

The Mole

... FOR ANYONE INSPIRED TO DIG DEEPER INTO CHEMISTRY

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Can solar power change the world?

Nina Chadwick and Neil Robertson find out how materials developed by chemists can provide power for all



SHUTTERSTOCK

Scientists must continue to develop solar cells which are cost effective and practical

Imagine a world without the sun. It is colder than humanly imaginable. Water doesn't exist, all we have is ice. There is never any daylight and plants can't photosynthesise, so they can't survive. Solar power has changed the world. Since the beginning of mankind, the sun has provided our most innate human requirements – warmth, light and food. Since the late eighteenth century, the sun has provided us with much more.

A simple life

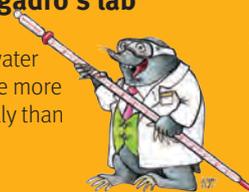
The mid 1700s saw the beginning of the industrial revolution. Before then, the majority of mankind lived a relatively simple life. However, mostly due to the development of the steam engine by James Watt in 1775, we began to work much faster and more efficiently. The subsequent economic growth was unprecedented, and since that time huge advances in technology have allowed us to use electricity as

► Ethylene glycol

Ever wondered how de-icer melts the ice on your windscreen?

► Avogadro's lab

Does hot water freeze more quickly than cold?



► Superconductivity

Super-cold metals and floating trains

► Cutting edge science

The world's smallest remote control car debuts

► On-screen chemistry

Titanic implications for tiny impurities

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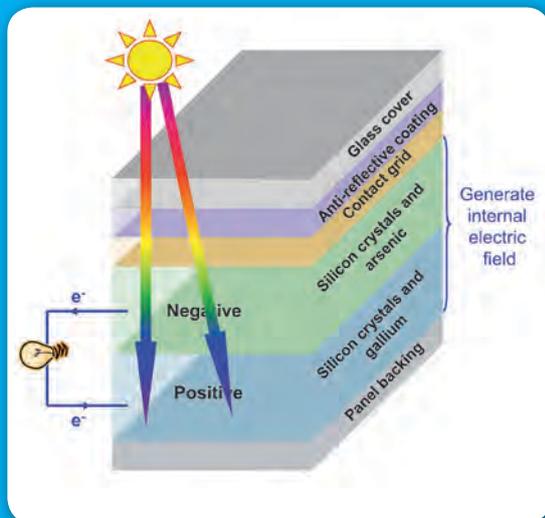
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Silicon solar cells use a small, controlled amount of impurities to allow an electrical field to be created



we wish and improve communications dramatically. Compared to times before the industrial revolution, we all live the life of royalty – the amount of energy we consume is the equivalent of having 125 human slaves working for each of us 24 hours a day, 7 days a week.

This increase in wealth and lifestyle is built on fossil fuels. Fossil fuels were formed from plants and animals which, ultimately, stored energy from the sun over hundreds of millions of years. The problem is that we are using this energy quickly. The rate at which we are currently using fossil fuels compared to the length of time they took to form, is the equivalent of someone spending their entire annual income in 30 seconds. The position of a person with no income for the rest of the year is the position we are currently creating for future generations. We are in the midst of 30 seconds of extravagance. What happens afterwards?

Energy from the sun

Thankfully, we still have the sun. Instead of continuing to use the minute stores of energy generated in plants millions of years ago, we now have the technology to use the sun's energy every day. The amount of energy reaching the Earth's surface every hour would meet the world's current energy demands for an entire year. So, we can continue to live like royalty, but we no longer need to gamble the lifestyles of future generations.

Take a moment to think about those people who don't live our life of luxury. There are 1.6 billion (more than 1 in 5) people in the world who have no access to reliable electricity. Instead, kerosene (which is bad for the health and expensive) is used to power unreliable generators to produce electricity. Solar power has begun to change all of this. Companies like Solar Aid are working with rural communities to install solar cells which provide electricity for power during the day and charge batteries to provide electricity through the night. This power can be used

for medical treatment, education, or work to provide an income for a family. In this way, solar technologies could help address the unbalance in the lifestyles of the developed and developing world.

Converting sunlight to energy

So how is it that we convert sunlight into useful energy? Firstly, the sun can be used for heating water which can be used for central heating systems. On a larger scale, this heat can be concentrated using mirrors so that solar power replaces coal in heating water for power plants. Secondly, some chemists and biologists are also working together to find ways to mimic photosynthesis in plants and use the sun's energy to produce different types of fuel. Finally, the sun's energy can also be directly converted into electricity using a solar cell.

Evolution of solar cells

The first solar cell was built by Charles Fritt in 1883. Since then, although the improvements in technology have been huge, their use has been limited.

In contrast, consider the mobile phone. The first mobile phone call was made in 1946 and the first hand held mobile phone was developed in 1973. Since then there has been an astonishing increase in the number of people using mobile phones. Due to this commercial success, the technology is still developing at an incredible rate. A similar phenomenon is beginning with solar cells.

Over the last five years, more and more people have installed solar cells on their roofs. The technology behind these solar cells is now incredibly advanced. Due to the increase in demand for solar cells, the technology is becoming cheaper and better. It is predicted that during the six years it would take to build a coal fired power station, it will become cheaper to obtain electricity from solar cells than from this power station.

But how effective are solar cells in the UK? It's often cloudy, it regularly rains and it's not often sunny. Think back to when you were last in a field in the UK. Was the grass green? Were there any trees or flowers? Enough sunlight reaches the UK for plants to thrive, despite our weather, and therefore enough sunlight reaches the UK for us to use solar cells.

There are many different types of solar cells but the most familiar, the type you see on rooftops, are silicon solar cells. These solar cells use the element silicon with a small amount of finely controlled impurities in it which allow an electric field to be created.

When the silicon absorbs a particle of sunlight (a photon) an electron is excited. This means that it is promoted to a higher energy level, and the energy of the photon has been transferred to the electron.

Find out
more

www.thesolarspark.co.uk

www.solar-aid.org

The science behind dye-sensitised solar cells
<http://slidesha.re/dyesolarcell>

www.g24i.com



Due to the internal electric field, the electron diffuses to one side of the cell. The other side of the cell therefore becomes positive and the electron moves around the circuit back to where it began. As lots of photons hit the cell, lots of electrons flow around the circuit and electricity is generated.

Portable solar cells

Although silicon solar cells have many advantages, they are brittle and comparatively heavy. Imagine that you are walking along a busy street. You take out your mobile phone to make a call to find the battery is dead. How convenient would it be to have a solar cell incorporated into your jacket or your rucksack so that you could charge your phone on the spot? This wouldn't be practical with silicon solar cells. However, researchers from nine UK universities involved in The Solar Spark project are helping to develop newer technologies which make this seemingly futuristic idea a very real possibility – in fact, it is now possible to purchase a rucksack with an incorporated solar cell.

Dye-sensitised and organic solar cells

These new types of technologies are called dye-sensitised and organic solar cells. They work in a very different way to silicon solar cells. Unlike silicon solar cells, which require an incredibly high purity of silicon

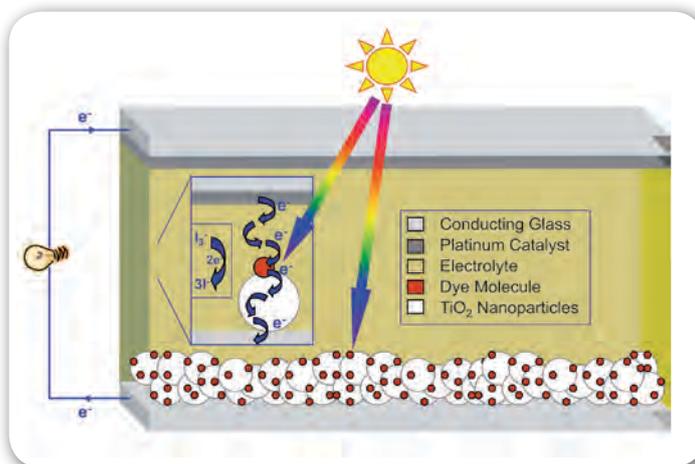
to work, they use materials which are cheap, readily available and non-toxic. You can make a solar cell using titanium dioxide (also found in paint, sun tan lotion and toothpaste), fruit dyes to absorb the sunlight and a liquid electrolyte made up of iodine and iodide anions which completes the electrical circuit. Try it for yourself.

Both organic and dye-sensitised solar cells can be literally printed onto a special type of plastic. As well as using cheap materials, they are very easy and cheap to manufacture. As they are printed onto plastic, they are flexible and more robust than silicon solar cells. Again, think about those who are less fortunate. Since these solar cells are cheap, portable and robust, the technology is much more accessible for the developing world than silicon solar cells.

The future

Due to the nature of the technology, the role of chemists is irreplaceable. Chemists must design new dyes, and develop materials for better transport of electrons. They must also 'characterise' each new material to ensure that the energy of the electron 'fits in' with the other materials – the rest of the solar cell. This is important as, like a car engine, if one part doesn't fit, the whole thing doesn't work. In this way, chemists, along with physicists and engineers must all work together to find the best materials which fit together to make the solar cell work as well as possible.

Can solar power change the world? For some communities in developing countries, it already has. Scientists must continue to work with businesses, economists, architects, designers and a whole host of other professions to make sure that solar cells are practical, cost effective and appealing. Solar cells will continue to make a large contribution to reducing the world's dependency on fossil fuels, closing the poverty gap and changing the world.



Try it yourself

Use the instructions for our *Grätzel cell* experiment and *solar cell in a straw* experiment on the 'teachers' page of our website and within an hour you will have made your own working solar cell!

www.thesolarspark.co.uk

Dye sensitised solar cells are easy and cheap to manufacture