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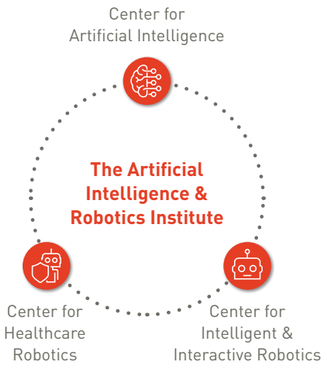

Through the fusion of AI and robot technology, digital human technology would have the ability to communicate with us as naturally as any human being. It is no longer seen as a technology of the distant future, but rather one which will soon be realized and commercialized. The Artificial Intelligence & Robotics Institute is the largest of its kind in Korea, and conducts R&D for fundamental technologies related to AI, next-generation media, and robotics to help solve the social and industrial challenges we face. We will continue to play a leading role in promoting Korea's AI and robotics technology in order to achieve global excellence through the convergence of technology across various related fields.

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Cover Story

Microwave-Processed Red Ginseng Becomes an Asset in Preventing Lung Cancer Metastasis

New Challenge in Adapting to Climate Change

In an effort to lower global temperatures, in October 2020, the Korean government announced its commitment to achieving zero carbon emissions by pursuing carbon neutrality. Developed countries across the world are formulating measures to prepare for climate change, such as stronger greenhouse gas reduction initiatives like the national carbon tax. However, even if we were to stop all carbon emissions immediately, it would be difficult to lower the Earth’s temperature. No one can predict the ramifications if yet another natural disaster threatens our lives in the future.

KIST is rising up to the challenge to better understand and adapt to a global environment affected by climate change through R&D. In July 2021, KIST launched the “Climate and Environmental Research Institute” to conduct R&D on ways to adapt to climate and environmental change.

Establishment of the KIST “Climate and Environmental Research Institute”

As droughts develop into a chronic issue as a result of climate change, interest in “artificial precipitation” is growing. The theoretical possibility of artificial precipitation was first proposed back in 1891. In 1946, the General Electric (GE) Research Laboratory in the United States conducted the first artificial precipitation experiment, in which an airplane sprayed dry ice into clouds. Artificial precipitation experiments were subsequently carried out worldwide until the 1960s, but the lack of any meaningful results led to interest in the technology gradually dissipating. However, as global climate change has recently become a serious issue, attention in the international community is again turning to the potential of artificial precipitation as a way to alleviate droughts and secure alternative water resources.

It might be difficult for Koreans to understand the current situation due to Korea’s abundance of water for a low cost, but Korea is classified as a “water-stressed country” because the amount of water available per person is only 1,488 cubic meters and the water intake rate from rivers is also low at 36%. In 2021, spring precipitation was higher than usual, but average humidity is dropping every year, and wildfires are intensifying. According to an analysis by the Korea Meteorological Administration and the Korea Forest Service, forest fires are occurring earlier in the year, and the size of the fires has continued to increase over the past 10 years, due to the lack of precipitation, dry weather, and frequent strong winds caused by climate change. Large-scale wildfires are also part of a vicious cycle that exacerbates climate change. This is because forests, which are important carbon sinks and reservoirs, are disappearing, and wood burning also generates large amounts of greenhouse gases.

Then, is it possible to solve this increasingly serious climate disaster with science and technology? Currently, the National Institute of Meteorological Sciences is continuing artificial precipitation experiments through aircraft-based cloud seed spraying. However, the rain cloud–forming effect of silver iodide, the compound used in cloud seed spraying, is not very reliable, and there is a high possibility that it will incur adverse environmental effects.

In order to secure a safer and more effective fundamental technology for artificial precipitation, it is necessary to put together more diverse academic and technological capabilities than currently exist. If effectiveness is a concern, it is necessary to increase our understanding of cloud formation and precipitation processes. If side environmental effects are a concern, it is imperative to find a way to reduce the impact on humans and nature by developing more eco-friendly alternatives. To this end, it is essential to formulate a new national R&D paradigm that goes beyond the barriers of existing interdisciplinary research, from the fundamental understanding of weather and climate to the combination of artificial intelligence, big data, chemistry, materials, sensors, and drones.

Since the Industrial Revolution began back in the 1750s, the average global temperature has risen by more than 1 degree Celsius. While this may seem inconsequential, if the temperature of the human body were to rise by the same amount, just 1 degree Celsius, the person would begin to experience abnormal body reactions such as dizziness and shivering.

Our planet is now suffering from an unusual temperature increase. This past summer, heavy rains measuring over 100 mm per hour fell upon China's Henan Province, resulting in more than 350 people dead or missing. Meanwhile, in the Western United States, wildfires incinerated an area 2.6 times the size of the Seoul metropolitan area. And in Córdoba, southern Spain, a heatwave reaching 47.4 degrees Celsius triggered devastating forest fires throughout the region. Altogether, more than 10 of these natural disasters swept across the world simultaneously in 2021. Could it be that these calamities which are threatening humanity are a final warning from the Earth?

Research and Policy as One Team, Research on Climate and Environmental Change

The focus of the research has been on reducing or capturing carbon emissions to prevent climate change. The Climate and Environmental Research Institute aims to develop scientific understanding and innovative technologies for natural phenomena to preemptively respond to climate and environmental change and minimize their effects and damage. KIST is the only research institute in Korea that performs R&D in response to global environmental changes.

Currently, the Climate and Environmental Research Institute is composed of three organizations — the Environmental Welfare Research Group, Water Resource Recycling Research Group, and Clean Air Center. The Environmental Welfare Research Group develops innovative technologies to respond to climate and environmental disasters. The Water Resource Recycling Research Group develops water recycling and recovery technologies to preemptively respond to changes in the water environment. The Clean Air Center identifies and pursues solutions to the causes of air quality change, and acts as the control tower for R&D policy.

The Climate and Environmental Research Institute is the first organization within KIST to consolidate research and policy within one division. It demonstrates KIST's willingness to move away from conducting research that lacks clearly-defined objectives, and instead develop practical technologies applicable to actual climate and environmental changes through cooperation among researchers.

In addition, KIST plans to establish a "climate science research group," consisting of experts in the climate environment and climate change technology areas, within the next two to three years in order to strengthen its research capabilities in the climate sector. By securing basic science capabilities through atmospheric and physical cloud measurement and using research, artificial intelligence, and big data to model the climate and environment, this is expected to create synergies with existing atmospheric and water recycling research.

Priority Project: Artificial Precipitation and Cloud Dissipation Technology

The Climate and Environmental Research Institute will prioritize the development of effective artificial precipitation and cloud dissipation technology in an attempt to use

The Climate and Environmental Research Institute is the first organization within KIST to consolidate research and policy within one division.

science and technology to respond to natural disasters like droughts and floods caused by climate change; for example, KIST is developing a technology that would trigger rain in drought-prone areas and prevent it in flood-prone areas. Their goal with this technology is to induce precipitation of 10 mm per hour.

KIST is focusing on four tasks during the development of artificial precipitation and cloud dissipation technologies. The first task is the development of "new materials." In order to create artificial rain, it is necessary to reach above or inside clouds by using drones or airplanes and spraying condensation nuclei or ice nucleating particles. The Climate and Environmental Research Institute plans to use computational science to develop alternative materials that are more effective than those conventionally used for cloud seeding particles, while also coming up with new materials that could possibly reduce heavy rain. It plans to mass-produce these materials in cooperation with the Korea Institute of Materials Science.

Second, KIST aims to construct its own cloud chamber to simulate the natural precipitation process and optimize precipitation and dissipation efficiency. This project will be accelerated through joint research with the National Institute of Meteorological Sciences, which is now building a cloud physics chamber.

Third, KIST is exploring how to create rain clouds directly, in order to simulate clouds in rising airflow that may occur in cumulonimbus clouds.

If these three tasks are successful, on-site artificial precipitation experiments will be conducted at the Korea Aerospace Research Institute, whose unmanned aerial vehicle technology is ranked fourth in the nation.

Research on seawater resources is also underway, in an effort to desalinate seawater and convert it into drinking water. The research aims to lay the foundation for extracting and utilizing useful resources from seawater, while improving the shortcomings of the existing reverse osmosis method (high energy and high cost). In addition, research to artificially store the discarded water from torrential summer rainstorms in the underground soil layer is also in progress.

If we fail to adapt to rapid climate change, we may face bigger disasters in the future. In this context, research on "greenhouse gas reduction" and "climate change adaptation" is expected to be the focus of the "Climate Change Response Technology Development Promotion Act" to be enacted on October 21 of this year.

Given the current scenario, we cannot delay research that could potentially strengthen our climate change adaptability beyond monitoring and predicting the effects of climate change. Therefore, we hope that KIST will take the lead in establishing a national system that can preemptively respond to the realities of climate change.

In Need of a "Renewal of Perspective" in the Era of Transition

Byung Gwon Lee
Principal Researcher
Clean Energy Research Center

The Era of Transition requires a major shift in perspective. The essence of recent digital transformation is not to replace or destroy existing systems, but simply to bring intelligence to the analogue.

These days, the term "transition" is frequently used in the media. The expression, "great transition," is used for further emphasis. Phrases related to transition, such as "capitalist transition," "civilization transition," and "wealth transition" abound in the aisles of bookstores. What is the rationale for using the term "transition," defined in the dictionary as "changing the condition or direction of," instead of terms like development, progress, or innovation?

It may be due to the perception that our society is at a crossroads in this chaotic era aggravated by COVID-19. Or, perhaps, the bigger reason is the element of "sustainability." For a long period of time, development and innovation in the fields of science and industry have shown a tendency to progress through the annihilation of existing systems. Thomas Kuhn and Joseph Schumpeter referred to this process as "scientific revolutions" and "creative destruction," respectively. Any phenomenon which is unexplained by existing science is transformed by the emergence of new theories. However, the term "transition" seems to retain the spirit of complementary progress, rather than confrontational development with the existing system.

Mankind has a history of great transition. The replacement of more primitive forms of energy, such as wood, coal, and oil, with modern

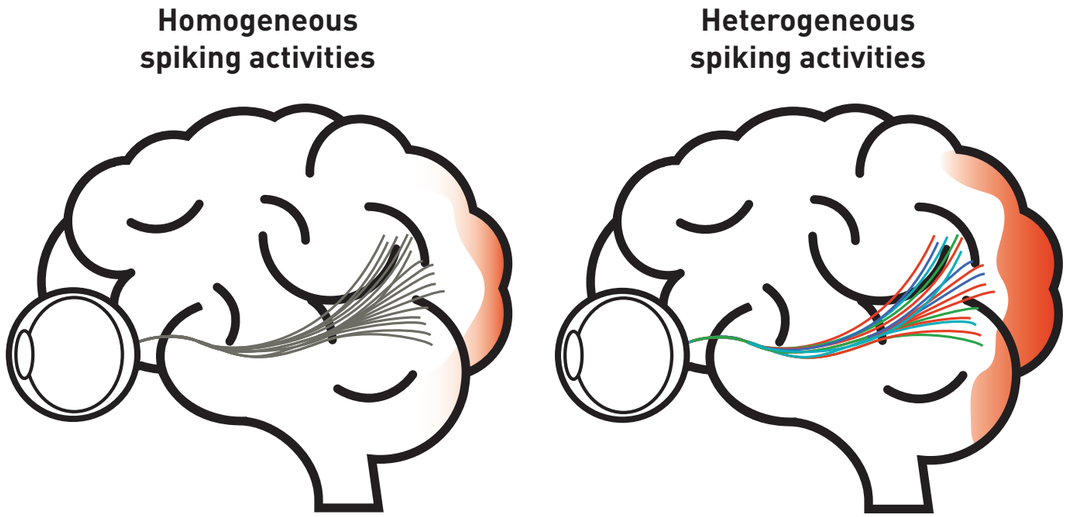
combustion sources was a process of transition in energy. Some scholars seek digital origins from Morse code and Turing machines in the short view, and others in the long view from signal fire, which has been in use since the ancient South American and Chinese Zhu Dynasty. It is a widely known fact that Gottfried Wilhelm Leibniz, who completed the binary system, was inspired by the philosophy behind yin and yang. The simple principle of turning off and turning on brought about dramatic change to human life, because it combines the knowledge and technology of a specific era.

Scholars who study social phenomena explain the “process of transition” and the enormous pressure created by social needs as a driving force for technological and institutional breakthroughs. It creates a niche among existing methods and forms a new system that directs the transition. This pressure is now past its critical point. The task of our time is to find triggers for creating niches in the existing system, such as by identifying so-called “game changers,” and establishing a political, institutional, and cultural infrastructure and consensus that will accelerate the formation of the new system. Science and technology, along with the economic and social systems that mankind has built thus far, have driven the "availability” of imagination; however, it has not yet been made “sustainable.” This is why the Digital New Deal and Green New Deal have emerged as core agendas for our society. The Era of Transition requires a major shift in perspective. The essence of recent digital transformation is not to replace or destroy existing systems, but simply to bring intelligence to the analogue. The transition to a hydrogen economy will also be attributed to lower dependence on carbon resources to a level that can ensure Earth’s sustainability.

We often describe phenomena related to growth, resources, and innovation which contradict with our expectations using words such as “paradox” or “curse.” Climate change and polarization are the products of numerous confrontational and exclusive growth and innovation paradoxes that have cascaded over nature and society. The Era of Transition represents our efforts to overcome this previous era of paradoxes and curses. Hence, we should now heed the perspective of “transition” as we transition from the physical age to the digital age, from the age of engines to the age of fuel celss, and from the carbon age to the hydrogen age.

Diverse Neural Signals are Key to Rich Visual Information!

Maesoon Im
Senior Researcher
Brain Science Institute



Our vision begins at the retina which is the neural tissue located at the back of the eye. The retina encodes our remarkably complex visual world using a wide variety of neurons including light-sensitive nerve cells so-called photoreceptors. It is known that retinal degenerative diseases such as retinitis pigmentosa and age-related macular degeneration gradually destroy the light-sensing neurons, resulting in a profound loss of vision. Although no cure is available for those ailments at this moment, microelectronic retinal prostheses can produce artificial vision by electrically stimulating the remaining retinal neurons such as bipolar cells and ganglion cells. However, such prosthetic vision is still far removed from our normal vision. During the efforts to further improve the quality of prosthetic artificial vision, Dr. Maesoon Im’s group at the Brain Science Institute recently found that the high signal heterogeneity across different retinal ganglion cells is a key element for the efficient transmission of visual information.

See more details at
https://doi.org/10.1109/TNSRE.2020.3048973

“Electric Stimulation Elicits Heterogeneous Responses in ON but Not OFF Retinal Ganglion Cells to Transmit Rich Neural Information”

IEEE Transactions on Neural Systems and Rehabilitation Engineering, 2021

Natural Products, Our Enduring Medicine

At the heart of all the chaos in the Netflix drama "Kingdom" is a little herb, which is capable of triggering an infectious disease that can bring the dead back to life as zombies. And, while the plant featured in "Kingdom" was toxic to humans, in reality, we have been using ingredients from plants as medicines since long ago.

Some of the most famous medicines derived from natural products include penicillin, the world's first antibiotic, developed from blue mold; aspirin, a substance procured from willow bark which has long been used as an anti-inflammatory pain reliever; and Taxol, the first blockbuster anticancer drug, obtained from the yew tree. And the swine flu (H1N1), which was of significant concern prior to the emergence of COVID-19, could have caused just as massive of a pandemic if Tamiflu, produced from star anise, had not been developed as a treatment.

Natural-product-based medicines are made from materials extracted from natural products, such as plants and animals, which are found all around us. They have the advantages of being less toxic and possessing fewer side effects than chemical-based products, and the fact that our ancestors have been using these natural products as medicines since the distant past attests to their safety and effectiveness.

However, there are many challenges that must be overcome in order to produce a medicine that is made from natural products. For instance, it takes a considerable amount of time and human resources to analyze the dozens of compounds contained in natural products, and it is difficult to then determine the mechanism of efficacy of those dozens of compound components. Determining how such a component is absorbed, distributed, metabolized, and excreted by the human body when taken is an important factor in drug development.

Nevertheless, as science and technology continues to move forward, research on natural products is accelerating due to the development of high-speed component analysis technologies. A technology that uses artificial intelligence to predict what compounds are present in natural products and their drug effect mechanisms is actively being developed, in the hopes of accelerating the development process for natural-product-derived drugs.

As the human lifespan becomes longer, and the incidence of chronic, intractable, and other aging-related diseases becomes more prevalent in turn, the importance of discovering new drugs and treatment methods is higher than ever before. With the world still struggling to overcome COVID-19, there is also a growing need for new drugs that can cope with such infectious diseases. Under these circumstances, natural products have a key role to play as a repository for potential new medicines and treatments that can further extend human life expectancy. Let us look forward to seeing what new treatments and medicines natural products have in store for mankind in the future.

Microwave-Processed Red Ginseng Becomes an Asset in Preventing Lung Cancer Metastasis

Extraction of red ginseng components achieved through microwave processing; efficacy on lung cancer metastasis investigated. Findings lead to initiation of research on hemp for treatment of epilepsy

See more details at
https://doi.org/10.1016/j.jgr.2020.02.005

"Ginsenosides Rk1 and Rg5 inhibit transforming growth factor-b1-induced epithelial-mesenchymal transition and suppress migration,invasion, anoikis resistance, and development of stem-like features in lung cancer"
Journal of Ginseng Research, 2020

Jungyeob Ham
Principal Researcher
Natural Products
Research Center

Red ginseng, known as one of the major health functional foods, is prepared by processing ginseng. The processing method is known as the 'nine-steaming nine-drying' method, and as the name suggests, involves steaming and drying the ginseng nine times to enhance the components that are nutritious for the human body and reduce the overall toxicity. In particular, red ginseng is known for the beneficial changes to its components and efficacy depending on the processing method used.

As a result, enhanced red ginseng components are attracting attention and are actively being researched as health functional food substances. The research group at the KIST Gangneung Institute of Natural Products, led by Dr. Jungyeob Ham, has been collaborating with Dr. Hyeon Seok Ko of the Asan Medical Centre to demonstrate that the components in red ginseng are effective in suppressing lung cancer metastasis.

Red ginseng research, triggered by an accidental discovery, leads to the prevention of cancer metastasis

"The process of preparing red ginseng is actually rather time-consuming. One day, we placed white ginseng into a microwave device in an attempt to speed up this process, and we found that the existing white ginseng components were transformed into red ginseng components, and this unexpected result officially initiated our research."

An accidental discovery marked the start of this study. The previous research of Dr. Ham involved processing white ginseng to discover new components and their subsequent effects. However, the challenge lay in the high cost and troublesome processing method for ginseng. At that moment, a microwave device that operated on the same principle as a microwave oven caught his eye.

White ginseng that was subjected to microwave processing in the laboratory underwent a transformation which involved the existing white ginseng components being converted to red ginseng components. It was a positive result, but further investigation was required. Repeatability and reproducibility are fundamentally required to be achieved in research results, and the team needed to verify whether the transformation happened through mere coincidence, or was indeed a genuine result. Since then, the reproducibility was verified for a period of approximately 2 years, and research on the composition of red ginseng by microwave processing was officially initiated in 2013.

A noteworthy point was that the microwave processing accomplished more than just simplifying the process – it also increased the content of Rg3, Rk1, and Rg5 ginsenosides by 20 times compared to that of red ginseng processed using existing methods. The research team named the red ginseng that had been produced by microwave processing "KMxG" and continued to research its efficacy.

The research team selected lung cancer as their target for efficacy testing. Dr. Ham stated, "Red ginseng is fundamentally difficult to obtain, and even if we do obtain it, we cannot easily research its anticancer properties, as only small amounts of the components are present," and added, "We chose lung cancer as our target because lung cancer metastasizes faster than other types of cancer and has a poor prognosis."

In addition to Rg3, which is known to exhibit anticancer effects, the research team

applied Rk1 and Rg5 to "TGF-β1," which is involved in the metastasis of lung cancer cells, and the experimental results showed that metastasis was significantly inhibited.

Although cancer cells were shown to be exterminated at concentrations above a certain level in some instances, Dr. Ham stated, "Owing to the risk of normal cells also being attacked, we focused on developing a substance derived from a health functional food with the characteristics of simply preventing metastasis and improving prognosis," and added, "Both anticancer drugs that destroy cancer cells and metastasis suppressants are being studied as medicinal products."

While performing the research on efficacy, the required equipment was also assembled. The microwave devices used for component conversion were already available in the laboratory; hence, devices which were optimized for processing were needed. Dr Ham was able to successfully secure the pilot-scale microwave devices through active consultation with KIST research equipment experts and other local companies. These devices are able to process 100 kg of white ginseng in a single cycle to extract their components, making them very suitable for research and commercialization purposes. The GMP facility will be also constructed after the appropriate license is obtained.

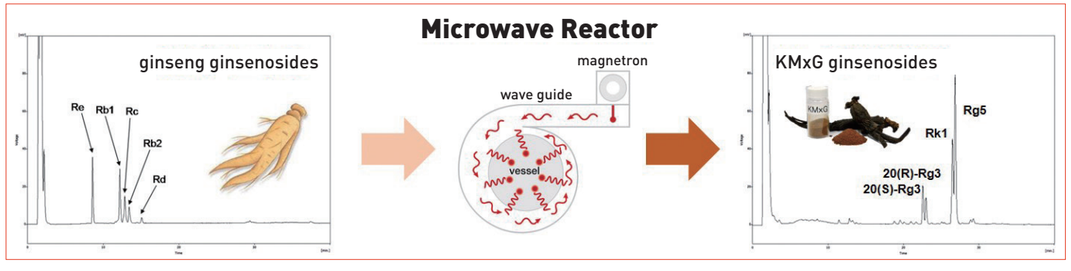
This study was completed as a manuscript in 2020; after more than a year of review, it was accepted for publication in the Journal of Ginseng Research (top 1.786% of JCR) in January of this year. Dr. Ham said, "You could say that this study started by accident, but we seized this opportunity and put in a lot of effort to produce meaningful results," and added, "We expect that our results can be applied to further anticancer drug research and treatments for other diseases." This technology was transferred to Ponin Bio for 800 million Korean won last year.

New potential for hemp with microwaves

Following this success, Dr. Ham began to explore the potential for new plant components through microwave processing. According to him, there are approximately 5,000 species of plants in Korea, with 450 being endemic species. In other words, replicable research can easily be conducted owing to the low number of species.

As plants have limited diversity, in order to provide diversity, some sort of modification needs to be conducted; however, the process

Schematic of the research, ginsenosides of KMxG are increased



KMxG Red ginseng manufactured through microwave processing

of genetic modification is quite complicated. A microwave, in contrast, uses microwaves to generate vibrations, thereby generating heat that alters the molecular structure, meaning that this type of modification is physical, rather than biological.

The next item to be subjected to the microwave device following red ginseng was hemp. If hemp is exposed to decarboxylation, a medical substance called cannabidiol (CBD) can be obtained, which is used as a key ingredient in treating epilepsy. Notably, CBD could be immediately extracted when hemp underwent microwave processing.

The fact that CBD, a rare medical drug, can be easily extracted provided sufficient research value. However, what hindered the research team was the nature and perception of hemp as an illegal narcotic material. Dr. Ham said, "It took us 2 months to persuade the Seoul Ministry of Food and Drug Safety to allow us to apply for research related to hemp, and it was difficult for us to get permission as hemp is fundamentally classified as an illegal narcotic materia in Korea, despite its medicinal properties."

As long as statutes remain unchanged, direct research on hemp will continue to be limited, but a policy termed "regulation freedom privilege" opened up new possibilities. The Regulation Freedom Privilege project started in 2019 and pursues the easing of regulations in specific areas. To study hemp, Dr. Ham pushed for Andong City, which is famous for hemp, and Gyeongsangbuk-do to be designated as applicable areas for regulation freedom privileges, and after much effort, Gyeongsangbuk-do was designated as a special "industrial hemp substantiation privileges" area on July 6, 2020.

In addition, NeoCannBio was established on June 7 of this year with investment assistance from KIST for full-scale research and commercialization purposes. Lately, Dr. Ham is busy serving as the corporate representative. He said, "Currently, Epidiolex and Sativex have been approved as medicinal drugs for epilepsy, although they cost more than 40 million won per year. We are trying to reduce the price for domestic medical drugs to a few million won to ease the pressure on patients and give hope to more than 400,000 potential epilepsy patients."

Dr. Ham declared, "We are hoping to follow up the success we achieved with processing red ginseng and hemp and find breakthroughs by processing various other plants," and added, "The Institute of Natural Products at KIST will endeavor to bring happiness to humanity through our research on natural products."

Lorenzo Oil, a Rare Disease Treatment Created with Parents' Love

Lorenzo Odone, a clever little boy, was diagnosed with the rare disease adrenoleukodystrophy (ALD) at the age of 5. ALD is an incurable genetic disease caused by an abnormal accumulation of fatty acids, which results in death within 2 years of the onset of symptoms. Lorenzo's parents visited specialists, seeking a cure for the disease. Instead, the specialists regarded Lorenzo as an experimental subject. Disappointed by this, the couple embarked on their own search for a cure. Their research of the available literature revealed that olive oil can inhibit the accumulation of saturated fatty acids.

Dr. Don Suddaby, a British biochemist, agreed to help the couple investigate if olive oil could prevent the progression of ALD. They succeeded in extracting pure olive oil and developed a treatment for ALD. Lorenzo, on whom the film "Lorenzo's Oil" is based, miraculously survived to the age of 30. The treatment was subsequently named "Lorenzo's oil", and has been approved by the United States Food and Drug Administration as a treatment for ALD.

Many commercially available treatments feature natural ingredients such as olive oil. Of the 175 small-molecule cancer drugs developed from the 1940s to 2019, 75% are natural compounds, and half of the small-molecule chemicals approved in 2010 are based on natural compounds.

In the 1980s, research on the medicinal value of natural compounds stagnated with the advent and widespread adoption of molecular biology and organic synthesis. Nevertheless, the interest in the medicinal value of natural compounds has been rekindled, as their anecdotal claims of safety were proven in clinical studies.

The identification of medicinally active natural compounds does require substantial time and effort, because many compounds must be screened. However, recent advancements in science and technology have reduced the analysis time required. With the increased prevalence of chronic and intractable diseases coinciding with the increased life expectancy of humans, the development of the next "Lorenzo's oil" through the rapid and accurate analysis of naturally occurring compounds is anticipated.

Lorenzo's Oil movie poster

Twist and Connect, and That's It! "Brain-Mimicking" Artificial Nerve Fibers that Recognize Language

01

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See more details at
https://doi.org/10.1002/adma.202100475

"Dendritic Network Implementable Organic Neurofiber Transistors with Enhanced Memory Cyclic Endurance for Spatiotemporal Iterative Learning"
Advanced Materials, 2021

With the development of the Internet, big data technologies capable of analyzing massive volumes of information flow are attracting much attention. Furthermore, with the advent of artificial intelligence (AI), technologies with rapid and accurate information processing are becoming increasingly important. However, sequential data processing with conventional computer calculations consumes significant time and power for the simultaneous processing of a large amount of data. In response to this challenge, the "neuromorphic computing device," a next-generation AI hardware technology that mimics the nervous system of the human brain, has come into the spotlight for breaking away from conventional hardware technologies.

Dr. Jung Ah Lim and Dr. Hyunsu Ju from the KIST Center of Opto-Electronic Materials and Devices have succeeded in developing an artificial nerve fiber material with structural and functional similarities to those of the human brain using organic semiconductors. The Center is the first of its kind to successfully develop artificial fibers that mimic the nervous system of living organisms.

This device, bestowed with the neuronal and synaptic properties of the human brain, can create a fibrous network by simply twisting and connecting. Because it operates much like our brains, using parallel processing as opposed to a serial connection, it is possible to perform a large number of computations with less energy. It is thus expected to be able to provide low-power neuromorphic computing.

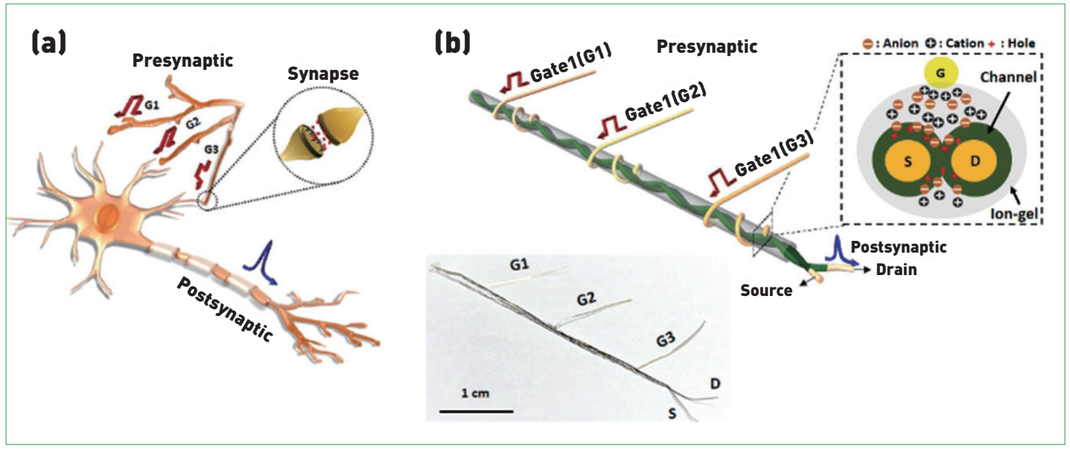
From an idea proposed while chatting, to artificial fibers mimicking the real brain

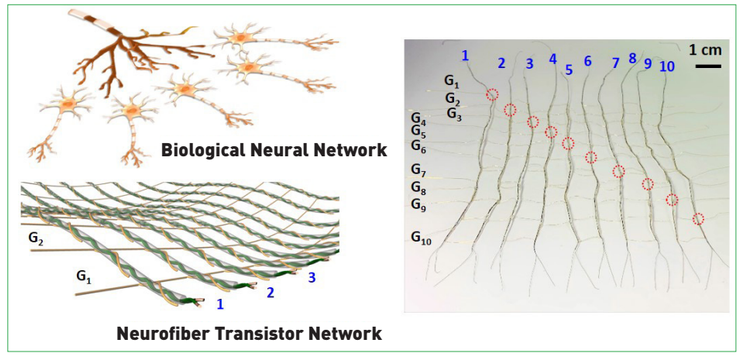
Dr. Lim and Dr. Ju have labs on the same floor, and they often meet to exchange ideas. Previously, they have conducted joint research projects related to common interests, such as semiconductor fingerprints and optical devices, which yielded positive results.

This study also started with a casual chat. In 2019, Dr. Ju knocked on Dr. Lim's door when he heard that Dr. Lim's team had developed a fiber-type transistor that looked like a thread. While they casually chatted, it occurred to Dr. Ju that the fiber-type transistor resembled the structure of the brain.

According to Dr. Ju, neurons have a fibrous structure ending with dendritic trees that simultaneously receive a huge amount of input signals. Signal transmission

(a) Schematic of biological presynaptic and postsynaptic neurons and a synapse
(b) Illustration of the device architecture for neurofiber-Organic Electrochemical Transistors





Schematic of biological neural network and neurofiber transistor network.
Photograph of a 10 × 10 array of neurofibers

The first artificial nerve fibers mimicking the structure of a biological nervous system

is carried out by the movement of ions triggered by electrical stimulations. He felt that this is where the fiber-type transistor developed by Dr. Lim might come into play, because it has all the conditions, such as electrical stimulation and ions, for developing an artificial fiber device.

When he gave the background for the joint research proposal, Dr. Ju explained, "Dr. Lim's device structure has two twisted wires. I felt that any number of nets could be created by just winding as many gates as needed. The human nervous system also looks like a net, so I thought it would be possible to create a system with a similar operation mechanism."

Expected to be applicable for motion control and signal processing in soft robots

After spending a significant amount of time and effort developing artificial fibers that resemble the human brain by testing different materials and memory characteristics, Dr. Lim succeeded in developing a memory transistor that can memorize and transmit signals with the magnitude of an electrical signal. Like a synapse, a redox reaction occurs between the ions present in the semiconductor and insulating film depending on the magnitude of the electrical stimulation arriving through the electrodes of the fiber-type transistor.

The artificial nerve fiber she developed exhibited properties of a neuron, with multiple electrical signals from different electrodes being naturally integrated in one device. Dr. Lim explained, "While existing neuromorphic hardware studies have mostly focused on only one behavioral characteristic of the nervous system, we have implemented a device that has both neuronal and synaptic properties, which is very similar to the behavioral characteristics of neurons in living organisms."

After developing the device, Dr. Lim also produced an artificial neural network consisting of 100 synapses by simply twisting artificial nerve fibers. By twisting more artificial nerve fibers, efficient large-scale AI training is expected to be possible.

Dr. Ju conducted a speech recognition training exercise with the developed artificial neural network and confirmed a speech recognition rate of 88.9%. He explained, "It is difficult even for humans to understand spoken language without missing a word. A speech recognition rate of 88.9% can be considered sufficient for the operation of a neuromorphic computing device."

Furthermore, the research team also investigated organic semiconductor-based neuromorphic devices that were incapable of repeated learning. They confirmed that

the device characteristics were maintained even upon completion of more than 50 test runs.

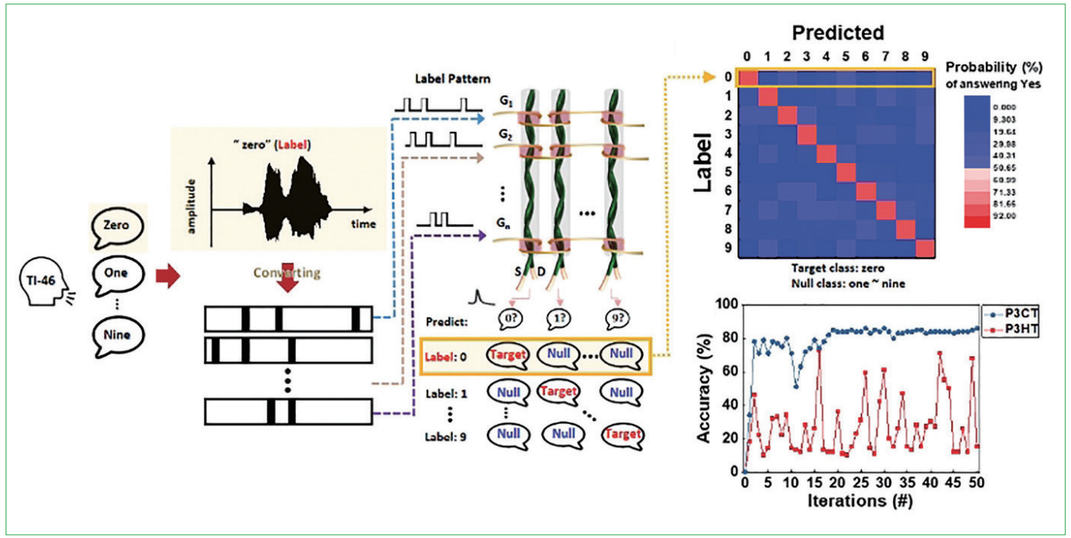
The two researchers expect that the proposed device can be used as a wearable device and in robotics for AI semiconductor devices. They chose soft robotics, in particular for motion control and signal processing, as the field in which the device would be first applied.

While admitting the limitations of the proposed device in its application to smart robots, Dr. Lim explained, "They used organic semiconductors, which leaves much to be desired compared to silicon semiconductors in terms of performance and speed. Parts of our nervous system, such as the cerebrum, cerebellum, and peripheral nerves, have their own roles, as do the individual parts of an artificial intelligence robot. Since the developed device has the advantages of low energy and flexibility, it will be able to play the same role as the peripheral nervous system, which is an intermediate bridge transmitting signals to the brain."

Dr. Ju noted, "Current AI systems require lengthy computations just to learn a single image, given insufficiencies caused by the fundamental design differences between the human brain and computers." He emphasized, "With the application fields for AI constantly increasing, much effort will be put into reducing the inefficient level of power consumption for AI training so that smart robots can learn and solve problems similar to human beings."

"Expected to serve as an intermediate bridge for brain signal transmission in soft robotics" Dr. Lim explained.

Process of speech recognition with the tempotron using the neurofiber



02

Accelerating the Commercialization of Lab-Level Artificial Photosynthesis Technology

Hyung-Suk Oh
Principal Researcher
Clean Energy Research Center

See more details at https://doi.org/10.1016/j.apcatb.2021.120427
W@Ag dendrites as efficient and durable electrocatalyst for solar-to-CO conversion using scalable photovoltaic-electrochemical system
Applied Catalysis B: Environmental, 2021

The changing weather is a sensitive factor when it comes to research on solar energy. In rainy or cloudy conditions, it is difficult to obtain research data, leading to the experiments being repeatedly interrupted. Last summer, Korea experienced over 40 cloudy days and frequent heavy rainfall events. Dr. Hyung-Suk Oh and Dr. Woong Hee Lee from the Clean Energy Research Center, who had long been waiting for summer to come so they could conduct their research on solar energy utilization, also felt anxious about doing their research under a dark, overcast sky.

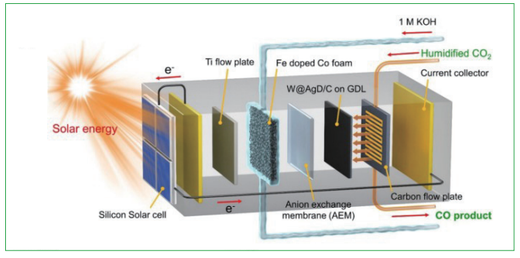
When the rain finally stopped in September, Dr. Oh's team rushed up to the rooftop to begin running experiments with their solar cell-based artificial photosynthesis system, which converts carbon dioxide to carbon monoxide. In a test run, they achieved a conversion efficiency of 12.1%, the highest ever recorded for an artificial photosynthesis system based on silicon solar cells. It was especially meaningful because the system achieved a high conversion efficiency despite the cloudy weather.

Dr. Oh, who led the research, said, "It was a breakthrough study that overcame the limitations of artificial photosynthesis research, which could not go beyond the small, lab-level scale." "It revealed the possibility that lab-scale technology for achieving carbon neutrality can evolve into a practical technology," he added.

An unexpected effect of the silver-tungsten mixture: a branch-like catalyst for enhancing efficacy

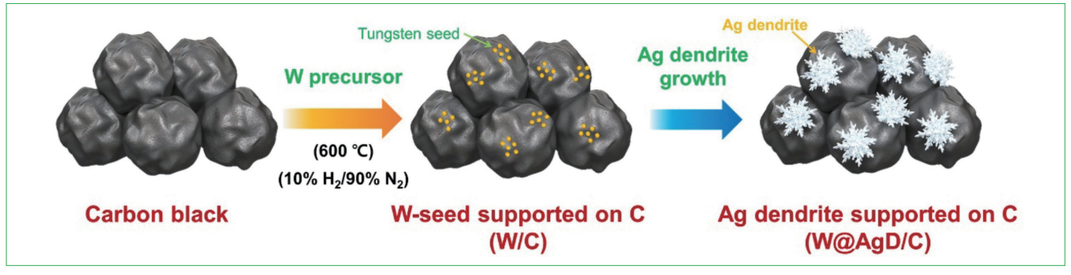
The purpose of this artificial photosynthesis R&D project conducted by Dr. Oh's team is to prevent climate change. Due to severe climate change, the Earth is becoming increasingly impacted by frequent natural disasters, such as floods, droughts, and forest fires, of unprecedented magnitude and impact. Without a drastic reduction in greenhouse gas (GHG) emissions, the global temperature will soon rise above its pre-industrialization level, which will likely bring about even more serious disasters. To reduce GHG emissions, many countries, including Korea, have declared a timeline to reach "carbon neutrality," i.e., net zero emissions.

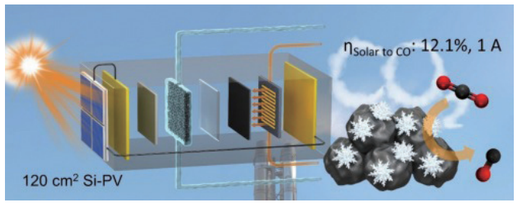
Due to severe climate change, the Earth is becoming increasingly impacted by frequent natural disasters



Schematic of solar-to-CO conversion system

Synthesis process and physical properties of W@AgD/C





Carbon-supported tungsten-seed-based 3D silver dendrite catalyst

One of the technologies that has attracted attention in relation to carbon neutrality is artificial photosynthesis. Similar to green plants using sunlight to synthesize food, artificial photosynthesis is a technology that converts carbon dioxide into high-value-added chemical compounds using solar energy. However, due to low economic feasibility and technological limitations, the related R&D remains at the laboratory level, and there are still significant challenges on the road towards commercialization.

In an effort to overcome this challenge, the research team led by Dr. Oh and Dr. Lee sought to manufacture catalyst electrodes and a large-scale artificial photosynthesis system that could achieve artificial photosynthesis in a natural sunlight environment.

First, they developed a novel tungsten-silver catalyst that could catalyze the conversion of carbon dioxide to carbon monoxide. According to the research team, silver is widely used as the catalyst for CO_2-to-CO conversion, but repeated use reduces its efficiency due to the surface area being reduced as a result of particle formation and agglomeration.

To address this drawback, Dr. Oh utilized tungsten, a known stabilizer. Although it is not yet commercialized as a raw material for catalyst production, it is occasionally used to enhance durability.

When the silver and tungsten were mixed, an unexpected result was achieved. Using the tungsten as seed material, the silver grew, generating nanoscale-sized, branch-like crystal structures. As the surface area increased due to the branching structure, performance also improved. The conversion efficiency increased with the increasing surface area proportional to the branch arrays generated. CO production efficiency improved by over 60% compared to a silver catalyst, and the silver-tungsten catalyst maintained high stability even at the end of a 100-hour test run.

Combination of catalyst and sunlight: conversion of carbon dioxide to carbon monoxide

The research team also developed a system that can convert carbon dioxide to carbon monoxide in a natural sunlit environment using their catalyst. To create a silicon solar cell optimized for artificial photosynthesis, optimal electrochemical reaction conditions were set prior to assembly. As a result, an artificial photosynthesis system was completed by combining the catalyst developed by the team with a 120cmx120cm silicon solar cell, and it was confirmed that it could be used without difficulty when connected to a commercial solar cell. Above all, achieving a high-efficiency CO_2-to-CO conversion was possible using only solar energy.

"We used purified carbon dioxide in the test. Since various other substances besides carbon dioxide are mixed in with the emissions from the chimneys of steel mills and petrochemical plants, we will conduct additional research to enable a direct capture of emissions and immediate conversion to carbon monoxide," added Dr. Oh.

Dr. Oh explained that hydrogen energy can also be obtained from solar energy with this device by exchanging the

Implemented an artificial photosynthesis system in commercial silicon solar cells

Silicon Solar Cell-Artificial Photosynthesis System

catalyst. “Since distributed power generation is possible, it can be used as a charging station for fuel cell bikes or as a hydrogen power charger for military purposes,” he added. Given the keen interest in hydrogen energy, this research is being conducted separately by other researchers from the same team.

The carbon monoxide obtained using the device is a pure substance that does not mix with other substances and has a variety of application possibilities, such as supporting catalyst regeneration and chemical reactions, as well as acting as an oxygen barrier. It is used as a raw material in the chemical industry or as a catalyst to reduce other chemical species.

For instance, by adjusting the voltage of the device, syngas mixed with hydrogen and carbon monoxide can be derived. “Syngas acts as an intermediate for the manufacture of synthetic petroleum products, and thus deserves more attention from small and medium-sized enterprises,” said Dr. Oh.

The lab-made tungsten-silver catalyst improved CO_2-to-CO conversion efficiency

Recently, stronger carbon reduction measures have been announced in Europe, such as a carbon border tax as well as the carbon tax. Korean companies which rely on overseas markets are thus compelled to adjust their carbon dioxide emissions. With the increasing market penetration of electric vehicles, petrochemical companies are also seeking new business models to ensure their survival.

However, new technologies such as carbon dioxide conversion are having difficulty entering the commercialization stage due to their low economic feasibility.

Dr. Oh confirmed the situation, saying, “Even though companies show keen interest in joint research to reduce carbon emissions, its implementation is a great challenge because there are still many technologies whose economic feasibility is yet to be established.” He concluded, “Ultimately, we have to find a technology that can replace the petrochemical industry. We will further develop our technologies to make them economically attractive to companies and keep conducting research to make them applicable to more diverse areas.”

This study, which was jointly conducted with Professor Jae Su Yu’s team at Kyunghee University, was published in Applied Catalysis B: Environmental, an international journal that publishes research in the fields of energy and the environment.

KIST-KRISS Quantum Technology Collaboration, the Birth of "Quantum Dream Team"

A quantum is the smallest unit of physical property. As can be guessed, a quantum cannot be further divided, and the property enables us to develop fundamentally unhackable communication systems.

Quantum research has produced a number of Nobel Prize laureates. The physicist Max Planck was awarded the Nobel Prize in 1918 for the first-ever quantum theory, and Albert Einstein won the Nobel Prize in 1905 for explaining the photoelectric effect by introducing quantization of light. Other Nobel Prize winners include Werner Heisenberg (1932), Max Born (1954), and Alexander Prokhorov (1964).

Quantum mechanics was particularly instrumental in advancing physics to what it is today. Quantum physics is a key concept in solid-state physics, and the development of this field led not only to the creation of the transistor, but also to the foundation of much of today's electronic engineering.

In 2014, the Ministry of Science, ICT and Future Planning (currently the Ministry of Science and ICT) promoted the "mid- and long-term strategy for quantum information and communication" and launched quantum research at the national level. The stated goal was to develop a 5-qubit quantum computer by investing about 43.5 billion won ($36.7 million) by 2023.

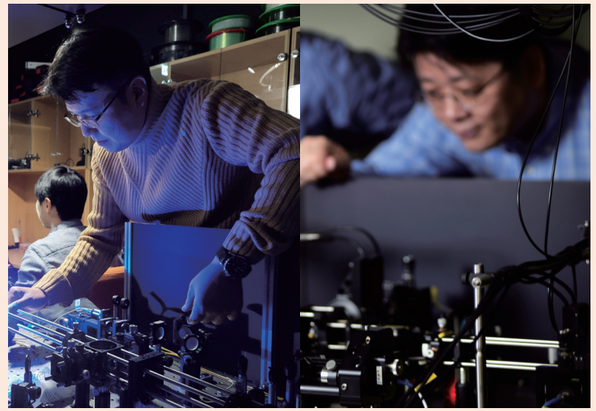
Scientists had recognized the importance of quantum technology and started research even before the government had set up a strategy. The KIST Quantum Information Research Center was central to this strategy. KIST established the first-ever quantum-specialized research organization among state-run research institutes in 2012, which is currently conducting studies on quantum communication, quantum computing, quantum simulation, and quantum sensors. In order to secure fundamental technology for long-distance quantum networks and large-scale quantum information processing, research is underway, ranging from quantum materials to systems.

In addition to KIST, the Korea Research Institute of Standards and Science (KRISS) and the Electronics and Telecommunications Research Institute (ETRI) are researching and developing quantum communication technology, and the National Security Research Institute is conducting research and development projects related to quantum key distribution and authentication, as well as verification technology.

All of these are under the rubric of quantum cryptography, but each institute has different strengths. KIST possesses excellent technology in the field of wired quantum cryptography communication, where communication occurs between optical cable networks.

So what is quantum cryptography? Quantum cryptography communication is an area of research in preparation for the possible weakening of the existing encryption system due to the development of quantum computers. It is a technology that communicates bits of information using light particles called "photons" and is known to have excellent security properties, due to the indivisible property of photons. Quantum cryptography can fundamentally prevent hacking threats by detecting the threat in advance when a third party attempts to break into the system.

Mobile telecom operators were the first to jump into the field of quantum cryptography in Korea, as they sought to protect their systems from hacking threats. SK Telecom started conducting research on quantum communication in 2011, and KT has since followed suit. KT opened a research center for quantum communication applications in cooperation with KIST, and is currently conducting research on the practical use of quantum quantum communication.



The Quantum Dream Team, KIST(left) and KRISS(right)

As a result, in 2018, KIST succeeded in establishing a one-to-many (1:N) test network for quantum cryptography communication through the joint research with KT. Designed so that one server and multiple clients exchange quantum encryption keys at the same time, it demonstrated the possibility of economical network construction by establishing a stable network of multiple nodes with one device. Dr. Sang-wook Han, director of the KIST Quantum Information Research Center, elaborated, "Korea's quantum cryptography communication technology is in the testing and verification stage prior to commercialization. China and Korea are the most advanced places that are promoting full-scale commercialization by private telecom operators."

KIST's success is expected to be ranked as the world's first R&D achievement based on its fields of research over the years. It was the shipbuilding industry that deployed the world's first quantum cryptography communication system. In December 2020, KIST formed a consortium with KT and successfully established a major secure communications infrastructure between the special ship division of Hyundai Heavy Industries, the main business building, and the offshore plant. Hyundai Heavy Industries claimed that through this project, it would be able to build a perfect security system to protect defense technology and industrial technology.

The Korean goverment and science and techonlogy policy experts begin to pay more attention to quantum techonlogy. Consequently, investment in quantum technology has increased dramatically. But can we create a legend just by pouring money into it? Dr. Han said, "The priority is to create an ecosystem that nurtures ample human resources in this field." The number of companies that can absorb the greatest amount of human resources by nurturing such human resources should increase and lead to an increase in related devices and services.

Dr. Han added the following:

The quantum communication devices currently supplied to KT and Hyundai Heavy Industries are developed and made in KIST. In the future, we need to create conditions so that small- and medium-sized enterprises can do this. Since we have developed sufficient basic technology to be able to commercialize products, we need to support interested companies, create special zones, and so forth to create opportunities for establishing the industry.

Despite the small number of specialists, domestic researchers are constantly seeking ways to cooperate to advance the field of quantum technology. As part of that effort, KIST and KRISS signed an agreement in March 2021.

The two institutes also decided to introduce an adjunct staff system for practical research cooperation. Visiting researcher qualifications are granted to researchers from both sides to facilitate access to related research facilities. In addition, for the next six years, KRISS, located in Daejeon, will share KIST's equipment and experimental spaces in Seoul and Suwon, and undertake collaborative tasks in the !eld of common research.

All involved intellectual property rights are to be jointly applied for and managed. From the start of the research to the management of the results, the two parties will work together closely. The annual joint budget is around 10 billion won ($8.44 million), and about 60 researchers are expected to be involved.

It is rare for state-run research institutes to jointly create such a diverse system for effective collaboration. We hope that researchers from both institutes will take an internationally leading position as a quantum technology "Avengers" team.

Research News. 01

Bio/Medical

Flickering the Neural Activities with LED Lights

See more details at
https://doi.org/10.1126/sciadv.abb9841

"A bird's-eye view of brain activity in socially interacting mice through mobile edge computing (MEC)"

Science Advances, 2020

Ji-hyun Choi
Principal Researcher
Brain Science Institute

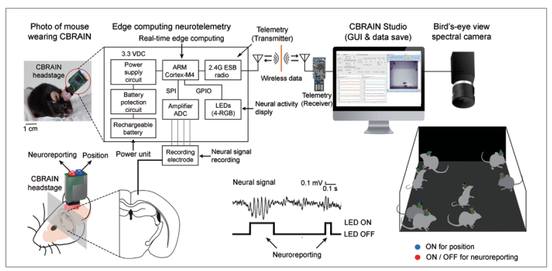
Living in a group has clear benefits. As a member of a societal group, one can share resources with the others, seek protection from predators, and forage in an efficient manner. In a 2020 paper published in Science Advances, the neuroscientist Jee Hyun Choi and her student Jisoo Kim of the Brain Science Institute argue that there are much more stories about the advantages of group living and social behaviors to the mammalian brain yet to be discovered. Their research was conducted using CBRAIN (Collective Brain Research Aided by Illuminating Neural activity), a unique neuro-telemetric device equipped with LED lights, which enables the measurement and real-time analysis of collective brain activities.

While many experiments were performed to determine the individual behaviors and stances under cost-benefit schemes, the question of how a group of animals form specific social behaviors has been receiving growing interests from the neuroscience community. Understanding how the individuals strategize to produce a concrete group behavior is central to understanding the social groups and their behavioral phenotypes. For instance, recent studies have found that the overall risk imposed on the predators during successful predation attempts is reduced when predation was coordinated as a group.

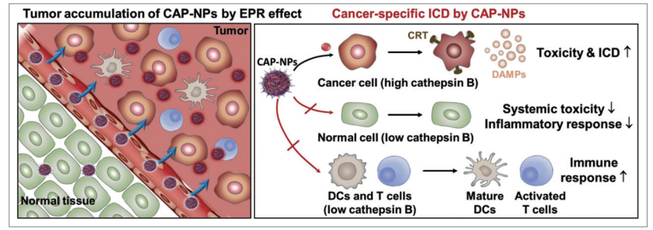
In collaboration with Sung Q Lee of the ETRI in South Korea, the research team developed CBRAIN, a wireless recording device with an edge-illuminated LED that fits on the head of a mouse. This tiny device was implanted in the subcortical brain to collect the voltage signals from specific sub-region of the amygdala called the basolateral amygdala (BLA), which is a brain area known to be highly sensitive to emotional stimuli such as stress and anxiety. When the frequency-specific rhythmic activity on the board occurs during a real-time scanning of the neural activities, the LED on the device is lightened up. These rhythmic events, along with the signals from a group of mice, are transmitted to a receiver. CBRAIN's ability to generate a live report of collective brain activities is striking in contrast to other neural recording devices that analyze the signals after all experiments are completed.

Choi and her team developed experimental protocols to confirm the electrode coordinates and calibrated transient fast rhythms in BLA comprised of the gamma frequency range, called the gamma bursts, across mice. The researchers studied this bursting phenomenon during active and passive displays of fear when a large group of mice was under attack by a spider-like robot. Using CBRAIN, they observed that the occurrence of the gamma bursts during fear-driven behaviors were dependent on the social situations. Mice displayed less gamma bursts when they encountered the robot as a group, and the mice avoided and defended themselves against the robot in a group, just as they do in the nature.

Schematic diagrams of the CBRAIN system



Unlike conventional cancer drugs that attack and kill cancer cells directly, anti-cancer immunotherapy, which kills cancer cells by strengthening the body's immunity, is a novel type of cancer treatment currently attracting increased attention. Unfortunately, a minority of cancer patients who have some degree of pre-existing immunity only benefit from anti-cancer immunotherapy.



Schematic illustration of preferential immune responses during the cancer-activated DOX prodrug nanoparticle-based chemotherapy

Recently, 'doxorubicin', a cancer treatment drug, has been shown to boost patients' immune response by releasing various components when cancer cells are killed. However, as the toxicity and inflammatory responses induced by doxorubicin can affect normal cells in addition to cancer cells, it can lower patients' immunity levels, which limits its effectiveness for immunotherapy.

To tackle this issue, a research team led by Dr. Ju Hee Ryu of the Center for Theragnosis has developed an anti-cancer prodrug that can improve anti-cancer immunotherapy by reacting only with cancer cells, thereby minimizing the toxicity to normal cells, including immune cells, and boosting patient immunity.

Last year, the Center for Theragnosis at KIST reported the development of an anti-cancer drug that targets cancer cells by suppressing the resistance to doxorubicin without reacting with normal cells. In contrast, Dr. Ryu's research team has developed a prodrug for anti-cancer immunotherapy that utilizes the immunity-boosting potential of doxorubicin.

The developed prodrug exhibits anticancer effects when activated by abundant enzymes present in cancer cells. As these enzymes are not present in normal cells, they do not experience toxicity and inflammatory responses. The ability to target cancer cells exclusively increases patient immunity, inducing an active anticancer immune response when doxorubicin is activated in cancer cells.

The developed anti-cancer drug significantly improved the anti-cancer immune response in nonclinical animal models and reduced side effects associated with inflammatory responses and toxicity in normal tissues. Therefore, the drug dosage can probably be increased to enhance its effectiveness for chemotherapy without causing notable side effects.

In addition, because the prodrug was developed by utilizing a drug already in clinical use, the commercialization process is expected to be relatively straightforward in terms of clinical trials and mass production.

Ju Hee Ryu
Senior Researcher
Theragnosis
Research Center

Research News. 02

Bio/Medical

Anti-Cancer Immunotherapy Drug with Reduced Side Effects and Increased Therapeutic Effects

See more details at
https://doi.org/10.1016/j.biomaterials.2021.120791

"Cancer-activated doxorubicin prodrug nanoparticles induce preferential immune response with minimal doxorubicin-related toxicity"

Biomaterials , 2021

Research News. 03

Material/Systems

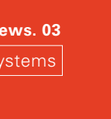
Hydrogen Peroxide, Universal Oxidizing Agent, High-Efficiency Production by Simple Process

See more details at
https://doi.org/10.1016/j.actamat.2020.116563

"Solid-Solution Alloying of Immiscible Pt and Au Boosts Catalytic Performance for H_2O_2 Direct Synthesis"

Acta Materialia 2021

Sang Soo Han
Principal Researcher
Computational Science Research Center



Hydrogen peroxide is used as a disinfectant, after dilution in water, to treat wounds. It is widely used across the industry as an eco-friendly oxidizing agent for impurity removal from semiconductors, waste treatment, etc. Currently, it is mainly produced by the sequential hydrogenation and oxidation of anthraquinone (AQ). However, this process is not only energy intensive and requires large-scale facilities, but AQ is also toxic.

As an alternative to the AQ process, hydrogen peroxide direct synthesis from hydrogen (H_2) and oxygen (O_2) using a palladium (Pd) catalyst was proposed. However, the commercialization of the technology has been challenging because the amount of water (H_2O) formed is more than hydrogen peroxide (H_2O_2) during the process.

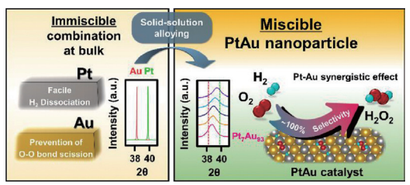
A joint research team of Dr. Sang Soo Han and Dr. Donghun Kim (Computational Science Research Center), Dr. Seung Yong Lee (Materials Architecturing Research Center), and Professor Kwan-Young Lee at Korea University (Korea University, President Jin Taek Chung) developed a platinum-gold alloy catalyst for hydrogen peroxide production based on a computer simulation. Hydrogen peroxide selectivity can be increased to 95% by using this catalyst, compared with only 30-40% for a palladium catalyst, which indicates that mostly hydrogen peroxide on the developed Pt-Au catalyst can be produced with a small amount of water.

The joint research team between KIST and Korea University developed a new type of Pt-Au alloyed nanoparticle catalyst. Although it is difficult to homogeniously mix Pt and Au to develop an alloyed catalyst due to the intrinsic immiscibility of the metals, the researchers could successfully synthesize nanoparticles in the form of alloys by forcibly reducing precursors of Pt and Au. Also, using this method, the content of each metal particle could be controlled by adjusting the amount of precursors of Pt and Au.

Hydrogen peroxide can be produced anywhere without large equipment by simply injecting both hydrogen gas and oxygen gas into an aqueous solution using the catalyst developed by the researchers. Unlike the Pd catalyst, the catalyst developed by the joint researchers can produce hydrogen peroxide up to 95% even at ambient temperature (10 ˚C) and atmospheric pressure (1 atm). In addition, a catalytic reaction can be maintained for longer than 8 h, resulting from the structural stability of the catalyst.

The researchers clearly established the crystal structure of Pt-Au alloy nanoparticles by performing additional computer simulations, which is difficult to solve using general material analysis techniques. Furthermore, the catalytic reaction mechanism via computer simulations was proposed at the atomic level in which the reason why the catalytic performance for hydrogen peroxide production is increased with increasing Au content was also clarified.

Schematic of gold-platinum nanoparticle composite



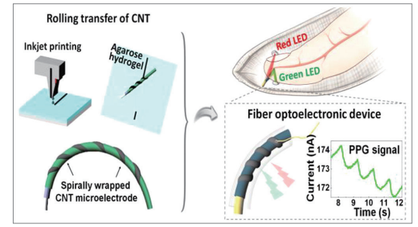
Optoelectronic devices are generally constructed using layers of semiconductors, electrodes, and insulators; their performance is greatly affected by the size and structure of the electrodes. Fiber electronic components for e-textiles need to be fabricated on thin, pliable threads; since these devices cannot be wider than threads having diameter of a few micrometers, it is a challenge to improve the performances of such fiber electronic components. However, a team of Korean scientists has been receiving attention after developing a new technology to overcome these limitations.

A team of researchers, led by Dr. Hyunjung Yi and Dr. Jung Ah Lim, at the Post-silicon Semiconductor Institute have developed a technique to manufacture fiber electronic components, such as transistors and photodiodes, with desired electrode structures by wrapping. Specifically, the desired electrode array can be fabricated using an inkjet printer, and an electrode thread coated with a semiconductor surface is rolled on top of these electrodes.

In 2019, Dr. Yi and her research team developed a technique to build an electrode array on a given surface by printing carbon nanotube (CNT) ink on a template made of a hydrophilic hydrogel and transferring the CNT ink to the desired surface (Nano Letters 2019, 19, 3684-3691). Once printed on the hydrogel, the CNT electrodes behave in a manner similar to floating on water.

Hence, the researchers predicted the possibility of transferring such electrodes intact to the surfaces of fibers by rolling the fibers on the electrodes. In a collaborative study with Dr. Lim and her team, the researchers were able to develop high-performance fiber electronic components without damaging the semiconductor layer or CNT electrodes. The fiber transistors wrapped with CNT electrodes maintained stable performances of at least 80% even with a sharp bend radius of 1.75 mm.

Using the semitransparent property of the CNT electrode, the researchers have also succeeded in developing fiber photodiodes to detect light by wrapping the CNT electrodes around electrode threads coated with a semiconductor that produces current upon absorption of light. The fiber photodiodes can detect a wide range of visible light and have excellent sensitivities that are comparable to those of rigid components. The researchers manufactured a glove from a fabric containing these photodiodes and light-emitting diodes (LEDs). The LEDs produce light, and the photodiodes measure the intensity of the light reflected by the fingers, which changes according to blood flow. Thus, the glove can be used to measure the wearer's pulse.



A schematic diagram of the photoelectric device implementation strategy for human signal monitoring with CNT electrode transcription

Hyunjung Yi
Principal Researcher
Center for Spintronics

Jung Ah Lim
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Center for Opto-Electronic Materials and Devices

Research News. 04

Material/Systems

Soft and Comfortable E-Textiles that can be used to Measure Pulse

See more details at
https://doi.org/10.1021/acsnano.0c07143

"Spirally Wrapped Carbon Nanotube Microelectrodes for Fiber Optoelectronic Devices beyond Geometrical Limitations toward Smart Wearable E.Textile Applications"

ACS Nano 2020

Research News. 05

Energy/Environment

Ceramic Fuel Cells: Reduced Nickel Content Leads to Improved Stability and Performance?

See more details at
https://doi.org/10.1016/j.actamat.2020.116580
"A nanoarchitectured cermet composite with extremely low Ni content for stable high-performance solid oxide fuel cells"
Acta Materialia 2021

Ji-Won Son
Principal Researcher
Energy Materials
Research Center

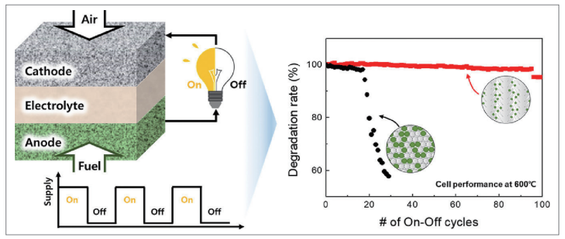
A research team in Korea has developed a ceramic fuel cell that offers both stability and high performance while reducing the required amount of catalyst by a factor of 20. The application range for ceramic fuel cells, which have so far only been used for large-scale power generation due to the difficulties associated with frequent start-ups, can be expected to expand to new fields, such as electric vehicles, robots, and drones.

A team led by Dr. Ji-Won Son at the Energy Materials Research Center, through joint research with Professor Seung Min Han at the Korea Advanced Institute of Science and Technology has developed a new technology that suppresses the deterioration brought on by the reduction-oxidation cycle, a major cause of ceramic fuel cell degradation, by significantly reducing the quantity and size of the nickel catalyst in the anode using a thin-film technology.

Ceramic fuel cells, representative of high-temperature fuel cells, generally operate at high temperatures - 800°C or higher. Therefore, inexpensive catalysts, such as nickel, can be used in these cells, as opposed to low-temperature polymer electrolyte fuel cells, which use expensive platinum catalysts. Nickel usually comprises approximately 40% of the anode volume of a ceramic fuel cell. However, since nickel agglomerates at high temperatures, when the ceramic fuel cell is exposed to the oxidation and reduction processes which accompany stop-restart cycles, uncontrollable expansion occurs. This results in the destruction of the entire ceramic fuel cell structure. This fatal drawback has prevented the generation of power by ceramic fuel cells from applications which require frequent start-ups.

In an effort to overcome this, Dr. Ji-Won Son's team at KIST developed a new concept for an anode which contains significantly less nickel, just 1/20 of a conventional ceramic fuel cell. This reduced amount of nickel enables the nickel particles in the anode to remain isolated from one another. To compensate for the reduced amount of the nickel catalyst, the nickel's surface area is drastically increased through the realization of an anode structure where nickel nanoparticles are evenly distributed throughout the ceramic matrix using a thin-film deposition process. In ceramic fuel cells utilizing this novel anode, no deterioration or performance degradation of the ceramic fuel cells was witnessed, even after more than 100 reduction-oxidation cycles, in comparison with conventional ceramic fuel cells, which failed after fewer than 20 cycles. Moreover, the power output of the novel anode ceramic fuel cells was improved by 1.5 times compared to conventional cells, despite the substantial reduction of the nickel content.

Conceptual diagram of oxidation-reduction cycle of ceramic fuel cells and Comparison of cell performance deterioration rate between new concept- and conventional anode



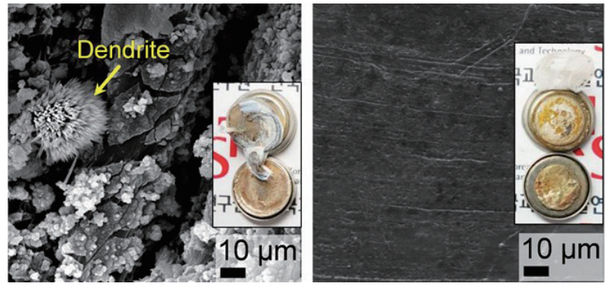
Despite rapid development of electric vehicles (EVs), the safety of the lithium-ion (Li-ion) batteries remains a concern as they are as a fire and explosion risk. Among the various approaches to tackle this issue, Korean researchers have used semiconductor technology to improve the safety of Li-ion batteries.

Research team led by Dr. Joong Kee Lee of the Energy Storage Research Center has succeeded in inhibiting the growth of dendrites, crystals with multiple branches that cause EV battery fires by forming protective semiconducting passivation layers on the surface of Li electrodes.

When Li-ion batteries are charged, Li ions are transported to the anode (the negative electrode) and are deposited on the surface as Li metal; at this point, tree-like dendrites are formed. These Li dendrites are responsible for the uncontrollable volumetric fluctuations and leads to reactions between the solid electrode and the liquid electrolyte, which causes a fire. Unsurprisingly, this severely degrades battery performance.

To prevent dendrite formation, the research team exposed fullerene (C60), a highly electronic conductive semiconductor material, to plasma, resulting in the formation of semiconducting passivation carbonaceous layers between the Li electrode and the electrolyte. The semiconducting passivation carbonaceous layers allow Li-ions to pass through while blocking electrons due to generation of Schottky barrier, and by preventing electrons and ions from interacting on the electrode surface and inside, they stops the formation of Li crystals and the consequent growth of dendrites.

The stability of the electrodes with the semiconducting passivation carbonaceous layers was tested using Li/Li symmetric cells in extreme electrochemical environments where typical Li electrodes remain stable for up to 20 charge/discharge cycles. The newly developed electrodes showed significantly enhanced stability, with Li dendrite growth suppressed for up to 1,200 cycles. Moreover, using a lithium cobalt oxide ($LiCoO_2$) cathode in addition to the developed electrode, approximately 81% of the initial battery capacity was maintained after 500 cycles, representing an improvement of approximately 60% over conventional Li electrodes.



Top-view SEM images and photographs (inset) of plain-Li, and Li@p-PCL electrodes after cycling tests with Li|Li symmetrical cells at 1.0 $mAcm^{-2}$ and 1.0 $mAhcm^{-2}$

Joong Kee Lee
Principal Researcher
Energy Storage
Research Center

Research News. 06

Energy/Environment

Semiconductor Technology Mitigates Fire Risk in Electric Vehicle Batteries

See more details at
https://doi.org/10.1021/acsenergylett.1c00150
"Metal-Semiconductor Ohmic and Schottky Contact Interfaces for Stable Li-Metal Electrodes"
ACS Energy Letters 2021

“Ready by 2024” – KIST Unveils New Artificial Cloud Chamber Dr. Seongsoo Yeom Oversees Research into Artificial Rainfall and the Construction of a Cloud Chamber

Dr. Seong Soo Yum,
Director-General, Climate and Environmental Research Institute

Although cloud research is still in the early phases, KIST is eager to take on the challenge.

“Did you know that climate predictions from various models differ a lot? I think this is because of a lack of understanding of clouds. We can only prepare for the future if we accurately predict climate change. This is a challenge that cannot be avoided any longer. As such, we will research and develop the technology necessary to predict future environmental changes and to help humans adapt to these changes.”

As the Korea Institute for Science and Technology (KIST) unveiled its new Climate and Environmental Research Institute in July, Dr. Seong Soo Yum began his tenure as its Director-General (R&D part) by declaring his commitment to the Institute. Dr. Yum, an expert in cloud observation and numerical modeling research, will lead the Climate and Environmental Research Institute alongside Director Jinyoung Kim. Together, they aim to set up a new research and development (R&D) enforcement strategy and promote the development of integrated, innovative technologies to respond to future climate disasters.

“Clouds are at the center of climate change research,” Dr. Yum asserted, explaining that a proper understanding of clouds may help address the impacts of climate change on water resources. Therefore, he plans to carry out intensive cloud-related research at KIST, stating, “We will create artificial clouds through cloud chambers and research the regulation of precipitation to minimize the impacts of droughts and flooding due to climate change.”

Scientists have long been giving warnings of the seriousness of climate change and have been conducting mitigation-related research. However, much of this research has focused on renewable energy sources, or on the reduction and capture of carbon emissions. The Climate and Environmental Research Institute, however, has a different vision. Its goal is to gain a scientific understanding of natural phenomena and develop innovative technologies to preemptively adapt to the impacts of climate change. This makes KIST the only organization to be actively pursuing R&D specifically to respond to future global environmental change.

As a professor and the first to jointly working at the Climate and Environmental Research Institute, Dr. Yum commended KIST, stating, “With climate change becoming more serious, the importance of atmospheric science and cloud research is being emphasized. It is significant that KIST has quickly reacted to this global trend and risen to the challenge of conducting research that has never been done before.” He added, “I feel a responsibility to use this opportunity, because atmospheric scientists will have a lot of work to do.”

Dr. Yum will oversee cloud-related research at the Institute, something KIST has never attempted before. There, his team will develop systems to understand cloud processes and eventually contribute to accurately predicting climate change, as well as artificial precipitation and cloud dissipation technologies that can bring rain to drought-stricken regions and prevent rainfall in flood-prone areas.

The first step will be to develop new materials to artificially trigger or prevent rainfall. This includes condensation nuclei that can turn ordinary clouds into rain clouds and new materials that could possibly reduce precipitation. “Research on artificial rainfall is active in the U.A.E. and China, but our cloud and atmospheric conditions are different from theirs. Any development of new materials must be suited to this region,” he said,

emphasizing the importance of securing independent technology.

A chamber will be constructed to produce artificial clouds. While the shape and size of the chamber is still under discussion, it has been decided to use various aerosols and water vapor content to create various clouds. "We are collecting the necessary information to build the chamber, hoping to have it ready by 2024. We will bring in new experts in the field of climate change technology, and we will discover the role clouds play in climate change," he said.

The chamber will also be used to test the performance of new materials. Dr. Yum has been working on artificial rainfall simulation models for some years, and his research is expected to gain momentum. "We will be able to measure what is happening inside the cloud chamber first-hand. Given the importance of simulations, we will work to foster synergy with the computational scientists at KIST," he said.

Are there any other cloud chambers in the country? According to Dr. Yum, there are only about seven or eight cloud chambers around the world that are actively in operation. Even in the United States, a country at the forefront of scientific research, currently only one is actively used in researcher. In South Korea, Dr. Yum and the National Institute of Meteorological Sciences are working together to build a cloud chamber and Dr. Yum is participating as a consultant.

According to Dr. Yum, "The National Institute of Meteorological Sciences has a chamber that expands air to create clouds, which would be different from KIST's method." He added, "We have been speaking with the people who lead a new cloud chamber design project in the U.S. to gather information. As climate change is an issue that all of humanity must address, research should be conducted in a collaborative manner."

If this project succeeds, KIST plans to use drones to study actual clouds. This will be accomplished through collaboration with the Korea Aerospace Research Institute, which possesses significant unmanned aircraft technology.

"There is no guarantee that this research will be successful," says Dr. Yum. However, he declares, "With our firm determination, the climate change adaptation technology we need can be developed..."

Every five to six years, the Intergovernmental Panel on Climate Change (IPCC) releases a comprehensive report that presents research results on predicted climate change scenarios from various countries. However, although the best technology from around the world is used to predict changes in the Earth's climate and environment, the results vary. Dr. Yum explained that the unattainable true value represents the uncertainty of climate change prediction.

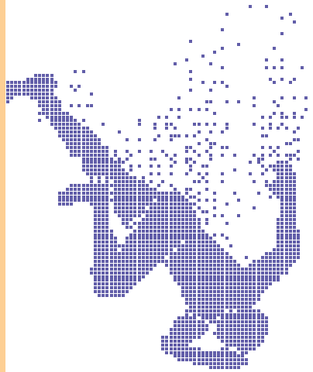
"Recently, a lot of attention has been paid to cloud-related research, with many researchers citing clouds as one of the most crucial causes of uncertainty, but such research is not as easy as it seems," he claims. "As in the saying that absurd dreamers 'grasp at floating clouds', clouds are above our heads, but difficult to reach and measure. The amount of water vapor held in each cloud and their aerosol distribution also change daily, which is another barrier to research."

Given the setbacks, Dr. Yum said, "There is no guarantee that this research will be successful." He further stressed, "Unlike universities which tend to conduct research independently, this Institute is a team-based organization where many people work in synergy with one another. Through firm determination, the climate change adaptation technology we need can be developed, provided that we don't rush, and remain focused on atmospheric science."

Finally, Dr. Yum said, "There are simulations that artificially eliminate high clouds that increase global temperatures. We call such interventions 'geoengineering', the large-scale manipulation of the Earth's physical and chemical properties. Although geoengineering is currently limited to simulations, it may be our last option if the impacts of climate change become too severe. We should all do our utmost in our respective positions to avoid a situation wherein nature must be artificially manipulated. Therefore, we will ensure that KIST retains its focus on preemptively responding to climate change."

Protecting Children's Health Using Virtual Sports

Jae-In Hwang
Center for Artificial Intelligence

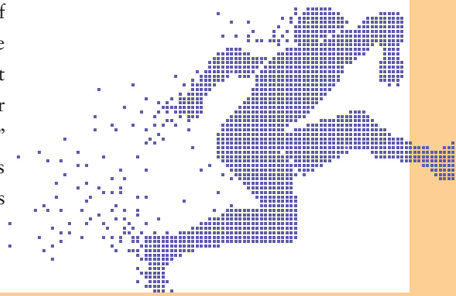


As a parent of a child attending elementary school, I feel it is becoming increasingly difficult for children to pursue outdoor sports activities. I usually played with my child outdoors during the spring and fall, but now, I often abandon the idea due to the fine and yellow dust blowing in from China. The threat of COVID-19 has also contributed to this decision. Virtual reality-based indoor sports activities have emerged as an alternative solution, because children can participate in them regardless of external circumstances. Once children are familiar with the experience of playing virtual games, they can improve their physical strength. And using empty classrooms, which are increasing in number due to the decline in the school-age population, for this purpose would be like killing two birds with one stone.

The Ministry of Culture, Sports and Tourism and the Korea Sports Promotion Foundation have already developed a "virtual reality sports room," and have been steadily setting it up in elementary schools over the past few years. Several users can simultaneously participate in ball-based activities in one or two classrooms with the help of projection screens and wall touch sensors. The Korea Sports Promotion Foundation has set up virtual reality sports rooms in 361 elementary schools since 2016, with plans to scale the project up by 100 more schools this year. This project was selected as one of the "Top 100 Excellent Achievements in National R&D" in 2019.

The virtual reality sports room is a rare innovation, and Korea, an information technology powerhouse, is leading the way. Korea is currently preparing to standardize virtual reality sports facilities at every school and establish a 5G-based content integration platform to enable the use of more than 200 different kinds of content. This is expected to reduce the development costs for content producers and increase satisfaction for teachers and students alike. "Peloton," the company responsible for this innovation, has attained unicorn status and gained the market reputation of being the "Netflix of the fitness industry." And exercise games that use glasses-type monitors, such as Oculus Quest, are gaining popularity in the single-person virtual reality market.

Under these circumstances, a new model for physical education can be realized by linking individual single-person virtual reality sports platforms with a school's virtual reality sports room. For example, if the physical strength data of students measured at home during a baseball class is linked to the virtual reality sports room, each student can then throw a ball at a different speed which corresponds to his or her measured strength. Korea is striving to improve virtual reality sports rooms and provide high-quality content through standardization and platformization. I hope that the world's best virtual reality sports technology will improve the health and physical strength of future generations.



A Successful Start to GRaND-K, an Audition-Style Start-Up Academy at Hongneung Innopolis

There is keen interest in GRaND-K, the cluster-based start-up academy program launched by KIST and Hongneung Innopolis. Hongneung, designated as the first special innopolis in Seoul, advocates a Korean-style version of London Tech City and the Boston Biocluster. Hongneung is making various efforts to establish a foundation to make the leap into becoming a global bio-startup cluster, and as a part of that, it has been preparing a unique start-up academy program which runs from April 19 to May 7. A total of 122 teams have applied to take part in the program.

The start-up academy conducts common start-up education courses for prospective and new (less than 3 years old) start-ups in the Hongneung area, and holds regular audition-style start-up competitions. In this competition, investment institutions participate as judges, evaluating start-ups' technologies, marketability, and innovation during the fourth round of the competition, while also supporting their capabilities through internship programs and consultations based on their unique strengths and specializations.

On April 11, KIST signed an investment agreement with 11 investment institutions: Samho Green Investment, SEMA Investment, SparkLabs, ID Ventures, Aju IB Investment, Yozma Group Korea, Infobank, K-Ground Ventures, K-Ground Partners, and Plan.H Ventures. For the start-up teams that successfully complete the program, KIST will support linkage efforts between the start-ups and investment institutions. After document screening for all 122 support teams is completed, the common education courses and competition will be held.

The President of KIST, Dr. Seok Jin Yoon, said, "I was surprised to find out that more start-up teams applied for the program than I originally expected, which proves that public interest in start-ups is very high," adding, "we will spare no effort to revitalize technology start-ups through organic support among key technology institutions in Hongneung, such as KIST, Kyung Hee University, and Korea University through this start-up academy, and to establish Hongneung as a mecca for technology start-ups."

From Disaster Medical Treatment to Industrial Accidents-Research for an Integrated Healthcare Innovation System

KIST and National Research Council of Science & Technology (NST) held a signboard-hanging ceremony to mark the foundation of the Augmented Safety System with Intelligence Sensing & Tracking (ASSIST) at KIST's headquarters in Seongbuk-gu on May 20 (Thursday).

With the NST's support, KIST's ASSIST team will focus on carrying out its three years of research for the purpose of "supporting medical systems based on on-site demands that can realize sustainable K-quarantine policies and prevent worker deaths and major injuries caused by industrial accidents."

The Disaster Medical Treatment/Industrial Accident Safety Enhancement convergence research team develops ICT convergent technologies which reduce the risk of industrial accidents and support stable operations in high-risk work environments during disaster situations such as the COVID-19 pandemic, including remote and mobile screening systems, non-face-to-face patient monitoring technology, and worker safety management systems.

Along with KIST, government-funded research institutes such as the Korea Institute of Energy Research, Korea Institute of Science and Technology Information, three university hospitals, four public institutes, and seven companies will participate in the joint research project.

Dr. Sang Kyung Kim, head of ASSIST, mentioned that "in order to suggest a research direction based on demands and solutions, many government-funded research institutes and hospitals have been monitoring these sites and conducting research together. We are planning to develop pioneering technologies to innovate medical systems in the post-COVID-19 era, from disease diagnosis and non-face-to-face diagnosis to industrial safety management."

The President of KIST, Dr. Seok Jin Yoon, stated that "the goal of this project is to develop technologies that can actually be used in disaster-related medical situations." He also added that "KIST will do its best to commercialize technologies developed during the project so that they can be linked to securing national growth engines, and create jobs in related industries by deriving fundamental technologies that comply with practical and convergent research projects."

How KIST and Companies Overcome Death Valley Together

KIST held a signboard unveiling ceremony for its first “Linking Lab,” created in conjunction with Keumyang Innovation (CEO : Seok Young Jang). “Linking Lab” is a new joint laboratory system which was implemented by KIST earlier this year to support the process of commercializing high-end technologies from small and medium-sized companies that have signed technology transfer contracts with KIST. As Linking Labs will enable technology consumers and suppliers to jointly conduct their research within the same laboratory, suppliers can actively support technology development and consumers can strengthen their research capabilities, thereby increasing the possibility for commercialization.

The KIST-Keumyang Innovation Co-Linking Lab is the first of these laboratories to be established since the implementation of the Linking Lab system, whose purpose is to promote the accelerated commercialization of “extremely small metal nanoparticle manufacturing technology and electrode and adsorption materials development technology,” which was transferred from KIST to Keumyang in September 2020. This technology is capable of miniaturizing the precious metal materials used in the energy and environmental fields and, as these materials are easy to mass-produce, is expected to enhance competitiveness in fields related to next-generation eco-friendly materials such as fuel cells, water electrolytes, and batteries.

Keumyang Innovation, a subsidiary of Keumyang, was established in October of 2020, with Mr. Jang the former Vice Minister of the Korean Ministry of Science and ICT, appointed as head on April 15, 2021 under the goal of pursuing strategic joint research with KIST. Mr. Jang said, "We are looking forward to seeing the performance of programs such as Linking Lab, which not only supports one-time technology transfers, but also follow-up research by companies, as it can help small and medium-sized companies commercialize high-end technology."

Meanwhile, the President of KIST, Dr. Seok Jin Yoon, stated, "Using the Keumyang Innovation Linking Lab as a starting point, we plan to expand our programs to include many more companies so that our excellent technologies can be more effectively commercialized. We will persistently continue to explore opportunities to transfer our key technologies to companies to secure their commercialization and, ultimately, make the future a better place."

Science Offers Solutions for the Rehabilitation of Men of National Merit

KIST and the Veterans Health Service Medical Center (VHS Medical Center; President : Geun Young Yoo) signed an agreement (MOU) on June 2 at KIST’s headquarters in Seongbuk-gu, Seoul to promote cooperation in research projects and mutual exchanges.

The agreement was signed in June to celebrate Patriots and Veterans Affairs Month, and is a follow-up working-level agreement between the Ministry of Science and ICT and the Ministry of Patriots and Veterans Affairs. It focuses on providing support for the rehabilitation and treatment of men of national merit through specialized R&D equipment for the disabled, by combining the clinical medical technologies of VHS Medical Center and the high-end S&T capabilities of government-funded research institutes such as KIST.

In the future, the two institutions plan to strengthen cooperation through the joint research and commercialization of high-end medical and health technologies, development of auxiliary devices to support the armed forces, co-utilization of facilities, equipment, spaces, academic and technological information, and so forth.

Dr. Seok Jin Yoon, the President of KIST, commented, "I feel grateful that the power of science and technology can be harnessed to aid men of national merit and the patriots who devoted themselves to our country. We hope that KIST’s advanced science and technology, combined with the abundant clinical experiences of the VHS Medical Center, will lead to breakthroughs in their rehabilitation.”

Computational Science Meets Agro-Fisheries Industry

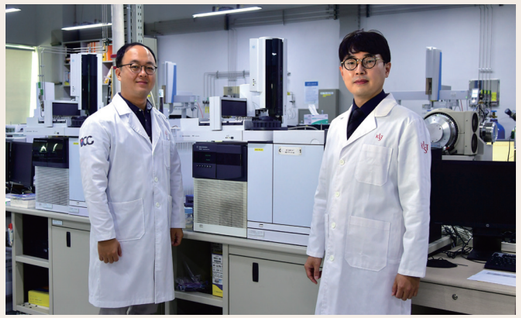
KIST and the Korea Agro-Fisheries & Food Trade Corporation (aT; President: Chun Jin Kim) signed an MOU on June 18 at KIST’s headquarters to expand utilization of big data in the agricultural and fisheries industries and strengthen digital competitiveness.

Under the agreement, KIST will utilize its computational science and artificial intelligence technologies to analyze aT's big data related to agricultural and fisheries food production, distribution, and consumption within the food and food service industries, in order to stabilize supply and demand for agro-fisheries products and promote the transition to a digital environment. In addition, joint research will be conducted for the development of practical and demonstrative technologies that can be applied on-site, such as improving agricultural productivity through the data analysis of high-end facilities such as smart farms.

The President of KIST, Dr. Seok Jin Yoon, stated that "this cooperative research will serve as an opportunity for

the agro & fisheries industries to be successfully digitized through cutting-edge science and technology, which will be an important foundation for Korea's food security in the future."

KIST Dispatches Doping Analysis Experts to the Tokyo 2020 Olympic Games



Korean doping experts, equipped with the world's best doping technology, were invited to the Tokyo 2020 Olympic Games, which were recently held. KIST announced that it would dispatch Dr. Junghyun Son(right), the Head of KIST's Doping Control Center, and Dr. Changmin Sung(left), a researcher from the same center, to the Tokyo 2020 Olympic Games.

Since its establishment in 1984 to aid with hosting the Asian Games and 1988 Olympic Games, the KIST Doping Control Center has been conducting research to develop the latest detection technology and analyzing athletes' biological samples for anti-doping drugs. It has played an important role in establishing Korea as a sports powerhouse by supporting doping analysis efforts for numerous international competitions over the past 40 years. Recently, the Center has been focusing on research to equip the latest analysis systems, such as Brain-doping, Gene-doping, DBS (Dried Blood Spot), and APMU (Athlete Passport Management Unit).

Growth hormone drugs, which have been increasingly used by elite athletes these days, are very difficult to detect and also very effective at breaking records, so detecting them is an important topic for this year's Olympic Games. According to data from the "Special Analysis Technology for High-Risk Items by Doping Centers around the World" report released by the World Anti-Doping Agency (WADA) in December 2020, there are only three countries worldwide that have analysis technology for prohibited drugs such as growth hormones: South Korea, the United States, and Brazil. As such, the Tokyo 2020 Olympic Games Anti-Doping Research Institute invited Dr. Son and Dr. Sung from KIST's Doping Control Center to come to the Games.

The two will share KIST's analysis technologies of growth hormones and similar prohibited drugs, and know-how in analyzing doping samples accumulated through the 2018 Pyeongchang Olympic Games, with the Tokyo 2020 Olympic Games Anti-Doping Research Institute. In addition, recent analysis technology for EPO (Erythropoietin), a banned hormone that production red cell production in the body and maximizes endurance, which became famous for being used by cycling star Lance Armstrong, will also be transferred.

The Head of the KIST Doping Control Center, Dr. Son, mentioned, "It is the role of anti-doping experts to develop the latest analysis technology and thoroughly verify athletes' samples so that the Olympic Games, a festival to celebrate athletes' efforts and determination, is not tainted by banned substances." He also mentioned that he is proud to have the opportunity to transfer KIST's excellent analysis skills and know-how to Japan, Korea's neighbor, and wished the Korean national team good luck at the event.

Introducing KIST's New Researchers

Joonho Kang
Brain Science Institute

Major
Physics

Research Interests
Single-cell biophysics, microfluidics

Life Sentence
Enjoy every moment

Changsoon Choi
Post-Silicon Semiconductor Institute

Major
Material Science and Engineering

Research Interests
2D material, bio-inspired optoelectronics

Life Sentence
Think hard, work hard!

Seongsik Park
Center for Neuromorphic Engineering

Major
Electrical Engineering and Computer Science

Research Interests
Neuromorphic Computing, Artificial Intellegence

Life Sentence
Stay hungry. Stay foolish.

Jeongryul Kim
Artificial Intelligence and Robotics Institute

Major
Robotics

Research Interests
Medical Robots, Surgical Robots, Bio-inspired Robots

Life Sentence
Luck is the residue of design.

Moon Son
Center for Water Cycle Research

Major
Environmental Engineering

Research Interests
Environmental Electrochemistry, Renewable Energy, Resource Recovery, Low-energy Desalination, Separations

Life Sentence
Life was like a box of chocolates.

Jun-Tae Kim
Center for Environment, Health and Welfare Research

Major
Environmental Chemistry

Research Interests
Environmental Chemistry of Anthropogenic Molecules

Life Sentence
Try again. Fail again. Fail better.

Sung Soo Kwak
Bionics Research Center

Major
Material Science and Engineering

Research Interests
Bioelectronics, Energy harvesting

Life Sentence
Luck is when preparedness meets opportunity.

Jin Yoo
Biomaterials Research Center

Major
Chemical & Biological Engineering

Research Interests
Biopolymer, Nanostructures, Interfacial Engineering

Life Sentence
Think deeply, act justly, live wholeheartedly

Byungju Lee
Computational Science
Research Center

Major
Materials Science

Research Interests
Rechargeable batteries, First-principle calculations, Machine learning

Life Sentence
Learn from yesterday, Live for today, Look to tomorrow, Rest this afternoon.

Ji-Soo Jang
Electronic Materials
Research Center

Major
Science and Engineering

Research Interests
Chemical sensor, gas separation membrane, Nanomaterials

Life Sentence
Nothing great in the world has been accomplished without passion.

Hyun Gyu Song
Sensor System
Research Center

Major
Semiconductor physics

Research Interests
Quantum resonance, Optical sensing, Quatum light source

Life Sentence
Never, never, never give up

Jung Ho Ahn
Clean Energy
Research Center

Major
Biological and Chemical Engineering

Research Interests
Systems Metabolic Engineering, Process Engineering, Biorefinery, C1 refinery

Life Sentence
Above all, don't fear difficult moments. The best comes from them.

Kyeongsu Kim
Clean Energy
Research Center

Major
Chemical and Biological Engineering

Research Interests
System Engieering

Life Sentence
I hope my death makes more cents than my life

Jinwoo Kim
Energy Materials
Research Center

Major
Materials Science and Engineering

Research Interests
Metallurgy, In situ material characterization, Hydrogen-metal interaction

Life Sentence
The world goes fine when everyone works in a right way in their field.

Jungjin Park
Energy Storage
Research Center

Major
Chemical and Biological Engineering

Research Interests
Rechargeable Batteries, Advanced Characterization Techniques, Data Driven Analyses

Life Sentence
Being more creative and innovative!

Jihyun Hong
Research Analysis &
Information Team

Major
Business Administration

Research Interests
Sharing economy, Product line design, Supply Chain

Life Sentence
Life is a matter of direction, not speed.

Sangsoo Choi
Technology Support Center

Major
Information & Communications

Research Interests
Equipment development, Optical Engineering

Life Sentence
Change before you have to.

Recruitment

KIST is looking to recruit creative and passionate research talent both in Korea and from abroad to continue our journey to preeminence in global research.

- **How to Apply**

Please refer to the details at the below websites
http://www.kist.re.kr
http://onest-kist.saramin.co.kr

Institutes and Research Areas

Brain Science Institute

- Discovery of brain higher functions
- Translational research on major brain diseases
- Neural circuit and network
- Discovery of drug candidates for brain diseases
- Development of neuro-tools

Post-Silicon Semiconductor Institute

- Spintronic for next-generation computing technology
- Quantum computing, communication, sensing
- Optoelectronic material growth/processing, High speed optoelectronic devices/systems, nanophotonics

Artificial Intelligence and Robotics Institute

- Technology for human-friendly artificial intelligence services
- AI applications and platforms
- XR and 3D display technologies
- Intelligent robotic platforms
- Immersive and intuitive VR/AR interaction
- Medical intelligence-based surgical navigation and robot system

Climate and Environmental Research Institute

- Detection and control of enviromentally harmful substances
- Climete science and weather control technologies
- Sustainable water cycle technology
- Prediction, impact assessment, and control of (nano) microplastics and pollutants
- Research on atmospheric science&technology PM
- Development of atmospheric environment policies

Biomedical Research Division

- Biomedical engineering based complexed solutions
- Innovative materials to replace or regenerate damaged tissues/organs
- Cancer immunotherapy and immune-guided regulation of aging
- Identification of disease physiology and diagnostic biomarkers
- Novel drug candidates / Identification and validation of new therapeutic targets

Advanced Materials Research Division

- Energy storage and conversion technology for IoT
- Advanced nanophotonics technology
- Advanced soft composite materials and platform
- Multi-scale assembly of nanomaterials for various applications
- Extreme catalitic materials for energy and environment
- AI-driven materials design
- Intelligent sensor platform, system

Clean Energy Research Division

- Conversion of CO_2, biomass, plastics and natural gas
- Advanced photovoltaic materials and devices for future carbon-neutral city
- Research on materials for energy generation, storage and utilization
- Next generation secondary batteries
- Innovative hydrogen production, storage, and utilization technologies

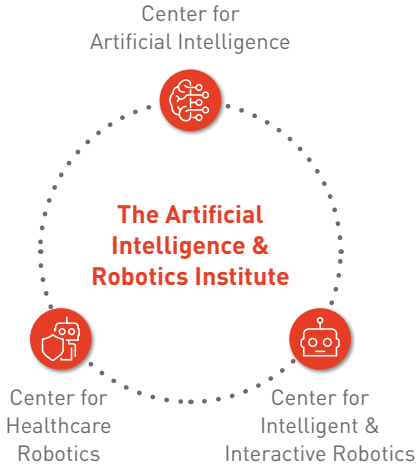
Institute of Natural Products
(*Must be able to work in Gangneung)

- Functional natural products
- Novel disease biomarkers for aging and chronic diseases
- Natural compounds and drug targets information
- Microbiome-natural product interaction and biological activities based on bioinformatics
- Multi-omics based modeling and mechanism research for plant growth and secondary metabolites
- AI based smart farm monitoring/control platforms

Instutite of Advanced Composite Materials
(*Must be able to work in Wanju)

- High-performing nanocarbon composite materials
- Low-dimensional nanomaterials
- Next-generation hybrid fibers
- Environmentally friendly resource-cycling composite materials
- Breakthrough lightweight composite materials
- Smart polymer materials

At the heart of robot, media, and ICT convergence research, paving the way toward the future



Through the fusion of AI and robot technology, digital human technology would have the ability to communicate with us as naturally as any human being. It is no longer seen as a technology of the distant future, but rather one which will soon be realized and commercialized. The Artificial Intelligence & Robotics Institute is the largest of its kind in Korea, and conducts R&D for fundamental technologies related to AI, next-generation media, and robotics to help solve the social and industrial challenges we face. We will continue to play a leading role in promoting Korea's AI and robotics technology in order to achieve global excellence through the convergence of technology across various related fields.

KIST
Korea Institute of
Science and Technology