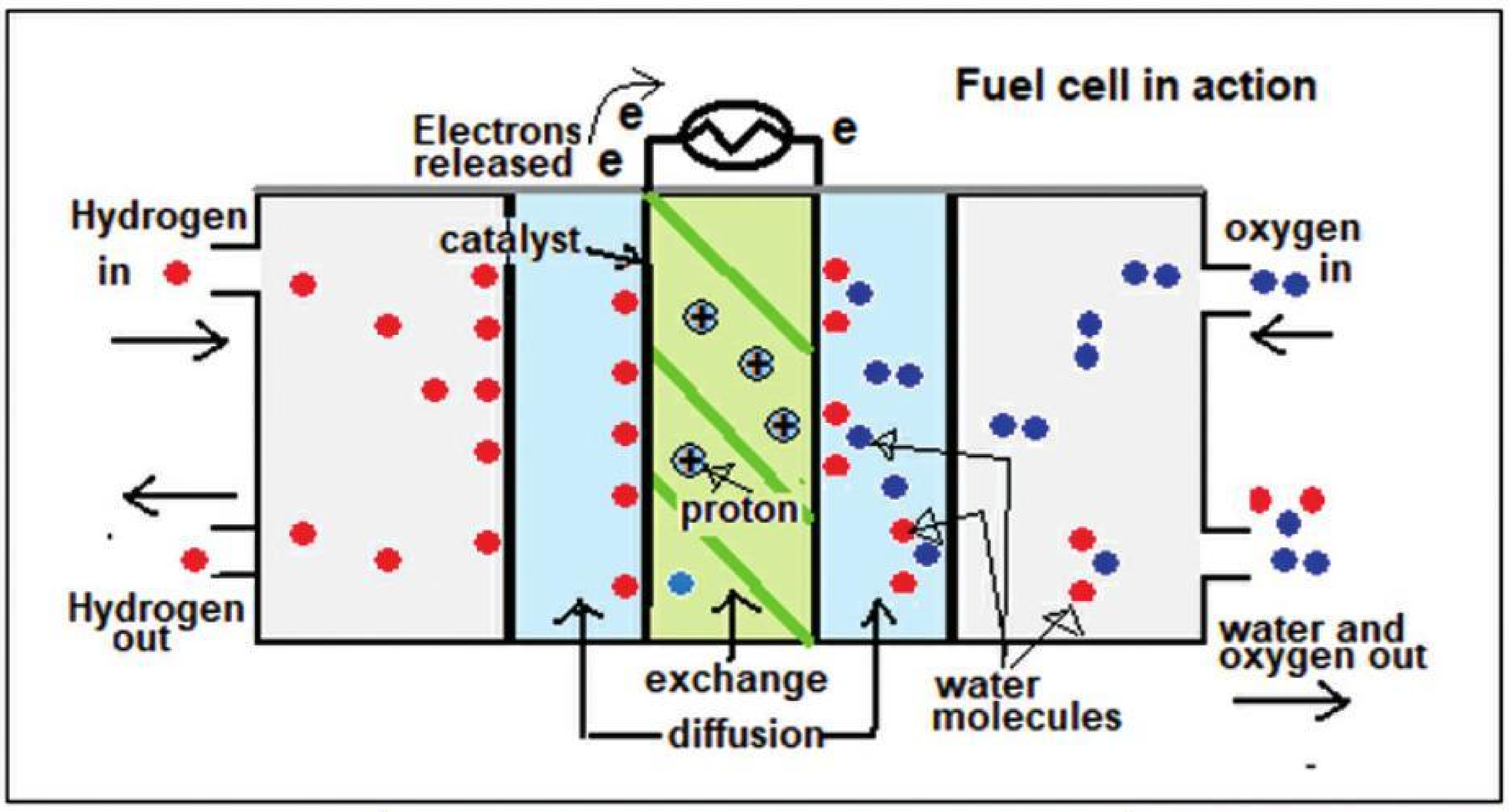
Greening our future

Hydrogen energy is clean but how about production?



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While the world hesitates to buckle down and use less energy, the quest is on to find the energy we need without the carbon that has always gone with it.

While coal and petroleum are still the main sources, and many questions remain about nuclear power, wind and solar have become important alternatives. Those, however, being intermittent, could do with technology to store power till it is needed. While electricity, where it is produced with low carbon, has become the green propellant in many areas, the storage battery brings in a dark, brown streak. In this context, hydrogen gas is emerging as an acceptable, low pollution intermediary in the transfer of energy.

The hydrogen-based fuel cell, which generates electricity, is being fast adapted for practical uses, and hydrogen has come forward as a lightweight container of energy. While there is a group that has devised a low-cost use of hydrogen to turn carbon dioxide into aviation fuel, there is worldwide interest in hydrogen use, and ways to generate hydrogen with the lightest carbon footprint.

The world's stock of energy is essentially chemical energy, in the form of coal or hydrocarbons, which have accumulated solar energy, captured by photosynthesis, over millennia. We then extract the energy by burning the fuel, to drive the steam engine, petrol engine or by using those engines, the electric generator. There is hence conversion of chemical energy to mechanical energy, and then to electricity. Electricity is then transmitted, to be available where required, usually to be converted to mechanical energy. Needless to say, the carbon dioxide goes back into the atmosphere.

The fuel cell reduces a step in this sequence, by converting chemical energy directly into electricity. While this would eliminate the wastage that arises because each conversion has limited efficiency, the use of hydrogen in the cell also eliminates the emission of carbon dioxide at the stage of the cell.

The principle of electrical cells is that energy is released when chemicals change from one form to another. While this energy could show as "heat released by the conversion", it can also be tapped and used to drive an electric current. In the hydrogen fuel cell, the energy used is what comes off when hydrogen combines with oxygen, to form water. Normally, this could be explosive, or it could be controlled, as in a flame. What happens in the fuel cell, however, is that the hydrogen fuel is stripped of electrons, with the help of a catalyst, and the electrons travel by a separate path, to re-join the hydrogen and oxygen where they get together, as water.

The fuel cell can thus generate electricity as long as the hydrogen and oxygen, or other fuel substances, are there. The first fuel cell was invented in 1838, and was resurrected, in the hydrogen-oxygen form, in 1932. The hydrogen-oxygen fuel cell now has many applications, a notable one being aboard satellites and space capsules. And even on the ground, the fuel cell electric car runs the same 300 kms on a tank of hydrogen, like a conventional car, but twice as efficiently.

To be considered as a replacement for conventional motive power, to drive vehicles or machinery, however, we need to ask the question: how much carbon dioxide is emitted when we produce the hydrogen? We know that the energy the fuel cell creates is the energy when H and O combine to form water. The energy to have the H, in the first place, is the energy it takes to separate the H and O, from water. As it is evident that the energy economics can never be in favour of the hydrogen fuel cell, the advantage must lie in using new sources of energy or energy that we would otherwise lose.

The cleanest known way to produce hydrogen is by electrolysis, or by splitting the water molecule using electricity. This could make sense if we created hydrogen at a place where we have electricity and carry hydrogen to a place where there is no other way. Yes, it could make sense, but if we consider that the bulk of electricity comes from coal-fired generation, using hydrogen to create electricity is finally a source of carbon dioxide in the atmosphere.

An alternative would be to use electricity from solar plants. Indeed, this is available, but not in quantity, and if we used it to generate hydrogen, it is at the cost of another application, which must now use coal-based electricity. Another green source could be from bioenergy, or burning agri-waste, which qualifies because the carbon dioxide it gives off is what it captured when it grew.

To generate hydrogen in quantity, however, we would need to use methods like cracking methane in natural gas or from coal, by splitting water, in the method to create coal gas. These are established and safe methods, already in use in many parts of the world. But these methods emit carbon dioxide, and traditionally, this was released into the atmosphere. Now, to create green hydrogen, the carbon dioxide would need to be captured and sequestered. If carbon capture is used with bio-energy, it would be doubly effective, with net reduction of atmospheric carbon dioxide. Brown power, based on fossil fuels, would clearly dominate for decades, but hydrogen, and the hydrogen fuel cell, would enable optimising the mix of methods to keep the atmospheric carbon dioxide down.

While finding means of generating green hydrogen is the key, the use of hydrogen as a means of heating, fuel for transport and for generating electricity has garnered great interest, worldwide. In the field of electrically powered transport, the fuel cell could replace the storage battery, an expensive component with its own carbon footprint. In India, heavy duty road transport is set to treble by 2040. The technology to power trucks by hydrogen fuel cells is now available. The rise in transport needs is a challenge, but also an opportunity, says a note from the Tata Energy Research Institute.

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Aviation fuel from hydrogen

Commercial aircraft may not be able to use hydrogen gas or electrical energy as the means of propulsion. With conventional fuel, however, aviation represents a major source of atmospheric carbon dioxide.

A group writing in the journal, *Nature Communications* announces that a simple, iron-based catalyst has been found effective in using hydrogen and carbon dioxide to synthesise aviation fuel. Existing methods of synthesising hydrocarbons do not include a method to convert carbon dioxide into the jet fuel range, the paper says. Work with an iron-manganese-potassium catalyst, however, has resulted in acceptable output of aviation fuel, along with other industrially useful compounds.

With a sustainable source of hydrogen, this process would represent mopping up the carbon dioxide emission of aviation in the process of generating aviation fuel.

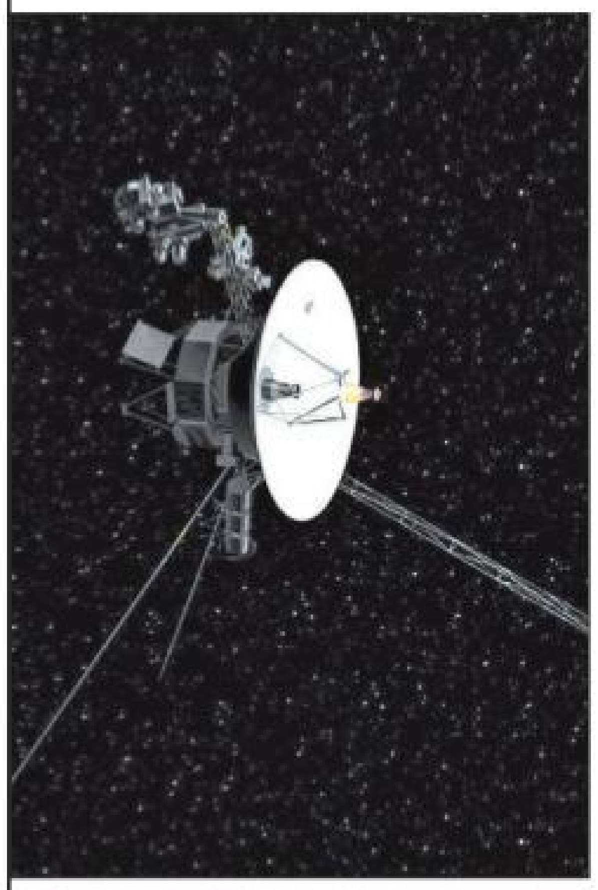
Artificial photosynthesis

The energy store on Earth arises from solar energy converted and stored by plants and as carbohydrates. The process, of photosynthesis, uses solar energy to separate the hydrogen from water and combine with carbon dioxide in the air, to form carbohydrates, and release oxygen. It is the mechanism that filled the atmosphere with oxygen and led to oxygen-based life, as we know it.

Our current methods to tap solar energy depend on silicon-based solar cells, or indirectly, by harnessing the wind. A group working in the Lawrence Berkeley National Laboratory and the University of California at Berkeley had reported in the journal, *Nano Letters*, their arrangement of nanowires made of silicon and titanium dioxide, to capture photons, and the bacterium, *Sporomusa ovata,* to use the energy to reduce carbon dioxide to useful organic chemicals. The method could, conceivably, be adapted to break water into hydrogen and oxygen, as a truly green source of hydrogen for fuel cells.

PLUS POINTS

Promise of alien life?



Scientists are investigating whether Uranus' moons could have oceans hidden beneath their surfaces, in their quest to find habitable worlds that could have hosted alien life.

Researchers believe that Miranda, Ariel, Umbriel, Titania, and Oberon, the five largest moons of Uranus would be prime candidates for investigation due to their similarities to Europa and Enceladus, the moons of Jupiter and Saturn. Europa has long been seen as a possible candidate to have extra-terrestrial life in our own solar system, but getting through the thick crust of ice on its surface presents a challenge to scientists hoping to reach the ocean and better study it.

These moons show evidence of cryovolcanism, which is when liquid and vapour material that might be trapped under the surface escapes and becomes frozen by hitting the low temperatures of space. Studying images sent from the Voyager 2 spacecraft in 1986, the moons show fresh uncratered material, ridges, valleys, and folds -- all of which could originate from subsurface oceans.

"The big question here is: Where are habitable environments in the solar system?" Benjamin Weiss, a planetary scientist at the Massachusetts Institute of Technology, said. Europa and Enceladus "make a lot of us wonder whether there are many moons out there that, although they're small, may still be warm."

The scientists calculated the strength of Uranus' magnetic field, and how that would impact any oceans underneath its moons' surfaces -- the same technique that Nasa used to confirm the presence of Europa's ocean and also the one on one of Jupiter's other moons, Callisto. If the moons could detect Uranus' magnetic field, and experience differences in strength and detection due to a moon's movement though said field, it could potentially generate an electrical current.

"If there's liquid water there and it's a little bit salty like ocean water on Earth, then it can be conducting, meaning currents can flow in it," Weiss said. That current then generates its own magnetic field -- known as an induced magnetic field -- and one that would be detectable by spacecraft, distinct from the field of Uranus.

Using models of the moon's fields, researchers suggest that Miranda's moon had the strongest magnetic presence (300 nanoteslas) while Oberon is likely to have the weakest, with a predicted three nanoteslas. As such, scientists predict that subsurface oceans on Miranda, Ariel, Umbriel, and Titania could all be measured, although Oberon's is probably too weak to be noticeable, being on the edge of what's currently detectable.

"The key is that Uranus' field is non-spin symmetric, unlike Saturn's, and it rotates. We know these things, so (the technique) should work," said David Stevenson, a planetary scientist at the California Institute of Technology, "The caveat is magnetospheric effects (of Uranus), which are not yet well characterised but are unlikely to kill the idea."

However, Stevenson notes, the oceans on Uranus' moons are likely to be found deeper than those on Jupiter's moons, as the icy shell is thicker, but such a factor might make them easier to detect. "Getting close enough to one or more of the satellites to see this -- you have to get close, meaning within a satellite radius, roughly -- is unlikely to be a feature of an early... mission to Uranus," which likely wouldn't arrive before 2042, Stevenson also said.

Weiss presented the research on 15 December at the American Geophysical Union's Fall Meeting 2020.

The independent

Covid-19 2.0

Here's why it matters that the coronavirus is changing -- and what this means for vaccine effectiveness

DAVID KENNEDY

A new variant of Sars-CoV-2 is spreading rapidly in a few countries. Sars-CoV-2, the virus that causes Covid-19, generally accumulates mutations slowly over time, but this new variant has accumulated many mutations quickly.

If this new version of the virus is here to stay, as it appears to be, what does that mean? Will this new version of the virus replace the old one? Will it be easier to catch? And, most importantly, will the current vaccines still be effective?

This interests me because I am an evolutionary microbiologist who studies the link between the transmission and evolution of infectious diseases. In particular, I spend a lot of time considering the effects of vaccines on pathogen evolution and the effects of pathogen evolution on the impact of vaccines.

What is the new Sars-CoV-2 mutant that has emerged?

The new version of Sars-CoV-2 -- named the B.1.1.7 lineage -- is spreading in the UK and beyond. The differences between the old and new virus include 23 mutations in the virus's genetic code that have altered four viral proteins.

Eight of these 23 mutations affect the spike protein. It matters because the spike protein enables the virus to enter human cells, and it is a key target of our immune response, both in fighting off the virus during infection and in protecting us from disease following vaccination with the Pfizer and Moderna vaccines.

If the changes to the spike protein help the virus enter human cells more easily, then the virus could be transmitted from person to person more readily.

These mutations may also alter how well the host's immune system combats the virus, potentially reducing the efficacy of the current vaccines.

What is different about this new version of Sars-CoV-2?

Samples of the new virus isolated from patients suggest that this variant has been increasing in relative frequency over the last three months.

The increase in frequency is concerning, as it suggests -- but does not prove -- that the B.1.1.7 isolates of Sars-CoV-2 are more transmissible than the original virus. Some have estimated that the new virus may be up to 70 per cent more transmissible than the old virus. While these estimates are consistent with the data, it is entirely too early to make a definitive conclusion.

If this increase in transmissibility is confirmed, it might be due to the mutations in the spike protein allowing it to bind more tightly to the ACE2 receptor, which provides a gateway for the virus to enter human cells.

But it might also be due to any of the other changes to the virus.

Is it more dangerous? If so, why?

If the new version, B.1.1.7, is indeed more transmissible than the old virus, it will be more dangerous in the sense that it will make more people sick.

However, I am not aware of good evidence that there is any difference in severity of disease caused by the new version of this virus compared with the older one. That said, with so few known cases, it may still be too early to say.

Will the Pfizer and Moderna vaccines still be effective against this new strain?

Both the Pfizer and Moderna vaccines work by training our immune systems to recognise a specific version of the viral spike protein. The version of the spike protein used by the vaccines was designed to match that of the old virus, not that of the B.1.1.7 virus. This means that the vaccines might become less effective than expected should this new virus spread widely.

Vaccine-virus mismatch is an ongoing challenge for scientists charged with developing the seasonal flu vaccine. But even with a virus-vaccine mismatch, the flu vaccine reduces the likelihood, and the severity, of disease.

The question is therefore not whether the vaccines will be effective, but rather how effective they will be. The severity of the mismatch matters, but the only way to determine its impact in this case is through scientific study, and to my knowledge, no data on that has yet been collected. In other words, it's too early to say whether and how this new variant will influence the overall effectiveness of the Pfizer and Moderna vaccines.

Should people still get the new mRNA vaccine?

The appearance of this new B.1.1.7 makes it even more important that people get vaccinated as soon as possible.

If this new version is more transmissible, or if the vaccine is less effective because of a virus-vaccine mismatch, more people will need to be vaccinated to achieve herd immunity and get this disease under control.

Moreover, we now have proof that the spike protein of Sars-CoV-2 can change drastically in a short time, and so it is critical that we get the virus under control to prevent it from evolving further and completely undermining vaccination efforts.

The writer is assistant professor of biology, Penn State University, US. This article first appeared on www.theconversation.com