Science

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Looking beyond silicon

Alternatives have been developed to make the solar cell environment friendly

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Renewable energy is the only visible solution to the crisis that the world finds itself in. While wind and hydroelectric energy can be used where we have the right coastlines or river valleys, solar panels have greater scope as they can be widely deployed.

The trouble is that solar panels use pure silicon, and mining and purifying silicon has a large carbon footprint, apart from social and other environmental costs. Although they provide electricity with no emissions, solar cells take over 15 years to work off the emissions produced during their manufacture. Solar panels now provide some three per cent of the world's energy. Raising it to a level that materially helps reduce emissions would call for massive silicon extraction.

The most efficient use of solar energy, of course, is in green vegetation, where chlorophyll helps sunlight break down carbon dioxide and produce hydrocarbons. Ways to use synthetics to mimic the process, using bacteria, are being developed and could lead to some cleaning of the environment. To turn this technology to generate electricity, however, would be a game changer.

That organic dyes can generate electricity when light shines on them was discovered in the late 1960s and the first dye-sensitised solar cell, or the DSSC, was developed by Brian O'Reagan and Michael Grätzel at University of California at Berkeley in 1988, and published from École Polytechnique Fédérale at Lausanne, in 1991. In the DSSC, a molecular dye absorbs sunlight, like the chlorophyll in green leaves, leading to collection of electric charge, rather than promoting a chemical reaction. The charge then drives an electric current, on the way back to the dye, where it gets the dye ready to absorb more sunlight.

The current issue of the journal, *Nature Communications*, contains a paper by Michael Grätzel, Dan Zhang, Marko Stojanovic, Yameng Ren, Yiming Cao, Felix T Eickemeyer, Etienne Socie, Nick Vlachopoulos, Jacques-E Moser, Shaik M Zakeeruddin and Anders Hagfeldt, from the institute in Lausanne, that reports advances that improve the performance of the DSSC, for greater relevance as a source of green energy.

The functioning of the conventional solar cell is thanks to the nature of the silicon atom. The atom of silicon has four electrons in its outermost shell, which is halfway between metals (that are good conductors) and nonmetals. It enables a uniform, "hand-holding" structure of the silicon crystal. If there is a trace impurity with one more outer shell electron than silicon, however, it can result in the extra electron being unpaired and "free". If the trace impurity is of atoms with one less outer shell electron than silicon, it creates a "shortage of an electron" or a "hole", which can also move over the crystal lattice.

In a junction of silicon with the two kinds of impurity, some of the "free" electrons would cross over to the other side, where there are "holes". It would create electrical tension. Now, if light falls on the "holes" side of the junction, an electron gets "freed", and the electrical tension drives it to the other side through a wire that connects to the two sides of the junction.

In the DSSC, in place of silicon, the source of electrons is an organic dye, which behaves like chlorophyll, releasing an electron when excited by light. While the principle had been discovered in the 1960s, O'Reagan and Grätzel worked out the arrangement where the electron is snared and sent out as an electrical current, with a method of sending it back to the organic molecule.

The principle is illustrated in the picture. Photons, or particles of light, pass through the transparent conductor on the left and strike titanium oxide nanoparticles, which carry molecules of the organic dye. The nanoparticles are for assuring a large surface area for dye molecules. Photons knock electrons out of the dye molecules, and the electrons are collected by the conducting electrode. The electrons form a current, to do work and reach the opposite electrode, which is of inert platinum. The medium between the two electrodes contains iodine, which can change form, to pick up electrons from the platinum electrode and carry them to the titanium oxide particles, which are left with a positive charge when they lost electrons. When the electrons reach the particles, they get back into the dye, and the dye molecules are ready for use again.

In practice, a glass sheet is coated with a thin layer of tin dioxide and then a layer of titanium dioxide, as a porous structure, with a large surface area. This layer is then coated with the photosensitizer dye. The second plate is a sheet of platinum, coated with a thin layer of the iodide electrolyte. And the two plates are joined and sealed.

The conventional solar cell, apart from being based on silicon, needs a thick layer of silicon, to be reasonably effective. Although "thin film" solar cells have been developed, the DSSC films can be far thinner and are substantially cheaper. That is despite the use of titanium and platinum, for which, again, replacements are rapidly becoming available.

The negative, however, has been that DSSCs are less efficient in converting light into electricity and that organic dyes degrade. What the Lausanne group has done is to use molecular engineering and develop a dye for use in conjunction with the current one, to enable the device to react to more parts of the spectrum of the incident light. The additive also prevents electrons that are emitted from being captured by neighbouring dye molecules before they move through the circuit. The result is greater production of electrons, a voltage of 1.24V or power conversion efficiency of 13.5 per cent. The DSSC is hence suitable for use in cloudy conditions or to power indoor devices, a press release says.

Existing photovoltaic devices convert only part, the lower frequency part of sunlight, into electricity. As the higher frequency range, even the ultraviolet, contains much of the energy in sunlight, not using this part of the spectrum amounts to wasted energy. What is more, this energy heats the PV device, which reduces its efficiency. Sheathing, with organic materials, has been developed, for use with conventional PV devices, to absorb blue and UV light and "step it down" to a frequency that the device can use. Another initiative has been to absorb lower frequency energy, in the infrared, and "step it up" to be useful for the PV cell.

On date, the conventional solar cell dominates in the market and it is viewed as a possible solution to the danger of pollution by fossil fuels,. However, the cost of silicon-based solar cells makes this unlikely. Alternatives to silicon, like cadmium telluride, have been developed, but there are limitations in use because of pollution concerns or performance. In this context, the rise of the organic, high performance and easily assembled DSSC holds out another branch of hope to achieving power generation without environmental damage.

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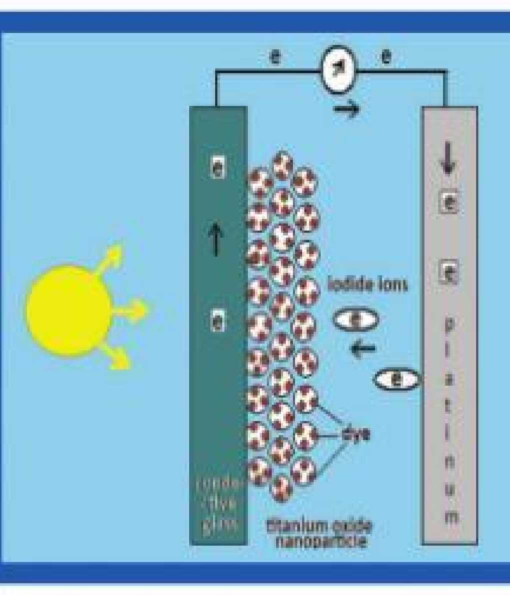
The Lausanne technique is used in the Swiss Tech Convention Centre to generate electricity



LEARNING FROM THE PAST

People gave up on flu pandemic measures a century ago when they tired of them – and paid a price

J ALEXANDER NAVARRO

Picture the United States struggling to deal with a deadly pandemic.

State and local officials enact a slate of social distancing measures, gathering bans, closure orders and mask mandates in an effort to stem the tide of cases and deaths.

The public responds with widespread compliance mixed with more than a hint of grumbling, pushback and even outright defiance. As the days turn into weeks turn into months, the strictures become harder to tolerate.

Theatre and dance hall owners complain about their financial losses. Clergy bemoan church closures while offices, factories and in some cases even saloons are allowed to remain open. Officials argue whether children are safer in classrooms or at home.

Many citizens refuse to don face masks while in public, some complaining that they're uncomfortable and others arguing that the government has no right to infringe on their civil liberties.

As familiar as it all may sound in 2021, these are real descriptions of the US during the deadly 1918 influenza pandemic. In my research as a historian of medicine, I've seen again and again the many ways our current pandemic has mirrored the one experienced by our forebears a century ago.

As the Covid-19 pandemic enters its second year, many people want to know when life will go back to how it was before the coronavirus. History, of course, isn't an exact template for what the future holds. But the way Americans emerged from the earlier pandemic could suggest what post-pandemic life will be like this time around.

Sick and tired, ready for pandemic's end

Like Covid-19, the 1918 influenza pandemic hit hard and fast, going from a handful of reported cases in a few cities to a nationwide outbreak within a few weeks. Many communities issued several rounds of various closure orders – corresponding to the ebbs and flows of their epidemics – in an attempt to keep the disease in check.

Those social distancing orders worked to reduce cases and deaths. Just as today, however, they often proved difficult to maintain. By the late autumn, just weeks after the social distancing orders went into effect, the pandemic seemed to be coming to an end as the number of new infections declined.

People clamoured to return to their normal lives. Businesses pressed officials to be allowed to reopen. Believing the pandemic was over, state and local authorities began rescinding public health edicts. The nation turned its efforts to addressing the devastation influenza had wrought.

For the friends, families and co-workers of the hundreds of thousands of Americans who had died, post-pandemic life was filled with sadness and grief. Many of those still recovering from their bouts with the malady required support and care as they recuperated.

At a time when there was no federal or state safety net, charitable organisations sprang into action to provide resources for families who had lost their breadwinners, or to take in the countless children left orphaned by the disease.

For the vast majority of Americans, though, life after the pandemic seemed to be a headlong rush to normalcy. Starved for weeks of their nights on the town, sporting events, religious services, classroom interactions and family gatherings, many were eager to return to their old lives.

Taking their cues from officials who had – somewhat prematurely – declared an end to the pandemic, Americans overwhelmingly hurried to return to their pre-pandemic routines. They packed into movie theatres and dance halls, crowded in stores and shops, and gathered with friends and family.

Officials had warned the nation that cases and deaths likely would continue for months to come. The burden of public health, however, now rested not on policy but rather on individual responsibility.

Predictably, the pandemic wore on, stretching into a third deadly wave that lasted through the spring of 1919, with a fourth wave hitting in the winter of 1920. Some officials blamed the resurgence on careless Americans. Others downplayed the new cases or turned their attention to more routine public health matters, including other diseases, restaurant inspections and sanitation.

Despite the persistence of the pandemic, influenza quickly became old news. Once a regular feature of front pages, reportage rapidly dwindled to small, sporadic clippings buried in the backs of the nation's newspapers. The nation carried on, inured to the toll the pandemic had taken and the deaths yet to come. People were largely unwilling to return to socially and economically disruptive public health measures.

It's hard to hang in there

Our predecessors might be forgiven for not staying the course longer. First, the nation was eager to celebrate the recent end of World War I, an event that perhaps loomed larger in the lives of Americans than even the pandemic.

Second, death from disease was a much larger part of life in the early 20th century, and scourges such as diphtheria, measles, tuberculosis, typhoid, whooping cough, scarlet fever and pneumonia each routinely killed tens of thousands of Americans every year. Moreover, neither the cause nor the epidemiology of influenza was well understood, and many experts remained unconvinced that social distancing measures had any measurable impact.

Finally, there were no effective flu vaccines to rescue the world from the ravages of the disease. In fact, the influenza virus would not be discovered for another 15 years, and a safe and effective vaccine was not available for the general population until 1945. Given the limited information they had and the tools at their disposal, Americans perhaps endured the public health restrictions for as long as they reasonably could.

A century later, and a year into the Covid-19 pandemic, it is understandable that people now are all too eager to return to their old lives. The end of this pandemic inevitably will come, as it has with every previous one humankind has experienced.

If we have anything to learn from the history of the 1918 influenza pandemic, as well as our experience thus far with Covid-19, however, it is that a premature return to pre-pandemic life risks more cases and more deaths.

And today's Americans have significant advantages over those of a century ago. We have a much better understanding of virology and epidemiology. We know that social distancing and masking work to help save lives. Most critically, we have multiple safe and effective vaccines that are being deployed, with the pace of vaccinations increasingly weekly.

Sticking with all these coronavirus-fighting factors or easing off on them could mean the difference between a new disease surge and a quicker end to the pandemic. Covid-19 is much more transmissible than influenza, and several troubling Sars-CoV-2 variants are already spreading around the globe. The deadly third wave of influenza in 1919 shows what can happen when people prematurely relax their guard.

The writer is assistant director of the Center for the History of Medicine, University of Michigan, US. This article first appeared on www.theconversation.com

PLUS POINTS

Space food

Scientists have identified new bacterial strains that they said could potentially support plant growth in space. The discovery could help astronauts grow their own food in space stations, otherwise known as "space farming", according to the University of Hyderabad.

New bacterial strains were identified from different locations on the International Space Station during flights. Scientists found the presence of genes involved in promoting plant growth in genome analysis of the new strains as part of the research, published in the journal *Frontiers in Microbiology.*

The findings may help in creating "fuel" which could support plants in withstanding stressful environments such as space, according to the University of Hyderabad, whose scientists worked with researchers in the US – including from Nasa's Jet Propulsion Laboratory – for the study.

The study's lead authors said the strains could possess "biotechnologically useful genetic determinants that may help growing plants in extreme places where resources are minimal".

For astronauts on the ISS, cargo ships transport their food to them, unlike the early days of space travel when food took the form of cubes and "semi-liquids stuffed inside tubes", according to Nasa.

In a paper published in *The Journal of Nutrition* last year, Nasa scientists outlined the requirements and challenges of creating a food system that can support missions between low-Earth orbit and Mars – which looked at nutrition, safety and reliability.

"Pre-packaged foods are a great candidate because they are easy to prepare, easy to consume. They already have a safe and long history in spaceflight, but there are some challenges with them – that nutrition and quality degrade over time," Grace Douglas, a Nasa scientist, said, "So, on longer missions, it would be nice to get a fresh component."

There may be issues over the reliability of growing food on space missions, she added. "One of the big concerns with growing food is that if it doesn't grow and you were depending on it, now you have insufficient food, which can be a very, very big concern when you're going on these missions," Douglas said.

Nasa astronauts said last year that the first ever space-grown lettuce was as safe to eat as one grown on Earth. The year before, China successfully germinated a seed taken to the Moon, making it the first time any biological matter had grown in space.

Further research is underway to determine what the discovery of the new bacterial strains found on the ISS could mean for space farming, according to the University of Hyderabad.

–THE INDEPENDENT

Science equality

Women still face a massive gender bias in science careers worldwide, the United Nations Educational, Scientific and Cultural Organisation reported recently, with several rich Western nations way behind poorer ones in terms of gender equality.

Despite a shortage of skills in most fields of the current technology revolution, women account for only 28 per cent of engineering graduates and 40 per cent of graduates in computer science and informatics, according to advance excerpts from the organisation's Science Report to be fully published in April.

The track record for members of the Organization for Economic Co-operation and Development – which groups mostly rich countries – came in lower than the global average in terms of the share of women among engineering graduates, the report found.

In France it was 26.1 per cent and Australia 23.2 per cent, slipping to 20.4 per cent in the United States, 20.1 per cent in South Korea, 16.1 per cent in Switzerland and 14 per cent in Japan.

Unesco found no distinct regional pattern, but noted that some of the highest proportions of female engineering graduates were found in Arab states, with Algeria at 48.5 per cent, Morocco at 42.2, Oman at 43.2, Syria at 43.9 and Tunisia at 44.2 per cent.

Latin America also did well, with female engineering graduates representing 41.7 per cent in Cuba, 47.5 in Peru and 45.9 in Uruguay.

–THE DAILY STAR/ANN