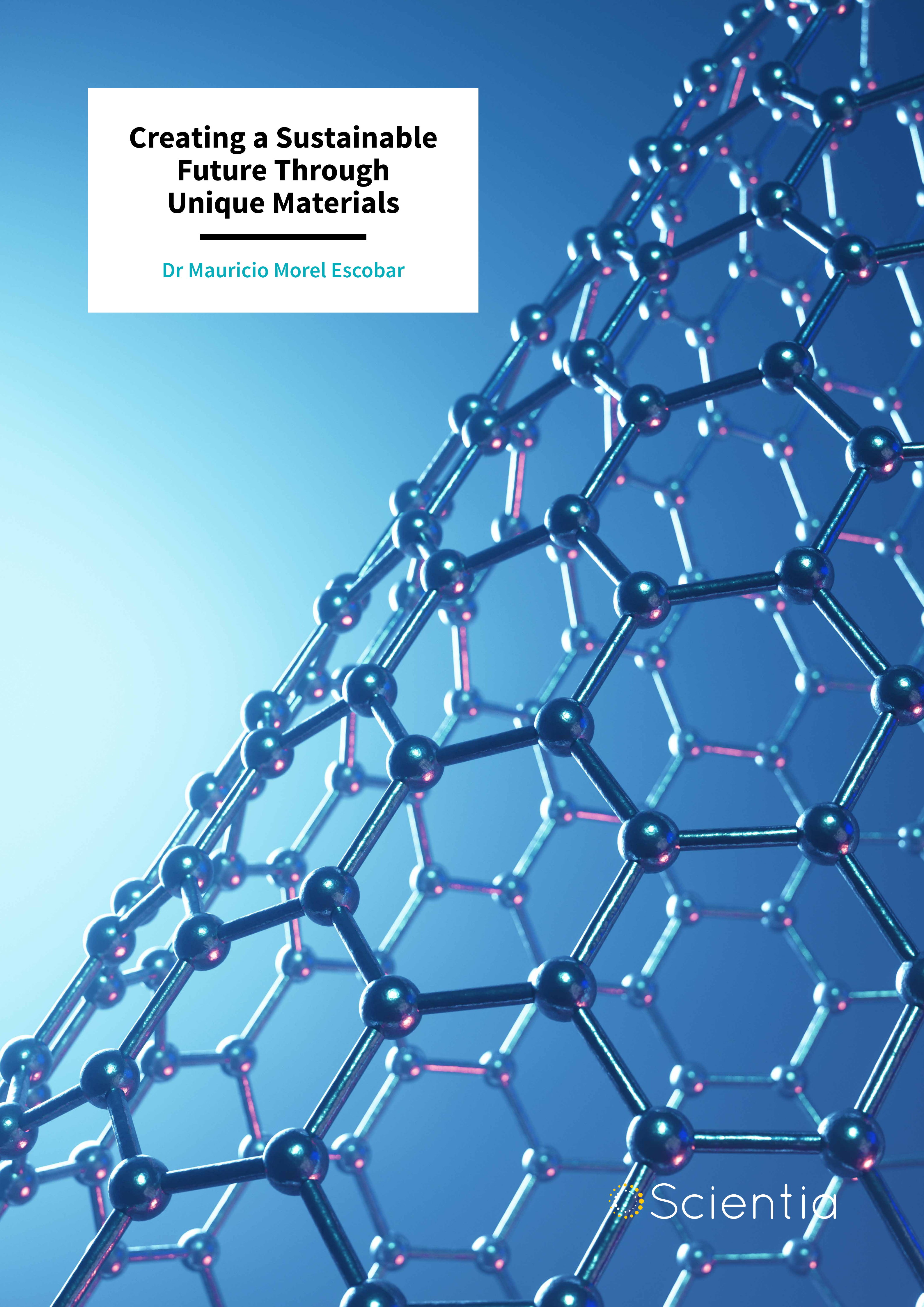
Creating a Sustainable Future Through Unique Materials

Dr Mauricio Morel Escobar



Scientia

CREATING A SUSTAINABLE FUTURE THROUGH UNIQUE MATERIALS

The process of inventing new and exciting technologies often begins with the development of unique and novel materials. The road to creating a new material has many stages, ranging from how we acquire the raw components, to how they are processed, and how they are ultimately used. **Dr Mauricio Morel Escobar** and his team at the Universidad de Atacama, Chile, have been investigating the synthesis, properties and optimisation of materials, towards the development of clean, energy-efficient technologies and manufacturing methods. They are also working to address the energy crisis, by exploring how materials can be used to store sustainable fuels.

The Need for New Materials

Modern civilisation is currently facing several environmental crises, including climate change, biodiversity loss and pollution. As such, there is an urgent need to drastically cut our carbon emissions by switching to clean and renewable sources of energy, and reducing the waste we produce.

Some of the biggest advances in science have relied on the creation and optimisation of new materials, and these environmental crises are likely to be solved in the same way. Materials can help us find new energy solutions, and build devices that can use this energy more efficiently. By researching how such materials are fabricated, we can even make the manufacturing process itself more sustainable and less harmful to the environment.

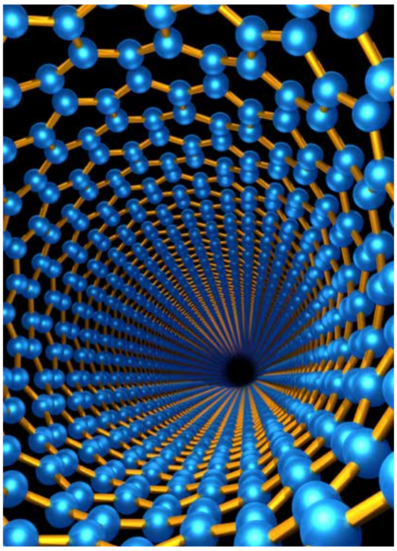
Dr Mauricio Morel Escobar and his colleagues at the Universidad de Atacama in Chile have been investigating these problems and creating innovative solutions, through the use of a range of cutting-edge materials.

Hydrogen Capture with Magnetite

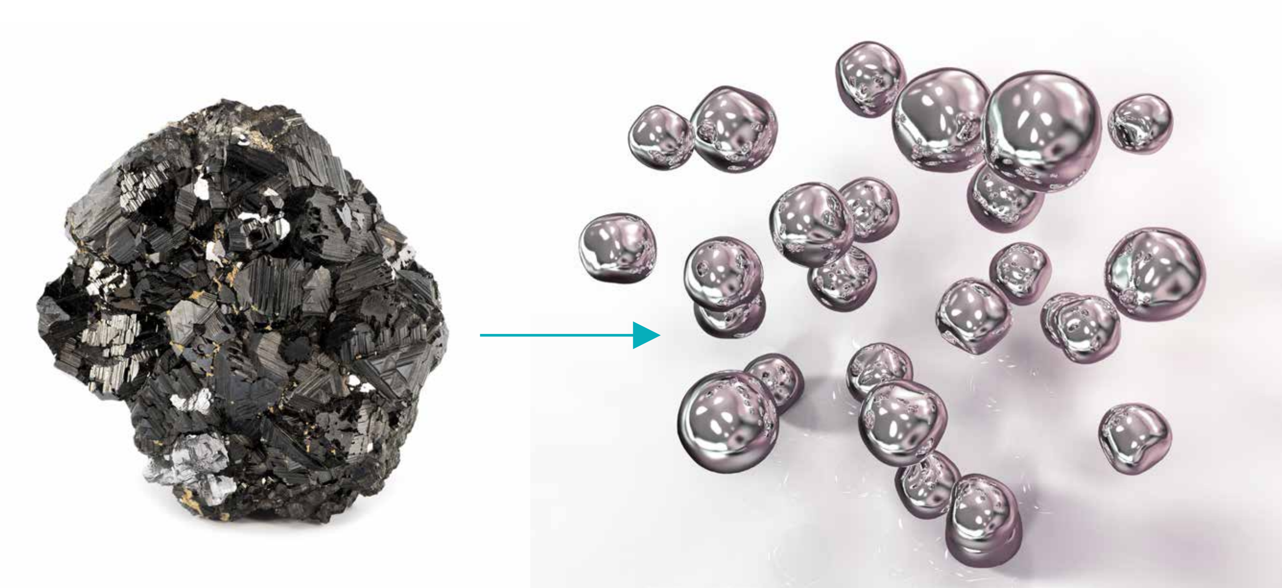
Carbon nanotubes are unique materials consisting entirely of carbon atoms which are linked together to form cylindrical tubes. These tubes are incredibly small, and can consist of a single wall of carbon atoms, or multiple. Carbon nanotubes have shown great potential in a wide range of applications, including electronic devices and energy storage technologies.

One of the most promising qualities of nanotubes is their ability to capture gas molecules. Their unique shape and firm structure mean that they can act like tiny cages, trapping the gas for later release. This property of nanotubes has garnered great interest, particularly for storing hydrogen gas.

Hydrogen gas is considered a sustainable alternative to fossil fuels; after all, the only product of burning



hydrogen is water, making it an incredibly clean fuel. However, the main problem with hydrogen is its highly combustible nature, meaning that it needs to be stored safely. One solution to this problem is to use materials that can store the gas in a non-explosive state, and release it again when it needs to be used. Many porous materials have been investigated for this purpose, and of these, carbon nanotubes show real promise.



However, carbon nanotubes can be tricky to fabricate. Their synthesis often requires highly specific conditions, and expensive materials as catalysts. Now, Dr Morel and his team have put forward a modified synthesis method that uses an unusual catalyst: magnetite.

Magnetite, with the chemical formula Fe_3O_4, is a relatively abundant mineral that is often used in the production of iron. Found in the Earth in the form of mineral deposits, magnetite requires minimal processing and purification. Dr Morel and his colleagues have been investigating whether this material could make a suitable catalyst, as this would make the production of carbon nanotubes significantly cheaper and more environmentally friendly.

The team found that the magnetite was in fact a suitable catalyst for the synthesis of nanotubes comprising multiple walls of carbon atoms. They even achieved a good yield that was very similar to those achieved using traditional catalysts.

The researchers also tested the hydrogen storage capacity of their synthesised nanotubes. They found that the structure of the nanotubes formed was dependent on the exact conditions used during synthesis, and that the hydrogen storage capacity was determined by the structure achieved. This outcome shows that by tuning the synthesis conditions, nanotubes with ideal structures for storing hydrogen can be created efficiently and inexpensively.

Synthesising Iron Nanoparticles from Magnetite

Scientists dedicate a lot of time and effort to developing the most efficient methods of synthesising materials, both in terms of energy and cost. Nanomaterials are certainly no different; their applications across various industries make them very desirable, yet they can be painfully difficult to create.

One of the most important factors is the precursor compounds that are used to synthesise nanomaterials. Certain nanomaterials can only be synthesised using precursors that have extremely high purity. This can mean that many extra steps are required to process these compounds before the synthesis even starts. This can incur large energy and monetary costs, which is not ideal when trying to develop sustainable materials.

Therefore, there has been a push for scientists to develop methods of producing these materials using naturally occurring precursor compounds that do not require much processing. An example of this is using metal oxides in their mineral state.

Dr Morel's work with mineral magnetite goes far beyond carbon nanotubes. In another study, he and his team developed a method of synthesising magnetite nanoparticles directly from the ore itself. The main benefit of this is that no extra processing is needed, and the nanoparticles retain some of magnetite's physical properties. These magnetite nanoparticles have numerous potential applications, including water purification and drug delivery.

Dr Morel and his team then expanded their work by synthesising other types of nanoparticles through a similar method, once again using magnetite as a precursor. The team even showed how these nanoparticles could be doped with organic molecules, including those used to initiate polymerisation reactions. This means that these doped nanoparticles could be used in the process of producing polymeric materials, giving them even more utility.

The team has once again demonstrated how useful nanomaterials can be developed using relatively simple methods that utilise common raw materials.

Energy Efficient Liquid Crystal Materials

Digital devices with high-quality displays are becoming increasingly common in our modern world. One of the most popular display technologies is based on liquid crystals. Liquid crystal display (LCD) technology has been the foundation for TVs, smartphones and computers for many years, and it continues to dominate the market. This means that scientists are always on the lookout for ways to optimise liquid crystal materials.

One of the biggest areas for improvement is energy efficiency. With climate change accelerating and the energy crisis looming, much effort is dedicated to making sure that our devices waste as little energy as possible.

Liquid crystals, like the name would suggest, are materials that have properties similar to both liquids and solids. They are made up of molecules that tend to assume a preferred orientation, but are able to rearrange themselves under the right conditions. LCD screens work by manipulating this property, allowing the liquid crystals to switch between states while a light is shone through the material. This light is then manipulated in a controlled way, allowing an image to be produced on the screen.

In order to improve the efficiency of this technology, a key point is to better understand how the liquid crystal molecules orientate themselves, and how we can control them using minimal energy. Dr Morel and his team have been investigating this phenomenon, to better understand how we can produce high-quality, energy-efficient devices.

They did this by developing two types of liquid crystal cells: one where the molecules are aligned parallel to the cell, and one where they are twisted. Then, by varying the external voltage applied to these cells, the team monitored changes to the light that passed through them. From this, the team gathered data on the ways in which the liquid crystal molecules were reorientating themselves as the external voltage was applied, and how this affected the colour of the light they transmitted. This is far from the only study that Dr Morel has done on optimising liquid crystal technologies. In a recent study, he looked into how molecular orientation in liquid crystal technology can be manipulated by using light itself, rather than passing electricity through the material.

When high-intensity blue and green light was shone through the liquid crystal cell, the team found that interesting ring patterns were produced in the transmitted light. By analysing these patterns, and the conditions that caused them to form, Dr Morel and the team were able to put together a model for how the molecules are influenced by the intense light, and how this causes them to take on specific arrangements.

Through these studies, the team was able to learn more on how liquid crystals can be manipulated using various stimuli. This is important to note, because a better understanding of how these molecules can be manipulated allows scientists to design technologies that can operate under minimum energy conditions.

Material-based Solutions to Global Issues

By exploring the synthesis, properties and optimisation of materials, Dr Morel and his colleagues have developed innovative solutions to several global issues. These solutions will hopefully go on to pave the route for a cleaner, more sustainable future for all of humanity.

Meet the researcher

Dr Mauricio Morel Escobar
Department of Chemistry and Biology
Faculty of Natural Sciences
Universidad de Atacama
Copiapó
Chile

Dr Mauricio Morel Escobar earned his PhD in Engineering Science with Material Science from the University of Chile in 2013. He then went on to teach at the university whilst carrying on his research on the topics of clean energy, fuel storage, liquid crystal technology and mineral processing. Dr Morel has since moved to the Universidad de Atacama in Chile, where he continues his research to this day. He has received several awards and scholarships from the Chilean government. He has a particular interest in the mining industry and its impacts on the environment, and hopes to produce solutions that transform minerals into more useful nanomaterials.

CONTACT

E: mauricio.morel@uda.cl
W: https://orcid.org/0000-0001-7124-801X

KEY COLLABORATORS

Dr Uday Uyabhaskar, Instituto de Investigaciones Científicas y Tecnológicas, IDICTEC, Universidad de Atacama
Dr Arun Thirumurugan, Instituto de Investigaciones Científicas y Tecnológicas, IDICTEC, Universidad de Atacama
Dr Alejandra Tello, Department of Chemistry and Biology, Faculty of Natural Sciences, Universidad de Atacama
Dr Marcel Clerc G. Department of Physics, Faculty of Physical and Mathematical Sciences, University of Chile
Dr Donovan Díaz D. Pontificia Universidad Católica de Chile
Dr Edgar Mosquera V. Department of Physics, Universidad del Valle

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