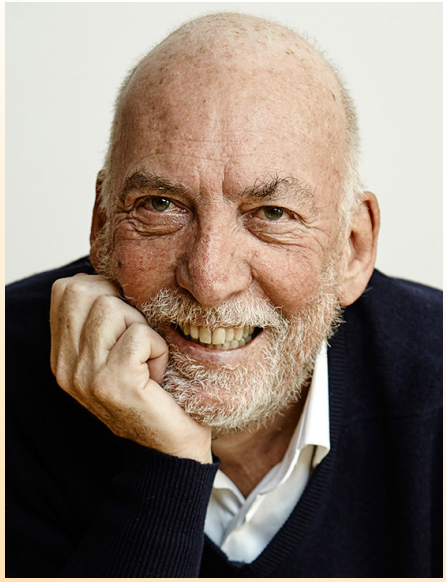
SG GUIDE
TO TECHNOLOGY,
INNOVATION
AND ENTERPRISE

RIE NEWS

January 2020

MEET THE SPEAKERS AT GLOBAL YOUNG SCIENTISTS SUMMIT 2020



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GLOBAL YOUNG SCIENTISTS SUMMIT

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REMOTE CARDIAC MONITORING

INTERVIEW

BEHIND NIOMETRICS' DEEP NETWORK ANALYTICS

NRF FELLOWSHIP

APPLICATION NOW OPEN

RESEARCH ROUNDUP

SCIENTISTS UNCOVER WAY TO CONVERT PLASTICS INTO CHEMICALS USING SUNLIGHT

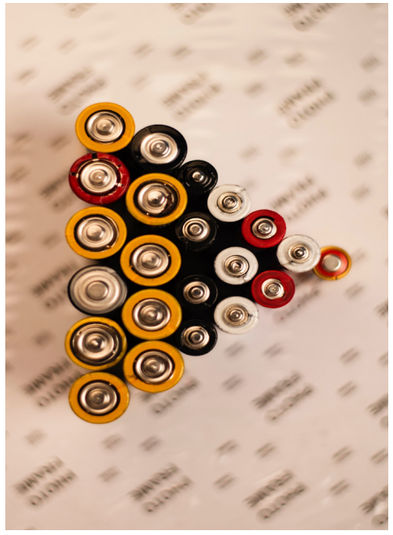
NTU scientists have discovered a method that could turn plastic waste into valuable chemicals by using sunlight. The team mixed plastics with a catalyst and exposed the mixture to artificial sunlight to form formic acid – a chemical used in fuel cells to produce electricity. The research team is now pursuing improvements to the process that may allow the breakdown of plastics to produce other useful chemical fuels, such as hydrogen gas.

FOOD-CENTRIC RESEARCH INSTITUTE TO OPEN THIS YEAR

A*STAR will set up a new research institute, the Singapore Institute of Food and Biotechnology Innovation in the first half of this year. The institute will bring together A*STAR's research capabilities in various food-related areas such as nutrition, agri-food technology, and food safety. It will also support partnerships between public agencies, universities, and companies. For example, it will collaborate with the Singapore Food Agency, NUS, and NTU in research areas such as alternative proteins, food structure engineering, and fermentation technology.

BETTER BATTERIES WITH INDUSTRY-ACADEMIA PARTNERSHIP

NRF has set up a new Singapore Battery Consortium that will help companies access research in battery materials, management systems and battery end-of-life recycling. To make better batteries, the Singapore Battery Consortium will bring research outcomes from our laboratories into market by enabling researchers to understand business requirements, while giving companies access to the latest battery research and technologies to augment their product development efforts. This will be done through networking sessions, workshops and seminars.

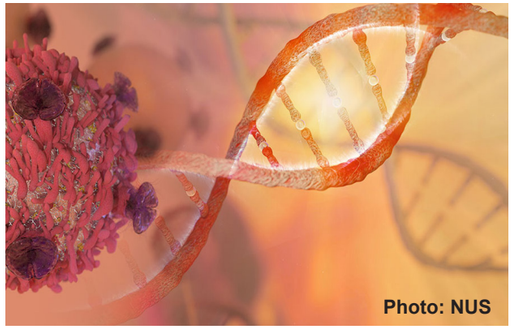


MIT Technology Review

SINGAPORE'S TOP INNOVATORS HONOURED

MIT Technology Review announced last month (3 Dec 2019) its annual list of Innovators Under 35 for the Asia Pacific Region, with Singapore-based innovators making up half of the 20 awardees. One Singapore-based awardee is Carine Lim from NUS, who developed a tool to unmask Alzheimer's disease with a simple and cost-effective blood test. Another is Stephanie Yap Hui Kit, who invented an advanced hand-held microfiber-based sensor for water quality monitoring. See the full list of awardees here.

ENZYME POINTS WAY TO BETTER CANCER TREATMENT



Natural killer T cell lymphoma (NKTL) is an aggressive form of cancer that affects the upper airways and digestive tracts in patients. It is known that the enzyme EZH2 is involved in the disordered physiological processes associated with NKTL and other cancers, as previous research has shown that levels of EZH2 are aberrantly high in cancer patients. Now, NUS researchers have identified an enzyme known as 'maternal embryonic leucine zipper kinase' (MELK) that is involved in the regulation and function of EZH2 in NKTL. This discovery means that the production of EZH2 could be indirectly targeted by targeting MELK, paving the way for a new treatment route for NKTL.

EVENT HIGHLIGHT

INSPIRING THE NEXT GENERATION OF SCIENTISTS

THE GLOBAL YOUNG SCIENTISTS SUMMIT 2020 IN SINGAPORE GATHERS NEW AND RETURNING EMINENT SCIENTISTS AND TALENTED YOUNG RESEARCHERS WORLDWIDE TO CONVENE IN SINGAPORE, TO SPARK NEW IDEAS AND INNOVATIONS.

The world is facing a litany of challenges, from growing antibiotic resistance to a looming shortage in data storage capacity.

To develop the solutions to these problems, young researchers need the help of their more experienced colleagues, and vice versa.

Collaborations across disciplines and nations are also vital to spark new ideas and innovations.

In January 2020, the latest edition of the annual Global Young Scientists Summit (GYSS) will provide a platform for such conversations on science and research, technology innovation, and potential answers to global issues.

Organised by the Singapore National Research Foundation, the GYSS 2020 will be held in Singapore from January 14 to 17, with the theme of "Advancing Science, Creating Technologies for a Better World". The event enables 325 outstanding young science graduates and post-doctoral fellows to interact with 17 eminent scientists, who gather in Singapore from across the world and from a wide variety of research fields, including physics, chemistry, medicine, mathematics, computer science and engineering.

Members of the public will have the opportunity to hear from the distinguished speakers at a series of free public lectures, meanwhile the delegates participate in plenary lectures, panel discussions and interactive group sessions.

A gathering of world-renowned scientists

The GYSS 2020 speakers include world-renowned recipients of the Nobel Prize, Fields Medal, Millennium Technology Prize and Turing Award.

Participating as speakers for the first time at the Summit are Sir Konstantin Novoselov (Nobel Prize in Physics, 2010), and Dr Kees Immink (Institute of Electrical and Electronics Engineers Medal of Honour, 2017).

Millennium Technology Prize winner Professor Michael Grätzel interacting with GYSS participants in 2019. Professor Grätzel will return to Singapore this year for GYSS this month.

Sir Konstantin and his colleague, Sir Andre Geim, who participated in GYSS 2017, isolated and mapped the properties of graphene, a wonder material that consists of a single layer of carbon atoms and is many times stronger than steel, lighter than paper, and an excellent conductor of heat and electricity.

Dr Immink has been one of the most prolific contributors to the field of consumer electronics in the late 20th century. His coding techniques have provided the foundation for generations of audio, video and data recording media.

The GYSS 2020 will also feature a special guest speaker: Professor Alain Fischer, Chair of Experimental Medicine at the Collège de France in Paris.

Professor Fischer has been a pioneer in the fight to understand and treat genetic diseases that are related to the immune system, uncovering many genetic defects that disrupt the human immune system.

He was also one of the first scientists to successfully use gene therapy to treat a rare form of severe combined immunodeficiency, often called the "bubble boy disease", after a well-known patient who lived for years in a plastic bubble filled with filtered air.

An opportunity not to be missed

The GYSS 2020 is the eighth edition of the event, and will span 15 plenary lectures, panel discussions and interactive small group sessions.

The participants will also go on site visits and engage in dialogue sessions with principal investigators and researchers to better understand the research opportunities in Singapore.

As part of the summit, panel discussions among the eminent scientists will take place at public forums at local universities and schools.

Participants at GYSS take part in lectures, poster sessions, and site visits to appreciate the sights and sounds of multicutural Singapore.

TECHNOLOGY GIANTS AT THE SUMMIT

Professor Ngô Bảo Châu
Fields Medal 2010

Professor Ngô Bảo Châu was awarded the Fields Medal in 2010 for his work in algebraic geometry, specifically "his proof of the Fundamental Lemma in the theory of automorphic forms."

The elementary-looking statement of the fundamental lemma hides beneath it a wealth of beautiful geometry which is prominent in mathematical physics, namely the Hitchin completely integrable system.

The proof of the fundamental lemma is thus not just a solution to a very difficult problem, but also opens up new connections to other domains of mathematics and new possibilities for adventure and discovery.

Professor Wendelin Werner
Fields Medal 2006

Professor Wendelin Werner was awarded the Fields Medal, regarded as the Nobel Prize of mathematics, for developing the mathematics to describe and shed light on what exactly happens when a substance undergoes a phase transition in two-dimensional space.

The Fields Medal committee said of his influential work, which combined his specialities of probability theory and complex analysis: "His research has developed a new conceptual framework for understanding critical phenomena arising in physical systems, and has brought new geometric insights that were missing before."

Professor Alain Fischer
Chair of Experimental Medicine at Collège de France

Genetic diseases affect millions of people worldwide, including one in three newborns who are admitted to intensive care units.

Professor Alain Fischer, who is Chair of Experimental Medicine at the Collège de France, has been a pioneer in the fight to understand and treat genetic diseases that are related to the immune system in particular.

In the 2000s, he was one of the first scientists to successfully use gene therapy to treat a rare form of severe combined immunodeficiency linked to a genetic fault on the X-chromosome. The disease is also often called the "bubble boy disease" after a well-known patient who lived for years in a plastic bubble filled with filtered air.

FEATURE

"LIQUID ECG" A GAME CHANGER FOR HEART PATIENTS

SGINNOVATE WORKS WITH ENTREPRENEURIAL SCIENTISTS TO BUILD AND SCALE THEIR COMPANIES. IN THIS ISSUE, WE CHAT WITH DR PHILIP WONG, THE CARDIOLOGIST BEHIND THE WORLD'S FIRST MEDICAL GRADE ECG WEARABLE.

Patients with a heart condition are used to travelling to the hospital to undergo an electrocardiology (ECG) test to measure the electrical activity of their hearts for detecting abnormal rhythms. But increasingly, patients have taken to ECG wearables that provide constant monitoring, allowing them to capture and send cardiac rhythm to doctors for review.

A cardiologist here has taken this development a step further by developing the world's first medical grade ECG wearable that can transmit data continuously through a smartphone to a cloud database.

Physicians can log in remotely and securely to their database and report their findings to patients.

Developed by Dr Philip Wong, a senior consultant at the National Heart Centre of Singapore, the wearable, named Spyder, is the flagship product of startup WEB Biotechnology. Dr Wong is the Chairman and Medical Director of the startup.

"The Spyder ECG provides data fluidity world-wide and we use the term "Liquid ECG" with users of our system. With Spyder, we can see an individual's ECG in the United States continuously here in Singapore 'live', just three to four seconds later," Dr Wong says.

"The device is a game changer as its data can be sent by an individual and received by a doctor in any part of the world," Dr Wong adds, "The small form factor of the device allows easy scalability, enabling any patient or healthcare facility in a data connected area to be monitored by a medical grade device."

The Spyder device weighs just 48 grams. When attached to the chest, it can transmit ECG data wirelessly to a mobile app and a cloud database. Photo: SGInnovate

Tracking your heart health with ease

Dr Wong is a cardiologist tapping biotechnology to help improve patient care. He wants patients to have an easier and better test, and to improve the diagnostic accuracy of the current standard test – the Holter ECG Test.

Current Holter devices are wired devices that usually have no transmission capabilities. This means that a patient has to travel to the hospital to have the device attached to them, and then return to the hospital again, so that their data can be downloaded for analysis.

Spyder, on the other hand, is wireless and allows patients to transmit their readings onto a cloud database where physicians can immediately retrieve and assess the ECG data coming in. The device has been used in patients for up to 30 days, and this improves the diagnostic yield of sometimes short but dangerous cardiac arrhythmias.

For instance, some dangerous arrhythmias such as paroxysmal atrial fibrillation can increase the risk of stroke by three to five times annually. Atrial fibrillation can begin with a short five to ten minutes burst, thus making single-day Holter ECG test ineffective in detecting them. A large proportion of symptoms also occur during sleep hours, making it unlikely for wrist-worn activated ECG monitors to detect these short bursts of arrhythmias.

Today, over 12,000 patients have used Spyder. 60 per cent of these are located outside of Singapore. What amazes Dr Wong the most is to see 'live' ECG signals being transmitted across the globe by patients using Spyder.

"This shows that Spyder is making a difference in patients' lives regardless of their location," Dr Wong says, "ECG signals coming from Indonesia, China, Russia, South America, the European Union, and the Middle East are all appearing in a screen in front of me."

He finds it particularly interesting that a standard smartphone, when properly enabled, can function as an ECG display and an interactive interface between a patient and a care provider located far away.

Dr Wong says that his team has responded to abnormal ECGs in patients hundreds of miles away and in some cases, these ECG showed abnormal rhythms that were life threatening.

"In some cases, a simple text message to patients and their doctors have resulted in patients being admitted directly to hospital for critical procedures such as permanent pacemakers," he says.

Rising importance of remote cardiac monitoring

Remote cardiac monitoring devices are gaining popularity among patients and healthcare providers due to their ease of use and tracking accuracy. Patients can receive the devices in hospitals, emergency rooms and primary healthcare clinics, and record their data prior to seeing a specialist.

Dr Wong believes that this "front-loading" of diagnostic test, compared to bulky and complex devices that need to be set up in hospital, can contribute significant savings in time and visits to hospitals.

"Specialists seeing a patient for the first time will have the health information of the patient on hand. They can therefore make correct clinical interventions and provide care plans without the need to order more tests," he adds.

Remote cardiac monitoring can also benefit a group of patients with stroke or those who have undergone major heart surgery such as bypass heart surgery or heart valve surgery. Dr Wong says that these patients are currently not monitored after they are discharged from the hospital, and Spyder is now an option that allows such high-risk patients to be monitored during the recovery phase.

As the use of remote cardiac monitoring devices slowly gains traction, Dr Wong feels that Artificial Intelligence (AI) can play a significant role in analysing patients' data to study trends and risks across different age and population groups for various cardiac arrhythmias. He has built a significant database of over 12,000 individual sessions, and is planning to apply AI solutions on the datasets soon.

"We are very excited about the use of AI in streaming ECG data in our system. Based on the quality and quantity of data we receive from an individual, AI can be used to predict the onset of abnormal rhythms in an individual in the future," he says.

Dr Wong is also concurrently refining Spyder's diagnostics and monitoring system so that it becomes even more intuitive for patient use. "Such equipment is traditionally held at healthcare facilities but we are optimistic that one day, all households in Singapore will have a high quality monitor to check the heart," he says.

Spyder ECG is developed by Dr Philip Wong, a senior consultant at the National Heart Centre of Singapore Photo: Dr Philip Wong

Staying focused on one's goal

Dr Wong said an entrepreneur's journey is filled with difficulties, so there is nothing more important than to focus on building a product that has value and helps people.

"To get any product to commercial viability, you have to keep going no matter what the circumstances are," he says.

Now, Dr Wong finds it most satisifying that he is improving the lives of heart patients from around the world. "Although the product was complex to conceptualise and build, it is now simple to use, and has improved the lives of many patients," he adds.

> "An entrepreneur's journey is filled with difficulties, so there is nothing more important than to focus on building a product that has value and helps people.
>
> - Dr Philip Wong on his journey as an entrepreneur

FEATURE

USING SMARTPHONES TO MONITOR WATER QUALITY

A NEW INVENTION BY NUS RESEARCHERS USES AN EVERYDAY SMARTPHONE TO DETECT ANOMALIES IN WATER SYSTEMS.

Today, smartphones are used for everything – communication, banking, gaming, commerce, and even computing. But Assistant Professor Bae Sung Woo and his team of engineers from the National University of Singapore have found a different use for the ubiquitous device: lab work.

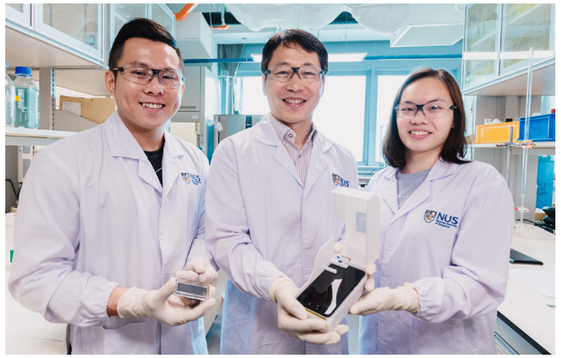
Having worked with microbial water quality for over ten years, Dr Bae is no stranger to the challenges accompanying it. As a PhD student, he realised that monitoring water quality was a tedious affair – not only was collecting the water samples labour-intensive work with bulky, heavy equipment, the process of sending the samples to the laboratory for analysis also meant the team had to wait days to receive the results. In remote areas, where access to laboratories was limited, the work was even more of a struggle.

The experience got him thinking about a different, faster way to detect microorganisms in water, without having to rely on laboratories. “Smartphones have a wide array of diverse sensors that can detect things like location, vibration, and images,” says Dr Bae. “So why not use it to detect water quality?”

This eventually led to the development of a novel algae detection device. The highly sensitive test kit is able to detect the presence of toxin-producing algae in water within 15 minutes. This means that results can be generated on-site, and findings reported in real-time.

The device comprises three sections: a microfluidic chip, a smartphone, and a customisable 3D-printed platform that houses optical and electrical components such as a portable power source and an LED light. The chip, which is coated with a photoconductive layer of polymer-based material, is placed on top of a screen of a smartphone. Droplets from a water sample are deposited onto the chip and mixed with a dye to stain any viable algal cells present. The droplets are then guided by light patterns towards the smartphone camera, which, thanks to the LED light source and a green filter embedded in the 3D-printed platform, allows the camera to capture fluorescent images of the stained algae cells.

Compared with conventional methods, the device is far easier to use — it doesn’t require a laboratory or



The NUS research team behind the novel algae detection device is led by Assistant Professor Bae Sung Woo (centre) who is holding the smartphone platform. With him are two team members: Mr Thio Si Kuan (left) who is holding the microfluidic chip, and Miss Chiang Li Ching Elaine (right). Photo: NUS

trained personnel, it doesn’t need bulky equipment, and the results can be obtained in a matter of minutes instead of days. It is far cheaper, costing less than $300 while conventional methods cost between $3,000 and over $100,000. And in a field where delayed outcomes could cause not only economic loss but also adverse impacts to public health, time is of the essence.

Even in urban places like Singapore, monitoring water quality is important. Algae blooms and their associated toxins can have unfavourable effects on human health, aquatic ecosystems, and water supply — for instance, in 2015, an algae bloom wiped out more than 500 tonnes of fish in Singapore, costing fish farmers millions of dollars.

This device could hence help fish farmers maintain their aquaculture ponds — and while the time-consuming nature of conventional water sampling processes is a deterrent, the new technology means fish farmers will now be able to monitor water samples regularly and easily, and take early action.

In the long run, Dr Bae hopes to take his invention a step further. Currently, the team is in the process of developing a new microfluidic chip to be integrated into a modified version of the smartphone platform to detect the presence of foodborne pathogens such as salmonella and other infectious pathogens. Currently, it is able to detect and quantify fecal bacteria within thirty minutes, a process which typically takes one to two days.

There are still challenges to overcome. As the project combines elements from different disciplines — microbiology, mechanical engineering, and environmental science — effective communication is important to ensure that the project goes smoothly. And as with all research, it is an ongoing process of trial and error.

“The research journey has seen many failures, looking back,” he says.

But Dr Bae is undeterred. He says he will continue working with government agencies and industry partners to further develop the technology. He has regular discussions with his team, where they share ideas and brainstorm on what new directions to take and what problems they can solve. He also says that he has been approached by companies for future collaborations — “hopefully it goes well,” he quips.

COMMENTARY

CLIMATE SCIENCE GAINING MOMENTUM

CLIMATE SCIENCE RESEARCH AND THE USE OF NEW TECHNOLOGIES ARE CRITICAL IN BOLSTERING SINGAPORE'S EFFORTS TO FIGHT THE EFFECTS OF CLIMATE CHANGE. RESEARCHERS AT THE CAMPUS FOR RESEARCH EXCELLENCE AND TECHNOLOGICAL ENTERPRISE (CREATE) TELL US HOW THEIR WORK CAN MAKE AN IMPACT IN THIS FIELD.

Using Tropical Peatlands to Fight Climate Change

Prof Charles Harvey,
Singapore-MIT Alliance for Research and Technology

Although the rise in greenhouse gas emissions is largely caused by fossil fuel consumption, it is not the only reason. In the region surrounding Singapore, enormous fluxes of carbon dioxide are also released by the artificial drainage of peatlands.

Peatlands are a type of wetland composed of peat, which is a soil composed of ancient plant material. Regional peatland store over fifty gigatons of carbon underground. But this means that when damaged, peatlands can end up releasing massive amounts of carbon into the atmosphere.

When farmers and plantations in the region convert the native forests that created peatlands into palm oil and acacia plantations, they build canals to drain the peatlands, exposing deeper layers of peat to oxygen. This results in the decomposition of the peat, releasing carbon dioxide and enabling the spread of below-ground fires that produce haze. In fact, it is burning peat, not forests, that causes most of the haze in Singapore. These processes emit more than one-hundred megatons of carbon dioxide per year, over twice the total carbon dioxide emitted in Singapore.

In the light of this, restoring damaged peatlands is likely the easiest and least expensive way that this region can fight climate change. This would also prevent haze from contaminating Singapore's air and the displacement of millions of people who live in coastal peatlands that are now subsiding towards sea level.

One way to do this is to raise the water table, which is the underground surface below which the soil is saturated by water. The water table can be lifted by designing canal systems and roads that reduce the flow of water from degraded peatlands. A higher water table keeps peat wetter, preventing its decomposition and the release of carbon dioxide as well as the incidence of fires. Peatlands can also be restored back to carbon sinks by regrowing forests to absorb carbon dioxide from the atmosphere and accumulate organic carbon in their soils.

A researcher installing a gas analyser for measuring the amount of carbon dioxide released when tropical peatlands dry out. Photo: Singapore-MIT Alliance for Research and Technology

However, managing peatlands to reduce, or reverse, carbon dioxide emissions requires a greater understanding of the hydrologic and ecological processes that occur in peatlands. Through the Singapore-MIT Alliance for Research and Technology (SMART) Centre, MIT's research enterprise at CREATE in Singapore, Singapore has built a unique research station that is already providing a fundamental understanding of peatland processes. Our research area includes one of the last remaining undisturbed natural tropical peat forests and is the only site in the region where researchers can study how natural peat forests function.

With data collected from this site, we have simulated historic peat accumulation patterns to explain the current topography of peatlands. At a nearby site, we are studying peatlands that have been drained and burned. There, we planted seedlings collected from the forest to study how burnt peatlands can be restored. Together, all of this data is providing the tools to manage peatlands, through the design of canals and other infrastructure, and to restore peatlands to minimise carbon emissions and prevent peat fires and haze.

Some fixes to keep carbon in the ground are simple, such as abstaining from using ditches as fire breaks in peatlands. This is because while in most landscapes, replacing vegetation with a water-filled ditch would make an excellent fire break, in peatlands, it is the opposite: fires are caused by drainage ditches because they lower the water table, making the nearby peat flammable. Other outstanding questions for the long-term management of peatlands are much more difficult: What restoration practices will best prevent fires, minimise emissions and provide income? What is the optimal water table depth to control emissions and fires while maintaining productive agriculture?

To answer such challenging questions, we need to maintain long-term studies like those SMART is conducting. We also need to conduct new large-scale experiments in plantations and develop management schemes based on the results of these scientifically-designed experiments.

Electric Buses to Lower Carbon Emission for Singapore

Mr Srikkanth Ramachandran & Dr Aybike Ongel
TUMCREATE

It is no secret that transport is a major contributor of greenhouse gas (GHG) emissions, accounting for about 25 per cent of the global CO_2 emissions. But although air transport has come under fire in recent months, road transport remains the biggest culprit, accounting for 74 per cent of this figure.

In Singapore, diesel buses account for around 20 per cent of GHG emissions from road transport, even though they only make up just two per cent of Singapore's vehicle fleet. Due to its higher mileage, a bus may emit 17 times more GHGs than a passenger car.

In comparison, electric buses are more efficient, lower maintenance, and produce zero tailpipe emissions. Their overall emissions depend primarily on the emissions of electricity production, which is good news as Singapore is mainly powered by natural gas – the fossil fuel which produces the lowest emissions per unit of electricity.

Furthermore, the research evaluation we are working on suggests that a battery-powered electric transit bus in Singapore may produce 40 per cent less GHG emissions as compared to its diesel counterpart (on a per km driven basis) during its lifetime.

At TUMCREATE, we have been looking into the emission mitigation potential in the road transport sector by establishing an inventory of transport and emission savings that can be achieved through various low carbon initiatives. Our research has shown that the electrification of buses could be a big step towards helping Singapore achieve its climate change objectives, especially as Singapore continues to move towards renewables in power generation. Furthermore, unlike other passenger vehicles, buses have well established routes with fixed schedules, which means planning for power demand and charging stations can be done in advance and with much more ease.

In addition, electric buses provide several other advantages such as reduced noise, heat, and particulate matter emission. With its dense population, Singapore could benefit immensely from these as well.

In Singapore, as part of the move towards a 100 per cent cleaner energy public bus fleet by 2040, the Land Transport Authority will progressively deploy electric buses for passenger service from early next year. This includes the plan to deploy 60 electric buses in the first half of 2020.

In line with this, researchers at TUMCREATE have developed interactive simulation tools that are able to determine the electric power needed for a completely electrified bus fleet and analyse its impact on electric power grid, while considering the cost and environmental benefits.

Using technology to turn trash into treasure

Mr Abhimanyu Goel
Energy and Environmental Sustainability Solutions for Megacities

Today, up to 79 per cent of Singapore's domestic waste ends up being incinerated. This process is effective in minimising space usage while generating energy – but as the Republic looks for focused ways to reduce greenhouse gas emissions, there might be other measures worth considering.

Some research projects we are working on at the Energy and Environmental Sustainability Solutions (E2S2) for Megacities programme involve alternative recycling technology solutions to tackle different waste streams in a more environmentally-friendly manner. One of the technologies we are looking at is gasification, a recycling method which converts organic waste into fuels such as syngas. Composed mainly of H2 and CO, syngas can be used to generate electricity or produce synthetic petroleum. This process involves reacting the waste material at high temperatures. But unlike incineration, gasification runs on electricity, does not involve combustion, does not require fossil fuels, and produces minimal carbon emissions.

Another process, known as pyrolysis, recycles plastic waste into hydrogen gas. Like gasification, pyrolysis produces only trace amounts of carbon emissions. This is significant as calculations done by E2S2 show that the CO_2 emitted by incinerating disposed plastics in Singapore in 2018 totals over 860,000 tonnes. Furthermore, the hydrogen produced could be used as a potential resource for hydrogen fuel cells that can power automobiles, or even homes in future!

When gasification and pyrolysis technologies are combined to tackle the different disposed waste streams – including plastic, food, wood, and horticulture – we could generate enough energy to power about 150,000* public household units and reduce about 300,000* tonnes of carbon dioxide emissions, equivalent to the amount produced by 65,000* vehicles a year. The E2S2 team is now studying the economic viability of using such technologies in Singapore.

In land-scarce Singapore, alternative recycling solutions also present a more space-efficient option than incineration. By recycling waste to produce energy instead of incinerating it, less waste would accumulate in our landfills. This is important as Semakau Landfill, Singapore's only landfill, is expected to run out of space by 2035.

**The values are rounded off to the middle of the output range and reductions in CO_2 emissions are potential reductions achieved from the research lab experiments done by the E2S2 team.*

INTERVIEW

CONVERTING RAW DATA INTO FRESH INSIGHTS

A*CCELERATE IS THE RESEARCH COMMERCIALISATION ARM OF THE AGENCY FOR SCIENCE, TECHNOLOGY AND RESEARCH (A*STAR). IT HAS SUPPORTED DEEPTECH STARTUP NIOMETRICS, ONE OF THE FASTEST GROWING TECH COMPANY IN SINGAPORE. WE CHAT WITH DR KOSTAS ANAGNOSTAKIS, SCIENTIST-TURNED-FOUNDER OF THE COMPANY.

Niometrics wants to help telcos monetise the data that they collect through serving their customers. How does Niometrics do that?

Telcos have witnessed significant value that can be created and captured by them through the data they acquire. That has prompted them to pursue new sources of competitive advantage within the technology space they participate in.

To reposition and reclaim relevance within the broader digital ecosystem, telcos are seeking a new class of data enablement, one that can uplift them from passive observers into more active agents of the experiences they help to fulfil.

Niometrics' network analytics technology helps them to do just that. It produces data intelligence that lets telcos drive customer experience improvements, foster product innovation, fuel digital partnerships and establish innovative data platforms.

It does so by detecting, analysing and deriving insights from the huge volumes of data traffic that flows through telco networks. Niometrics' network analytics technology transforms all that data into higher-order insights that can feed innovative initiatives for telcos to pursue.

What do you think sets Niometrics apart from other data analytics companies?

Niometrics' network analytics technology features a unique full-stack software approach, with end-to-end control over how different components come together to deliver deeper and faster analytical performance.

Unlike traditional solutions, Niometrics focuses on vertical specialisation for network analytics. We build a seamless value chain of data extraction, interaction, mediation and visualisation, avoiding the integration pitfalls that companies face with fragmented, multi-vendor tools.

In addition, our system uses a hardware more efficiently, and this results in lower footprint requirement. This is because our network analytics platform delivers a big data experience out of significantly smaller server requirements, demanding up to 80% less hardware than other alternatives would. In an environment where hardware

The management team of Niometrics comprising Founder and Chief Executive Officer Kostas Anagnostakis (centre), Chief Technology Officer Periklis Akritidis (left) and Chief Operating Officer Zach Tigkas.

"

Niometrics' network analytics technology transforms all that data into higher-order insights that can feed innovative initiatives for telcos to pursue.

- Dr Kostas Anagnostakis on Niometrics' key technology use

investments can reach millions of dollars, while weakening insights is not an acceptable alternative to minimising costs, that degree of efficiency makes a big difference.

As a very important bonus, that smaller hardware requirement also translates into significantly lower energy consumption, doing its part in helping information technology platforms to become less energy-hungry and greener.

Lastly, we provide real-time analytical data. Our analytics give communication service providers the advantage of speed – going from trillions of raw metadata to first-order events in a split second – without compromising on accessibility, retainability, and timeliness of critical data. It is highly performance-scalable so that infrastructure costs do not commensurate with data traffic growth.

You developed Niometrics' network traffic analysis engine when working as a research scientist at A*STAR. What was the process like with starting and growing a research spin-off?

Moving from research to spin-off mode injected a whole new world of practical considerations into me and my co-founders' day-to-day operations. From a more acute drive to find applications to our research to the engineering of a sustainable business model around it, we paid attention to every little reality-check.

A*ccelerate made valuable contributions at various stages of our development. For example, it proposed for Niometrics to apply its signature validation technology to the then up-and-coming applications in deep packet inspection (DPI), and brought in industry collaborators to advise on potential commercial models around them.

In addition, A*ccelerate facilitated the team's pitching to potential pilot users, which resulted in one of the first large-scale deployments for the company. The agency also gap-funded the development of Niometrics' algorithm into reusable software engines/ SDKs.

It's been 10 years since Niometrics was spun off using A*STAR's network traffic analytics software. What is the end goal for Niometric, and when do you hope to achieve it?

Our end goal is to maximise the impact that our technology can have in making deeper sense of digital moments. On that, we believe there is still a lot to be achieved. These include expanding the breadth of intelligence that we generate for telcos and applying our core technology into adjacent areas, like cybersecurity.

We plan to do these through investments or other corporate milestones. We have been lucky enough to be profitable since our inception. This allows us to chase our plans in a very organic manner.

What, in your opinion, is the future of network analytics?

First, there is a need to build privacy protection through privacy engineering. A network analytics platform that does not follow privacy engineering methods risks overstepping the privacy standards of both today and tomorrow. From basic anonymisation to more structural privacy-protection mechanisms, network analytics is expected to reconcile its ability to generate intelligence-driven impact while delivering safe data experiences.

Second, we need to enhance 5G deployment with pointed intelligence guidance. 5G is increasing the complexity involved in operating and managing mobile communication networks. By enabling ubiquitous IoT adoption and creating a standard framework for ultra-low latency applications through edge computing, a 5G network reality will require a great deal of optimisation, largely driven by network analytics.

Niometrics has expanded its footprint internationally with offices in countries such as Singapore, Indonesia, Australia, Greece, and Romania. What has been your most surprising finding about how data is being utilised by companies in different countries?

Perhaps the most surprising finding is that in all countries, no matter where they are in their digital maturity journeys, combining intelligence generation with privacy protection has become a non-negotiable imperative. Those two forces – the need to advance on data insights without compromising on privacy – are becoming more and more indissociable.

And that's how it should be. In Niometrics, we believe that progress in data analytics must come at no cost to privacy. And that advances in privacy protection must not exact any toll on the richness of data analytics. Both must drive each other forward in mutually reinforcing fashion.

What valuable lesson did you gain as a researcher-turned-entrepreneur?

That becoming a researcher-turned-entrepreneur means, first and foremost, surrounding yourself early on with the right people.

Two senior members of our pioneering team (our current CTO, Periklis Akritidis, and our current COO, Zach Tigkas) joined Niometrics in a very early stage, making instrumental contributions to our technology development and business expansion.

While researchers may be used to working predominantly alone, entrepreneurs must tirelessly seek out the support and collaboration of others. It is only through collective efforts, combining different skills and personalities, that ideas can genuinely turn into impact.

STRETCHING THE LIMITS OF COMPOSITE MATERIALS

A STRONG AND TOUGH MATERIAL THAT CAN MORPH, GROW, AND HEAL ITSELF: THAT IS NRF FELLOW DR HORTENSE LE FERRAND'S DREAM.

Today, composite materials form the backbone of nearly every industry in today's world, from transportation and medicine to defence. Materials such as plywood and fiberglass have transformed society as we know it – and Dr Hortense Le Ferrand, an assistant professor at Nanyang Technological University (NTU) and National Research Foundation Fellow, hopes to one day add on to the list.

Dr Le Ferrand arrived in Singapore in 2017 as a visiting research fellow from the Swiss National Science Foundation, and joined NTU's School of Materials Science and Engineering. After spending two years investigating how to use proteins to fabricate materials, she moved to NTU's School of Mechanical and Aerospace Engineering in January 2019.

Since then, she has built a research team that investigates composite materials with a high concentration of reinforcing elements – which, when compared to materials with lower concentrations of reinforcement, are stronger, can withstand higher mechanical loads and impact, and can be used for protection or support applications such as the frames of cars and aeroplanes.

Dubbed the Laboratory for Dense and Multifunctional Composites (LDMC), the team looks at how properties of materials change with the concentration of reinforcement, their orientation, and their position in the matrix. For example, a polymer reinforced with ceramic microdiscs is usually relatively brittle. But when the concentration in the microdisc exceeds 80 per cent, the material becomes very tough and strong. The team also examines closely the potential applications for those materials – for instance, one of the students in the lab is currently developing materials for dental restorations, and another is working on impact shielding.

Furthermore, to ensure that the outcome of the research can be translated for real-world applications, the team is collaborating with biologists and dentists from NTU and the National Dental Centre Singapore, as well as modelling teams from A*STAR's Institute of High Performance Computing. The goal behind two preliminary projects is to fabricate a material that exhibits the same mechanical and biological properties of a tooth to be used as an implant, as well as to better understand how such a material can fail.

While such composites have exciting possibilities, they pose a processing challenge: commonly available composites only contain 60 per cent reinforcement, as maintaining a low concentration of reinforcing elements allows for the ingredients to be mixed homogeneously while avoiding too high viscosity.

Furthermore, in order to pack the elements at a higher concentration, they need to be arranged in a more defined manner, like bricks in a wall. As a result, in order to achieve high-concentration materials with properties for specific applications, scientists have to develop the materials from the raw ingredients, the fabrication process, all the way to the characterisation of the materials' microstructure and properties.

Dr Hortense Le Ferrand is an NRF Fellow (Class of 2020) investigating composite materials. Photo: Dr Hortense Le Ferrand

Despite the challenges involved, Dr Le Ferrand is aiming high for her research. Her plan is to develop an additive manufacturing framework to design the microstructure of composites, drawing inspiration from natural materials, and study the resulting properties.

By the end of the five-year Fellowship period, she hopes to have a fabrication set-up where scientists can control the local microstructure and composition of highly concentrated and complex composites, which could be used to control and predict the local and global mechanical properties of materials – and, ultimately, produce final composites that are ideally as strong as a ceramic, but as tough as metal. Once this method is available, Dr Le Ferrand foresees that there will be opportunities to further change the parameters of the materials, such as its raw chemistry and design, in order to realise specific properties.

In the light of this, Dr Le Ferrand says that the Fellowship is both a great relief, as well as tremendously exciting. Apart from allowing her to focus more on the research, the resources provided – including a team of researchers from multiple backgrounds – will allow her to bring it to fruition.

As for what advice she can give to aspiring Fellows, Dr Le Ferrand says: "I think one unique feature of the NRFF is to promote ambitious, risky, disruptive, yet realisable projects…I would encourage anyone with a big idea to apply."

NRF FELLOWSHIP

TOWARDS ADVANCED ELECTRIC MOTORS

NRF FELLOW ASSISTANT PROFESSOR CHRISTOPHER LEE FROM NANYANG TECHNOLOGICAL UNIVERSITY'S SCHOOL OF ELECTRICAL & ELECTRONIC ENGINEERING IS REINVENTING ELECTRIC MOTORS FOR NEXT-GENERATION VEHICLES AND AIRCRAFTS.

Born and raised in the seaside town of Aberdeen, Hong Kong, Assistant Professor Christopher Lee did not grow up wanting to be a scientist.

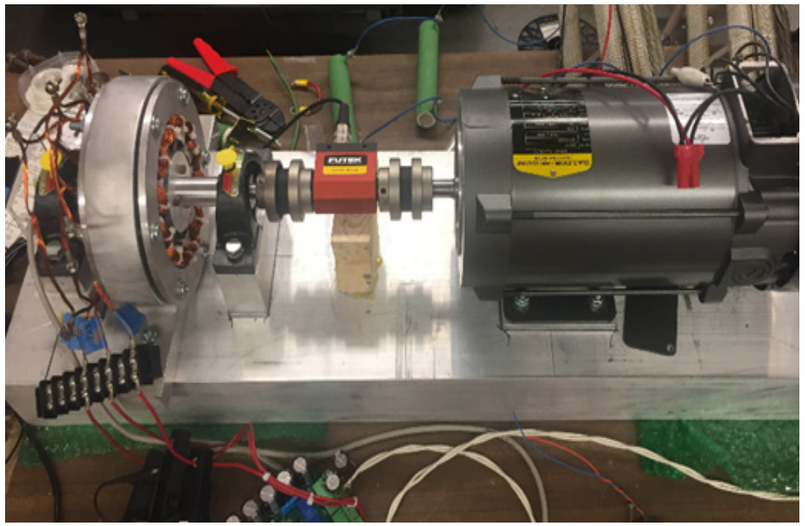
His childhood ambition was to be a high school teacher, which offered a rewarding and stable career. "I planned to study hard and get a good job to change my life," he says. For a while, life seemed to be going according to plan – he graduated from university at the top of his class and became a high school teacher, a career which he thought he would stay in for good.

But that changed in 2011, when tsunami waves hit Fukushima and left many reeling from the nuclear disaster. Watching the scenes play out on the television, Dr Lee realised that his science degree could be put to a better use – in the development and application of other, safer sources of sustainable energy. In March that year, Dr Lee quit his job at the high school and returned to academia at his alma mater, The University of Hong Kong, with this newfound ambition. His bachelor's degree in electrical engineering meant a natural pivot to focus on electric vehicles, which Dr Lee believes is a "very promising solution...to ever-increasing concerns about the energy crisis and environmental pollution".

"I would not say that electricity can replace fossil fuel energy, but I am very confident that electrical energy will step up gradually in the next few decades," he adds. "I can foresee that both fossil fuel and electrical energy will be used in parallel in our future society."

Reinventing a century-old technology

Invented over a century ago, electric motors are today used in almost every modern-day appliance, including refrigerators and computer hard drives. And they are promising – electric cars, for instance, do away with the need for gasoline and diesel by relying on these motors to convert electrical energy into mechanical energy, propelling its motion.



An experimental setup for motor testing. Photo: Dr Christopher Lee

With the move towards such appliances, which are more efficient and power-intensive, increasingly advanced electric motors are required, says Dr Lee. "Existing technology suffers from some inherited problems that cannot fulfill requirements for latest applications. As such, extensive research for further development on this classical technology is very important," he explains.

However, fabricating advanced electric motors is not an easy task, even with the usage of robotic systems that are now commonplace to automate the assembly process. The most challenging part is the fabrication of metal core and permanent-magnet materials, which play a key role in the conversion of electrical energy into mechanical energy using electromagnetism.

Since moving to Singapore and joining Nanyang Technological University (NTU) two years ago, Dr Lee has worked on developing tools to tailor-make metal core and permanent-magnet materials. For example, adding metal alloys can make the materials hardier, which could be useful for situations with higher pressure or temperature.

Now an Assistant Professor at NTU's School of Electrical & Electronic Engineering, Dr Lee is also developing 3D-printing techniques to fabricate auxiliary components in electric motors. These include the screws, frame, shield, seal and flange, which act as the glue to hold and connect the major components of an electric motor. In a bid to produce higher-performing electric motors with greater design

Dr Christopher Lee is an NRF Fellow (Class of 2020) investigating advanced electric motors. Photo: Dr Christopher Lee

flexibility, he wants to eventually 3D-print the metal core and permanent-magnet materials too.

These technologies will be increasingly relevant, Dr Lee explains, as more land, sea and air vehicles become electrified or hybridised (driven by a combination of electric motor and combustion engine). In fact, he and his research team are now working with global MNCs such as Rolls-Royce and Schaeffler Group to develop next-generation electric aircrafts and automated ground vehicles.

Fellowship opens new opportunities

Although electric motors have been around for years, existing research teams usually focus only on one particular area, such as electrical engineering or material science, says Dr Lee. Only a handful of research teams can afford to focus on more than research area – but Dr Lee believes that, in the development of such motors, there is a need to consider different disciplines.

In this, the NRF Fellowship offered a solution. After having successfully applied for the Fellowship last year, Dr Lee now has the resources he needs to assemble a research team involving experts from multiple disciplines – "one of the very few motor teams in the world that can afford to do so".

He is also planning on buying more sophisticated equipment, such as a laser machine for metal customisation, which is seldom seen in material science and motor laboratories. The resources will be channelled towards solving problems in electric vehicles: for example, the team hopes to develop customised materials and components to enhance the performance of electric motors, such as a gearless structure to replace mechanical gearboxes – which are subject to poor lubrication, misalignment, or wear and tear – in existing electric vehicles.

With the support of the Fellowship, Dr Lee has high hopes for the future. "I'm confident that five years from now, our team can become one of the market leaders in the motor field," he says, adding that he hopes that the team's research can someday be widely implemented across the world.

The NRF Fellowship is a competitive programme that provides opportunities for early career researchers to carry out independent research in Singapore. It is open to all areas of science and technology, and outstanding young scientists and researchers of all nationalities are welcome to apply. Application closes on 28 February 2020. Visit www.nrf.gov.sg/NRFfellowship for details.

SCIENCE IN PICTURE

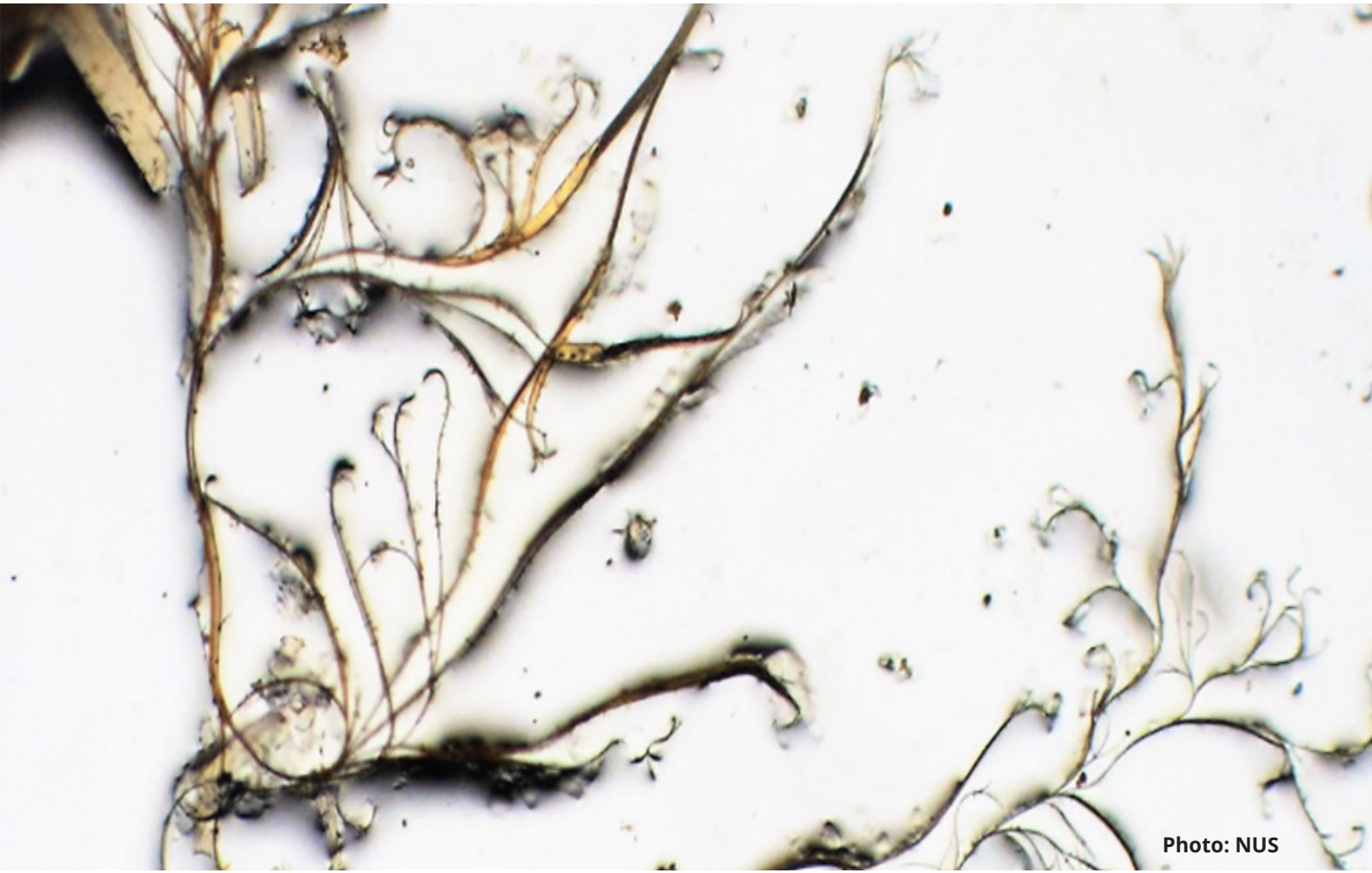


Photo: NUS

Crystals are usually thought of as being naturally beautiful with straight edges and flat sides that can be cut cleanly across, cleaving them into geometric shapes like precious stones and diamonds.

So it came as a surprise to the NUS Chemistry researchers when they obtained normal straight crystals, but also elastically bendable crystals and permanently bent crystals, when they recrystallised trans-4-phenylazobenzoic acid, an organic compound.

This phenomenon is known as 'polymorphism', where the same chemical substance has more than one crystal structure — just like how diamond, graphite, and graphene are all different arrangements of carbon.