Gravity helps freshen air

The electrolysis of water is slowed down by weightlessness

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Creating oxygen by passing electricity is an expensive source, but when in outer space, it could be a good way to help astronauts breathe, as well as burn fuel. And it would be the only method to support an outpost located on the Moon or on Mars.

How fast oxygen gets generated, however, is found to depend on the force of gravity. As the gravity on the Moon or on Mars is much less than it is on Earth, it could be a problem to sustain an establishment there. Bethany A Lomax, Gunter H Just, Patrick J McHugh, Paul K Broadley, Gregory C Hutchings, Paul A Burke, Matthew J Roy, Katharine L Smith and Mark D Symes, from the University of Glasgow, European Space Research Centre, Noordwijk, Netherlands, University of Manchester and John Hopkins University in Maryland, United States, describe in the journal, *Nature Communications*, the nature of this problem and how it is being studied. The subject has become important, the paper says, in light of increasing interest in creating a presence on the Moon, and evidence that water may be a local resource.

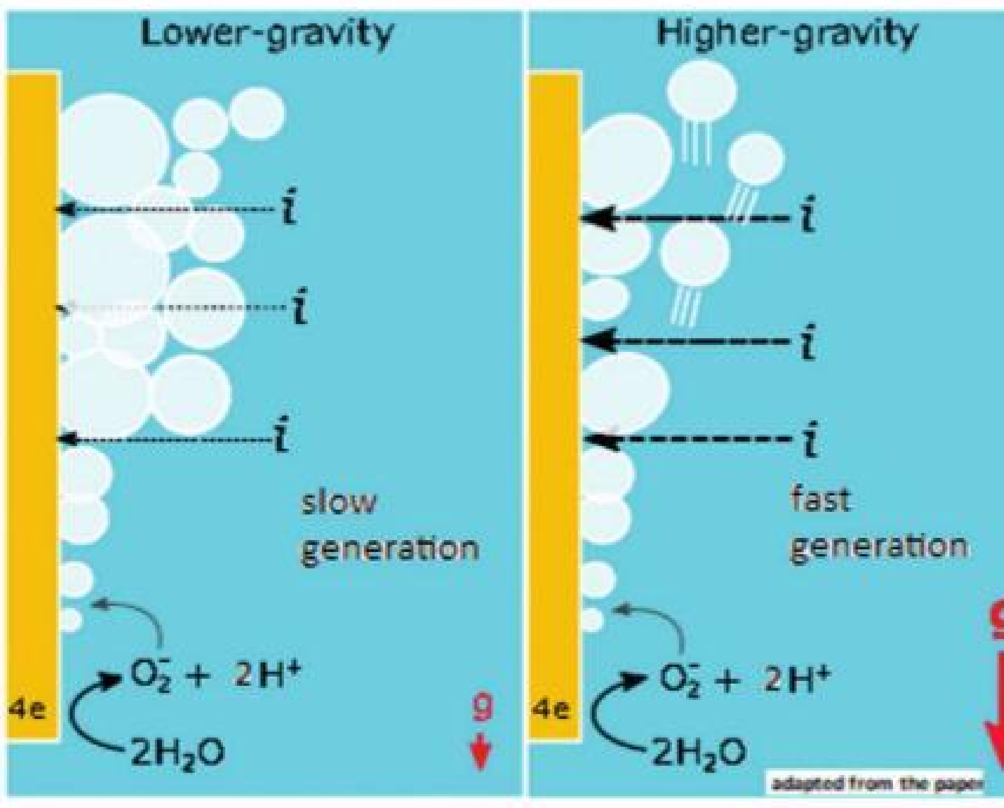
The oxygen atom, when by itself, has a tendency to "become whole", either pairing with another oxygen atom, to form O_2, or by combining with a complementary atom like hydrogen, carbon or iron, to form oxides, like water, carbon dioxide, or the oxide of iron, which is rust. And the oxide form is the low energy, stable form. Hence, it takes energy to prise the oxygen atom out of the oxide.

A well-known instance, where oxygen separates from carbon dioxide is photosynthesis, where green plants pull the oxygen out of the carbon dioxide molecule with the help of energy supplied by sunlight. And another method is electrolysis, where oxygen is separated from water with the energy supplied by passing an electric current.

The nature of the water molecule, which is like other oxides, is that the atom of hydrogen has given up an electron, which has a negative charge, and the oxygen atom has gained this electron. The atom of hydrogen is hence left positively charged, while the oxygen atom has a negative charge. And some of the molecules split, with the positively charged hydrogen atoms and the negatively charged oxygen atoms floating free. Now, if there are two plates in the water, with a difference of voltage, the charged atoms are drawn to the positive and negative ends, where the charges are neutralised, and the gases are set free.

So, where does gravity enter the picture? Well, when the oxygen atoms reach the positive end, they give up the negative charge they are carrying and then pair up, as oxygen gas. But, as oxygen gas, they are not attracted to one side or the other, and they would "stay put", with molecules of oxygen collecting as bubbles of gas. The effect of a layer of gas around the plate with the positive voltage would then be to prevent more negatively charged oxygen atoms from reaching the plate and formation of the gas would stop.

Fortunately, even if electrical forces do not move the oxygen gas away, the pressure of the water does push the gas bubble upwards, in the same way as the "up thrust" on any object that is immersed in a liquid. And the reason for this pressure, of the liquid, is nothing but gravity, which is pulling the liquid down, to fill the space occupied by the bubble.



The bubbles of oxygen then stream upwards, where they can be captured and bottled. And the bubble moving away clears the positive plate, which can go on with the good work of taking up the negative charge from oxygen atoms of water molecules, and setting them free, as gas. We can imagine that the stronger the force of gravity pressing down on the water, the faster the production of oxygen gas.

But in outer space, far from massive objects like Earth, gravity is feeble, and electrolysis would stop as soon as it starts. On the Moon, or on Mars, where the gravity is just one-sixth and one-third of that on Earth, respectively, electrolysis would be slow. And given this fact, scientists who design the facilities at these outposts would need to know how much electrolysis gets retarded when gravity drops, to half, or a tenth, or, specifically, to one-third or one-sixth of the gravity on Earth.

Now, how can experiments be carried out to test electrolysis under reduced gravity? One way to conduct the experiment is in a lab that is in "free fall". Inside such a chamber, the so-called "drop tower", there is no gravity, or very low gravity. But the free fall down a tower that is, say 100 metres high, would last just 2.5 seconds.

The paper speaks of the more common method of creating weightlessness in an aircraft in a "parabolic flight", where the aircraft moves forward, but is in free fall. In this method, the drops can be considerably more than 100 m, and last up to 22 seconds. And experiments have been conducted on electrolysis under very low gravity. The trouble, the paper says, is that it is not clear that these very low gravity results can be extended to work out what it would be like in the gravity on the Moon or on Mars. And while better data is possible in parabolic flights, the experiments are expensive, cumbersome and short-lived.

Trials involving higher gravity, however, are easier to organise -- using a centrifuge, or a rapidly rotating container. The centrifugal force experienced amounts to increased gravity, pointing away from the centre of rotation, and this can be maintained for prolonged periods. High gravity, or hyper gravity, experiments were hence conducted to see how electrolysis behaved between low gravity levels and gravity eight times as strong as on Earth. And the findings at different levels of gravity were compared.

The results, the paper says, show that there is a uniform trend of the efficiency of oxygen generation rising as the level of gravity increases. Although this can be expected, it is not evident without being verified, the paper says. Based on the experiments, however, it was found that it is true and the more reliable data from ground-based centrifuges can be used to work out what it would be like at the gravity found on the Moon, the paper says.

And it is found that an electrolytic cell working on the Moon would generate 11 per cent less oxygen. This is a modest reduction and it shows that the additional power that the cell would consume on the Moon is not substantial.

It looks like "appropriately designed ground-based hypergravity systems can be used to determine the ideal operating conditions for a given system in low gravity, potentially negating the need for costly and complex parabolic flight experiments," the paper says.

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Looks similar, feels different

Olympic skiers and snowboarders are competing on 100 per cent fake snow -- here's the science of how it's made and how it affects performance

The Winter Olympics conjure up images of snowy mountain ranges, frozen ice rinks and athletes in cold-weather gear. And for good reason. Winter Olympic venues have often been in places that receive an average snowfall of 300 inches every year or more.

Barring some extremely anomalous weather patterns, however, the mountains surrounding the snow events for the Beijing Winter Olympics will be tones of brown and green and nearly devoid of snow. The region typically receives only a few inches of snowfall in each winter month. This means that basically all of the snow the athletes will be competing on will be human made.

I am an atmospheric scientist who specialises in mountain weather and snow. I am also the founder of a snowmaking start-up and an avid skier.

There are distinct differences between natural and artificial snow, and it will be interesting to see if these differences have any effect on competition.

How to make fake snow

Though artificial snow and natural snow are both frozen water, most skiers and snowboarders are able to immediately recognise that the two are very different.

Traditional snowmaking uses high pressure water, compressed air and specialised nozzles to blow tiny liquid droplets into the air that then freeze as they fall to the ground. But snowmaking is not as simple as just making sure the air is sufficiently cold.

Pure water does not freeze until it is cooled to nearly -40° C. It is only the presence of microscopic suspended particles in water that allow it to freeze at the familiar 0° C. These particles, known as ice nuclei, act as a sort of scaffolding to help ice crystals form. Without these particles, water struggles to turn into ice. Different particles can raise or lower freezing temperatures depending on their specific molecular configuration.

Two of the best ice nuclei are silver iodide and a protein produced by the bacteria *Pseudomonas syringae*. Most snowmaking systems add a commercial form of the bacterial protein to water to ensure most of the tiny droplets freeze before they hit the ground.

Sliding on human-made snow

Natural snow starts as a tiny ice crystal on an ice nucleus in a cloud. As the crystal falls through the air, it slowly grows into the classic six-sided snowflake.

By comparison, human-made snow freezes quickly from a single droplet of water. The resulting snow consists of billions of tiny spherical balls of ice. It may resemble natural snow to the naked eye on a ski run, but the natural and artificial snow "feel" very different.

Due to the fact that the tiny ice balls pack together quite densely -- and that some of them may have not frozen until they touched the ground -- artificial snow often feels hard and icy. Fresh natural "powder" snow, on the other hand, provides skiers and snowboarders an almost weightless feeling as they soar down the mountainside. This is largely because the natural snow crystals stack very loosely -- a fresh layer of powder is as much as 95 per cent or more air.

While fresh powder is what most recreational skiers dream of, Olympic skiers have different tastes. Racers want to be able to glide as fast as possible and use their sharp edges to make powerful, tight turns. The dense, icy conditions of artificial snow are actually better in these regards. In fact, race organisers often add liquid water to racecourses of natural snow which will freeze and ensure a durable, consistent surface for racers.

Another consideration is the fact that natural snowstorms produce dull, flat lighting and low visibility -- hard conditions to race or jump in. Heavy natural snowfall will often cancel ski races, as happened during the snowy 1998 Nagano Games. For racers, clear skies and artificial snow provide the advantage there, too.

But hard human-made snow does have its downsides. Freestyle skiers and snowboarders who are flying off jumps or sliding on rails high above the ground seem to prefer the softer surface of natural snow for safety reasons. This is also true of Nordic skiers, who recently flagged the dangers of artificial snow in the event of crashes as icy, hard surfaces can lead to more injuries.

Mimicking nature

While Olympic athletes have mixed needs for their snow, for the vast majority of recreational skiers, natural snow is far better. Due to the air-filled crystals, it is much softer and more enjoyable to ski or snowboard on.

Scientists have been trying for decades to create more natural snow on demand. The first way that people tried to make "real" snow was by seeding natural clouds with silver iodide. The goal was to facilitate moisture in clouds turning into falling snow crystals. If you could make this process -- called the Wegener-Bergeron-Findeisen process -- occur more easily, it would theoretically increase the snowfall rate.

In practice, it has historically been difficult to prove the efficacy of seeding. Recent work, however, using large, meticulously deployed sets of atmospheric instruments has shown that -- for a fraction of storms with the proper conditions -- seeding clouds with silver iodide does indeed yield modest increases in the total amount of snowfall.

Another option -- which doesn't require storm clouds to seed in the first place -- is to create snowmaking machines that can grow fluffy natural snow crystals. Scientists have been growing snowflakes in laboratories for many decades, but the process is delicate, and typically researchers only produce a few flakes at a time.

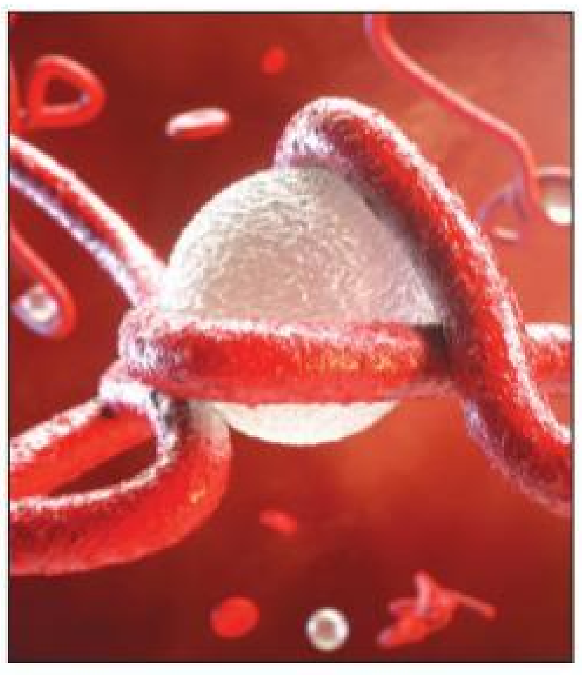
Because ice crystals typically grow slowly, it has been tricky for researchers to scale the process up by the many orders of magnitude needed to grow enough snow for skiing. But in a quest to produce fluffy powder for skiers and snowboarders, my colleague Trey Alvey and I developed a process that can produce snowflakes in larger quantities using a technique that mimics the natural crystal formation process. We're commercialising it through our company called Quantum Snow.

The dry, barren mountains hosting the 2022 Winter Olympic venues are not exactly a skiing destination. But thanks to snowmaking science, the athletes will have reliable, if icy, runs to compete on. And sports fans can be thankful for the technology that allows them to enjoy the high-speed spectacle put on by the brave souls who compete in the skiing and snowboarding events.

The writer is professor of atmospheric science, University of Utah, United States. This article first appeared on *www.theconversation.com*

PLUS POINTS

Brain-lurker



The Ebola virus can persist in some parts of the body, including in brain fluid, and re-emerge long after treatment and recovery to cause fatal disease, reveals a new ground-breaking study.

The findings, published last week in the journal *Science Translational Medicine*, have major implications for long-term follow-up efforts to reduce relapse in individuals who recover from the disease as well as to lower the risk of future Ebola virus outbreaks.

While scientists have known that some recent Ebola infection outbreaks in Africa were linked to persistent infection in patients who survived previous outbreaks, the exact "hiding place" of the deadly virus and underlying mechanism by which recurring disease affects survivors remained unknown until now.

Pathology of disease recurrence, especially in those previously treated with therapeutic monoclonal antibodies, was largely unknown, said researchers from the United States Army Medical Research Institute of Infectious Diseases in Maryland. In the new study, scientists used a monkey disease model -- one with very similar Ebola disease manifestation signs as humans -- to shed more light on where the virus tends to hide.

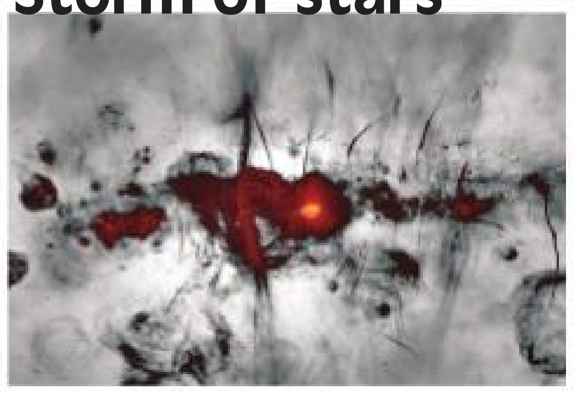
The research found two monkeys, which had initially recovered from Ebola-related disease after treatment with antibody therapeutics, had recurrence of severe infection with the virus and succumbed to the disease. Inflammation and "massive Ebola virus infection" were present in the brain ventricular system with no obvious pathology and no viral infection was found in other organs, scientists said.

"We found that about 20 per cent of monkeys that survived lethal Ebola virus exposure after treatment with monoclonal antibody therapeutics still had persistent Ebola virus infection -- specifically in the brain ventricular system, in which cerebrospinal fluid is produced, circulated, and contained -- even when Ebola virus was cleared from all other organs," Xiankun (Kevin) Zeng, study senior author, said in a statement, "Ours is the first study to reveal the hiding place of brain Ebola virus persistence and the pathology causing subsequent fatal recrudescent Ebola virus-related disease in the non-human primate model."

Ebola viral disease is one of the deadliest infectious diseases known to humans with a case fatality rate ranging from 25 to 90 per cent in past outbreaks, and 50 per cent on average. The virus -- still a major threat in Africa with three outbreaks occurring in 2021 alone -- is transmitted to people from wild animals and spreads among humans via contact with blood, secretion organs or other bodily fluids of an infected individual.

The independent

Storm of stars



Chaos swirls at the heart of the Milky Way galaxy, as seen in a new radio image (above) of electrical storms captured by South African astronomers, revealing the frenzy that a hundred million or so stars can get up to.

Oxford University researcher Ian Heywood and the South African Radio Astronomy Observatory captured the image using the MeerKAT radio telescope, an array of 64 antennae spread across the desert in northern South Africa, and published their results last week in the *Astrophysical Journal*.

The Milky Way's disc, where most stars and exoplanets reside, appears in the image as a ragged horizontal streak. A blob of energy in the middle marks the spot where a black hole lurks. The surrounding region is filled with glowing filaments -- theorised to be formed by magnetised tubes of gas and high-energy particles -- which are up to 100 light years long.

Emanating above and below the galactic disc are a matched pair of radio bubbles, possibly the remains of supernova explosions several million years ago. In the background, the radio image is speckled with the dots of supermassive black holes in faraway galaxies.

The straits times/ANN