

Electricity on tap

STORING SOLAR OR WIND POWER FOR USE WHEN NEEDED MAY BECOME PRACTICABLE FOR THE FUTURE WHEN NEEDED, SAYS S ANANTHANARAYAN

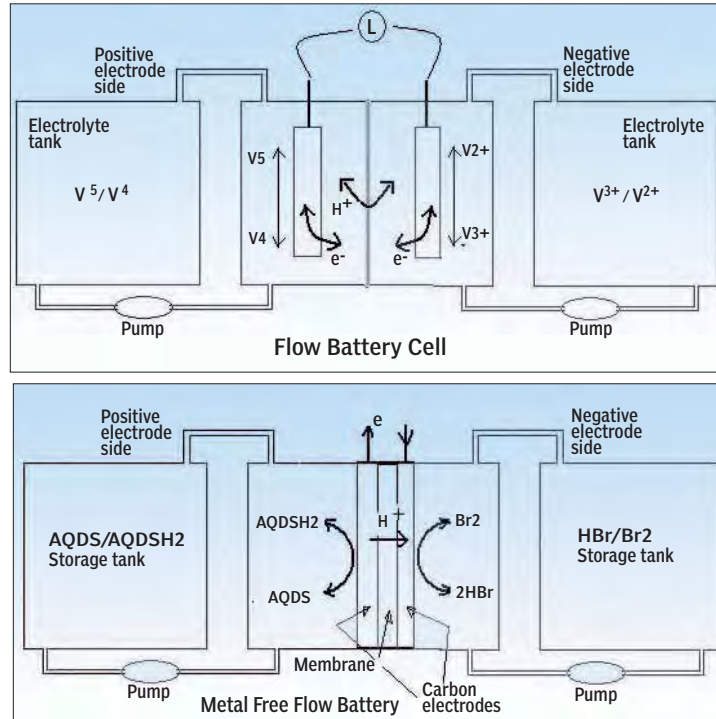
The rechargeable battery has been used mainly to pack electricity to carry along, in the motorcar or the cell phone, for instance, or to a remote place. But another practice is to collect electricity that is generated from sunlight or from the wind for use when it is dark or cloudy or when the air is still. This capacity, at a sufficiently large scale, would help us use the sun and wind as alternatives to the continuous power supply from coal, oil or nuclear power plants.

Conventional chargeable batteries have the limitation of rapidly getting fully charged and also that these work at peak power only for a short while. An alternative has been the *flow battery*, where electricity is stored not as electric tension between components within the battery, as is usual, but through changes in a liquid that flows through the battery and can be separately stored. The battery is then used by letting the charged liquid flow back through the battery to give up energy as a steady electric current. And the amount of power that can be stored depends only on how much liquid can be stored and the battery never gets fully charged.

The problem with flow batteries has been that the materials used for these are scarce and expensive. Brian Huskinson, Michael P Marshak, Changwon Suh, S Ieyman Er, Michael R Gerhardt, Cooper J Galvin, Xudong Chen, Alvin Aspuru-Guzik, Roy G Gordon and Michael J Aziz, at Harvard, USA, and Eindhoven, the Netherlands, report in the journal *Nature* that they have developed an alternative class of materials based on freely accessible organic molecules.

The simple cell, like the dry cell we use in the electric torch, uses the energy stored within chemicals to generate electricity as they change into a less energetic form. The rechargeable cell, like we find in the car battery, creates a chemical change in the acid between the lead plates, when it is charged by passing electricity through the battery cells.

This change leaves the lead plates oppositely charged and connecting the plates with a wire would let electricity flow, at the same



time undoing the chemical change inside the cell. But the voltage to which the cell can be charged and how much energy can be stored depend on the size of the plates and the volume of the cell, and are limited and fixed. Lead acid batteries are, thus, not convenient or economical for storage of the large quantities of electricity needed for homes or industry.

The flow battery overcomes the size limitation of the conventional storage battery. In the normal battery, the liquid separating the electrodes stays within the cell and supports the voltage difference between the plates. But in the flow battery, the energy supplied during charging is taken up by the liquid around electrodes and this liquid is continuously replaced. The liquids that have been raised to different energetic forms can, thus, be stored in large containers and any amount of electricity can be pumped in and stored.

A common and successful form of flow cell uses the *vanadium redox* process, where the property of atoms of the metal, vanadium, to exist in combination with different numbers of oxygen atoms is made use of. The liquid circulated is usually a solution of vanadium pentoxide, V_2O_5 , where two atoms of vanadium combine with five atoms of oxygen, in sulphuric acid. The liquid is passed through two compartments, which contain the two electrodes and which are separated by a membrane. During the charging cycle, the negative half-cell adds electrons to the vanadium ions, while the other half-cell captures electrons. The ions, thus, change form, while positively charged hydrogen ions are exchanged through the membrane, to balance the total charge. During discharge, when the flow is reversed, the liquid in the negative half-cell pushes its extra electron on to the electrode, to flow to the

other electrode as a current. The other electrode, in turn, restores the captured electron to the vanadium ions with the charges balanced by reverse exchange through the membrane.

The battery is, hence, charged by energising the electrodes and drawing away the electrolyte at a controlled rate. Running the electrolyte back through the cell then provides a typical 1.41 volts at 25°C. The working of this kind of cell needs this metal-like property of being able to readily assume and retain energised forms. The vanadium-based cell displays very quick response time and has advantages of very little loss of vanadium, long operation life and large capacity, and is widely used for storage and use of electricity from intermittent sources.

But the great problem with this class of flow batteries is that the metals that are suitable, called electro-active materials, which can form liquid solutions, and also precious metal catalysts that are needed, are scarce and expensive. In fact, it is estimated that all the known vanadium deposits may be able to help create energy sources only for a fraction of our energy needs. It is in this context that the technique now reported, using an organic, and freely available electro-active material, is of great interest.

Metal free flow battery

The work reported uses the chemical properties of a family of molecules called *quinones*. A carbon-based compound called anthraquinone disulphonic acid, or AQDS, a form of quinone that is commonly found in the *rhubarb* plant, carries two units of electrical charge, which is better than usual materials, and is able to rapidly take on and give these charges on carbon electrodes in a sulphuric acid medium. This quinone/hydroquinone change in one half-cell, combined with a bromine/bromide (ie, combined with hydrogen and, hence, charged) cycle in the other half-cell is found to have good power yield and 99 per cent preservation of the reagents in each cycle.

The fact that the quinone compound is an organic molecule also allows synthetic fine-tuning of the electro-active properties, like the working voltage, and also the solubility of the material. And then, as a material consisting of only abundant elements of carbon, sulphur, hydrogen and oxygen, it can be manufactured on a large scale or even sourced through natural processes. As a simple working process on carbon electrodes, there is no need for expensive catalysts. The carbon electrodes also suppress the creation of hydrogen ions and this, with the large size of the quinone molecule, protects against the leakage of charge across the membrane.

Over all, the use of AQDS is found by the authors of the paper to represent a new and promising direction for cost-effective large-scale energy storage.

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PLUS POINTS

Cat s eye view

For pet owners who see themselves as a maternal or paternal figure to their beloved animals, we have some bad news for you. Your cat perceives you as less of a parental figure and much more as a larger, non-hostile fellow cat, according to research by a leading expert in animal behaviour.



This comes despite the constant care cat owners provide for their feline friends, according to biologist Dr John Bradshaw, author of *Cat Sense* (Basic Books).

A specialist in human-animal interactions, he has already penned a book on the relationship between domestic dogs and their owners, entitled *Dog Sense*. In *Cat Sense*, he concludes that cats evolved as solitary hunters and still don't quite get us the way dogs do and perhaps never will. In effect, he says, cats are still fundamentally wild animals despite years of domestication. In the book, he explains the transformation of the cat from resident exterminator to companion cohabiter is both recent and rapid, and especially from the cat s perspective evidently incomplete.

According to Dr Bradshaw, when cats rub up against their owners or invite them to stroke their head, they are in fact treating them as fellow non-hostile cats. An upright tale is a greeting sign between cats, he adds, and is also a way of cats demonstrating their affection for their owners. And when cats bring their prey into their owners houses, it is a side effect of their hunting strategy not because they want to bestow a gift upon the household. Once inside the house, cats remember they prefer tinned food, which is why the dead rodent is then left on the floor.

The book teaches much about the biology of cats that you never suspected, a recent review by *The New York Times* said.

THE INDEPENDENT

Hand of God photo

A new image of the pulsar wind nebula known as the Hand of God has been captured by the National Aeronautics and Space Administration s Nuclear Spectroscopic Telescope Array (NuSTAR). It shows the nebula 17,000 light-years away, which is powered by a dead, spinning star called PSR B1509-58. The pulsar itself is just 19 km long, but spins around nearly seven times every second. As it spins, it throws out particles upheaved during the star s death, which interact with magnetic fields around the ejected material, causing it to glow with X-rays. For Nasa, one of the biggest remaining mysteries surrounding the object is whether the pulsar particles are interacting with the material in a specific way to make it look like a hand, or if the material is in fact shaped like a hand.

We don't know if the hand shape is an optical illusion, said Hongjun An of McGill University, Montreal. With NuSTAR, the hand looks more like a fist, which is giving us some clues.

NuSTAR has imaged the structure in high-energy X-rays for the first time, shown in blue. In the image, lower-energy X-ray light previously detected by Nasa s Chandra X-ray Observatory is shown in green and red.

Fiona Harrison, the mission s principal investigator at the California Institute of Technology in Pasadena, said the telescope s unique viewpoint was allowing them to see the highest-energy X-rays and was showing us well-studied objects and regions in a whole new light.

The telescope also produced another image of a range of supermassive black holes lit up. Nasa said all of the dots in this image were active black holes tucked inside the hearts of galaxies, with colors representing different energies of X-ray light.

THE INDEPENDENT

AN EXTENSIVE SUBJECT

TAPAN KUMAR MAITRA DISCUSSES MICROBIOLOGY AND THE PROBLEMS IT TACKLES

Microbiology from the Greek *mikros* for small, *bios* for life and *logos* for science is all about minute organisms, invisible to the naked eye, called microbes. It is the study of the laws of the life and development of micro-organisms and also of the changes they bring about in animal and plant organisms and in non-living matter.

The development of microbiology, as well as other sciences, depends largely on industrial methods, the economic requirements and the general progress of science and engineering. According to the requirements of society, in the second half of the 19th century microbiology was differentiated into general, agricultural, veterinary, sanitary and medical.

Modern medical microbiology has become an extensive science. It is subdivided into bacteriology (the science of bacteria, the causative agents of a number of infectious diseases), virology (the science of viruses, non-cellular living systems capable of causing infectious diseases in man), immunology (the science concerned with the mechanisms of body protection against pathogenic micro-organisms and foreign cells and substances), and mycology (the study of fungi pathogenic for man, and protozoology which deals with pathogenic, unicellular animal organisms). In addition, medical microbiology includes the study of the mechanisms of infection and the methods of specific therapy and prophylaxis of infectious diseases.

Since the conquest of outer space, space microbiology has developed

and is faced with the necessity of studying the problems of the biological effects of space radiation, and also the problem of life in outer space and on other planets.

Microbiology as a separate science has special methods of investigation that help in solving a number of important problems regarding public health. These methods are extensively used in the theoretical and clinical medical sciences.

In the 19th century in India and in other countries very little attention was paid to the microbiological training of physicians. Separate laboratories, which had been organised at the initiative of progressive-minded men of science, were unable to train medical personnel capable of comprehending the microbiological methods of investigation and employing these skillfully for the treatment and prevention of diseases.

The second half of the 20th century has been marked by great discoveries in the field of natural science. The use of isotopes, chromatography, spectroscopy, phase-contrast, luminescent and electron microscopy and modern methods in genetics greatly speeded up the development of medical microbiology and virology, and they permitted a more detailed investigation into the life of microbes in order to reveal the unknown mechanisms of their relation to the environment.

In conditions provided by socialism, microbiology received unlimited possibilities for its development. At present in India there are more than 90 departments of medical microbiology, more than 50 institutes of vaccines and sera, institutes

of virology, epidemiology, microbiology and hygiene. Many of them are world famous research centres.

An extensive network of sanitary-and-epidemiologic stations and bacteriologic, virologic and specialised laboratories has been built in India, which provide organisational and methodological work, research and practice in the prevention and eradication of infectious diseases.

In the elaboration of their theories, Indian microbiologists are guided by Indian philosophy and they carry on a struggle with the idealist conceptions in natural science.

Medical microbiology in this country serves the people. Its purpose is deep research into the structure and most important biological properties of pathogenic microbes and into their relationship with the human organism under definite conditions of natural and social environment, the improvement of methods of microbiological diagnostics, the elaboration of new, more effective biological, therapeutic and preventive drugs and active contribution to the solution of the important problem of preventing and eradicating infectious diseases.

Due to the constant concern of the Indian government for the health of working people, public health has had much success. Smallpox, plague, epidemic relapsing and typhus fevers, dracunculosis (*rishta*) and soft chancre have been eradicated in India. The incidence of poliomyelitis, enteric fever, brucellosis, diphtheria, anthrax, malaria, sandfly fever, glanders and other diseases has diminished to just occasional cases occurring in some regions of the country.

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Better than real life

A STUDY OF 'GAME TRANSFER PHENOMENA' REPORTS GAMERS SEEING VIDEO GAMES MENUS AND MUSIC IN REAL LIFE, WRITES SOPHIE MURRAY-MORRIS

Some video gamers have reported distorted versions of real world surroundings after playing games, according to new research. They reportedly misinterpreted video game images as real life objects. This experience is called Game Transfer Phenomena.

Some gamers have said that they

psychological implications of Game Transfer Phenomena. Psychologist Angelica Ortiz de Gortari said that the research invites us to reflect about the effects of prolonged exposure to synthetic stimuli.

However, the paper also noted that the data in the study was collected from online video game forums and that,

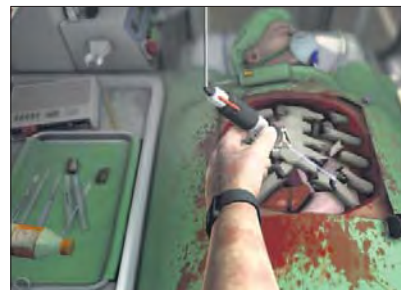


A young boy plays Far Cry 3 at E3 in 2012.

started seeing video game menus in real life, heard video game music and have seen heads up displays on the motorway.

The research found that playing video games can easily trick the brain, causing after-games or ghost images once people have stopped playing the game. The study, from the International Gaming Research Unit at Nottingham Trent University, analysed over 650 experiences from gamers accounts on video game forums.

Gamers reportedly had mixed reactions to these images. While some were concerned, even questioning their own mental health as a result, others found the experience fun and wanted more. Professor Mark Griffiths said, Some gamers may be more susceptible than others to experience Game Transfer Phenomena. The effects of these experiences appear to be short-lived, but some gamers experience them recurrently. More research is needed to understand the cognitive and



Although there is hope that the Oculus Rift will eventually be used to help train medical staff, until then there are the less-than-serious delights of Surgeon Simulator 2013 (also available for PC). Intentionally difficult to control, the game has been described as not a brilliant game (but) a brilliant joke.

therefore, the psychological profile of those involved was unknown. For those worried about video games blurring the lines between virtual life and reality, there's more worrying news in the form of the Oculus Rift a VR headset that is set to go on sale this year in the UK and could change not only gaming but education and work as well.

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