaction, particularly reduction of water to hydrogen, reduction of carbon dioxide to formic acid, formaldehyde, methanol and ultimately methane, etc. When any source of carbon is used as a fuel (wood, coal, coke, kerosene, petrol, diesel, etc.) and burnt, then carbon dioxide is produced as final product of oxidation and it produces heat. It increases the amount of carbon dioxide in atmosphere leading to global warming as well as scarcity of fuel. The global average atmospheric carbon dioxide in 2019 was 409.8 parts per million (ppm). Today carbon dioxide levels are higher than this. If carbon dioxide is reduced photocatalytically into its reduction products (formic acid by two electron reduction, formaldehyde by four electron reduction, methanol by six

electron reduction and ultimately methane by eight electron reduction; of course in steps of two electron reduction), then these reaction products can be used in fuel cells as synthetic fuels, and they will provide energy in the form of electricity. Once you get this form of energy, it can be converted and used as heat. However, this will not reduce the percentage of carbon dioxide in atmosphere, but it will not increase the carbon dioxide also. One molecule of

carbon dioxide will be reduced to one molecule of this reduced product and therefore, it can be considered as a short term loan of carbon dioxide from atmosphere, which will be returned back on burning this synthetic fuel in fuel cell. It will also provide a solution to both these problems (Global warming and energy crises, simultaneously).

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