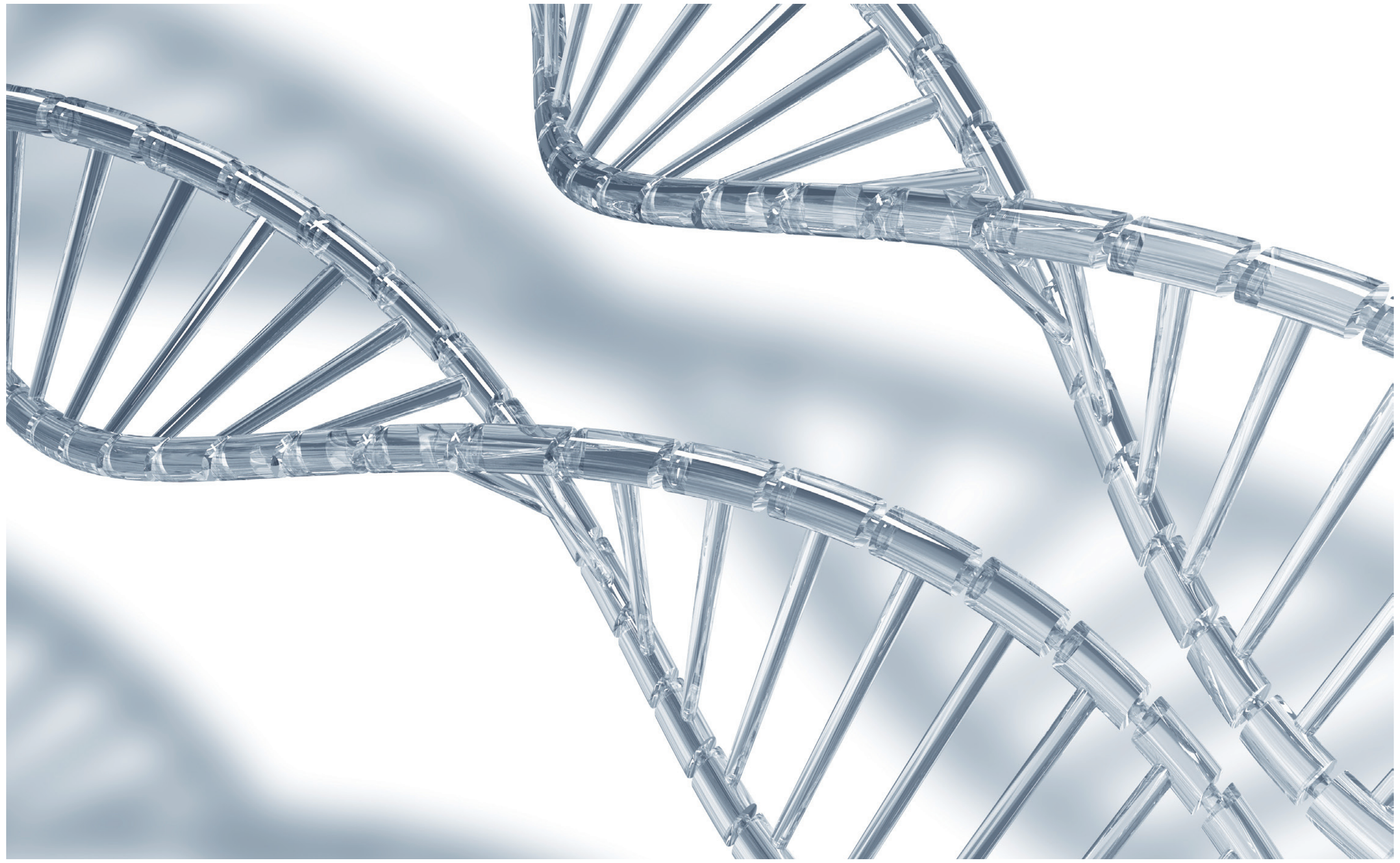
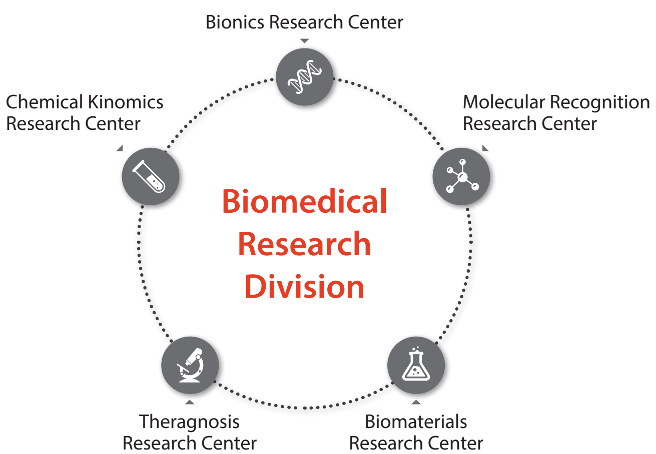


We are dedicated to improving human health and quality of life

Research Organizations



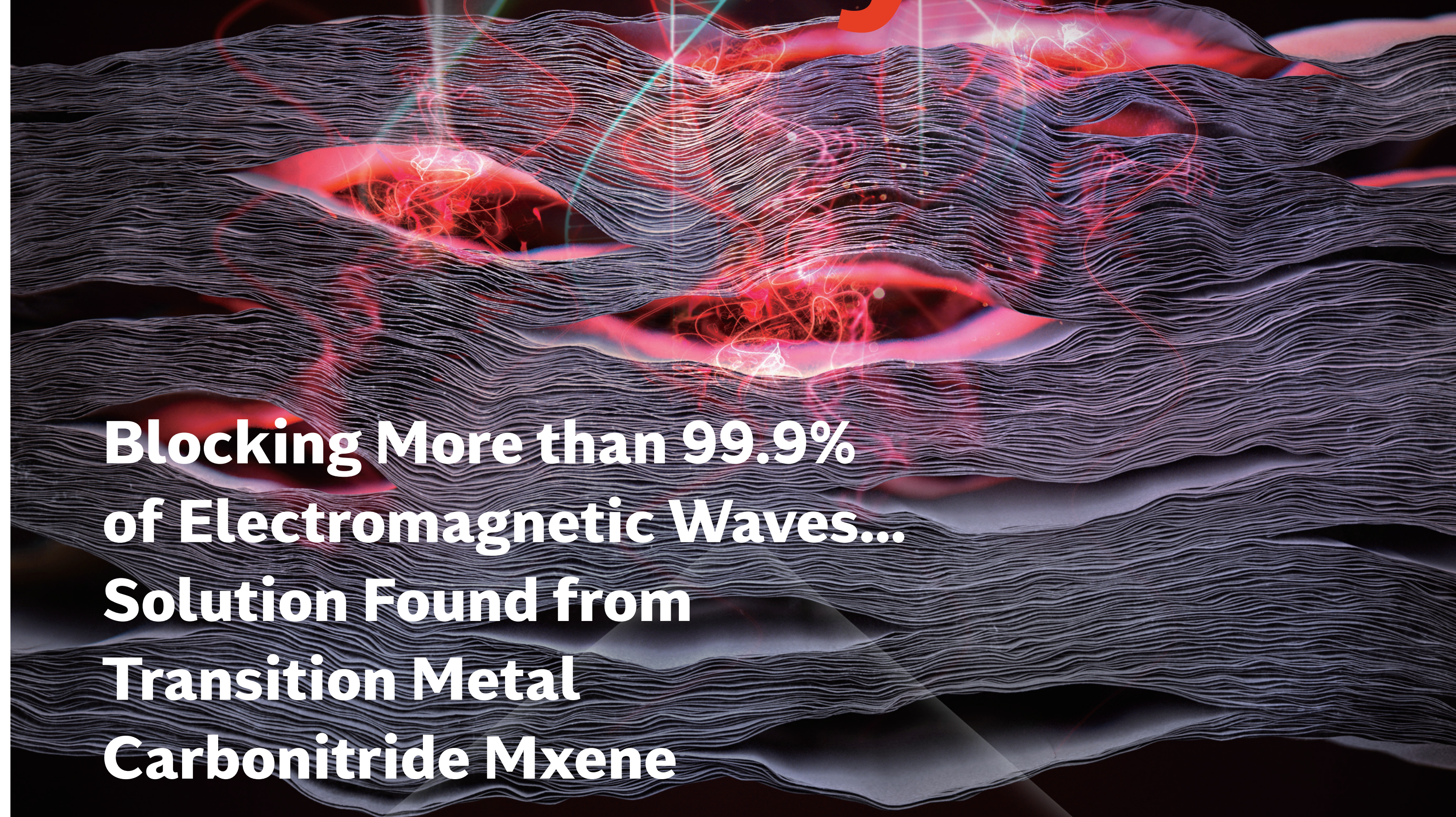
As KIST is seeking ways for people to live longer and healthier, the KIST Biomedical Research Division is committed to integrating the engineering and biological sciences with the clinical sciences to lead biomedical innovation. We develop cognitive and physical rehabilitation technologies to promote quality of life for the elderly and/or disabled, and devise strategies for repair-and-regeneration, and functional materials for replacing human tissues and organs. We are also heavily involved in the study of cutting-edge medical technologies enabling improved diagnosis and treatment for personalized medicine, thereby positioning ourselves as the epicenter of biomedical research in Korea.

KIST
Korea Institute of Science and Technology

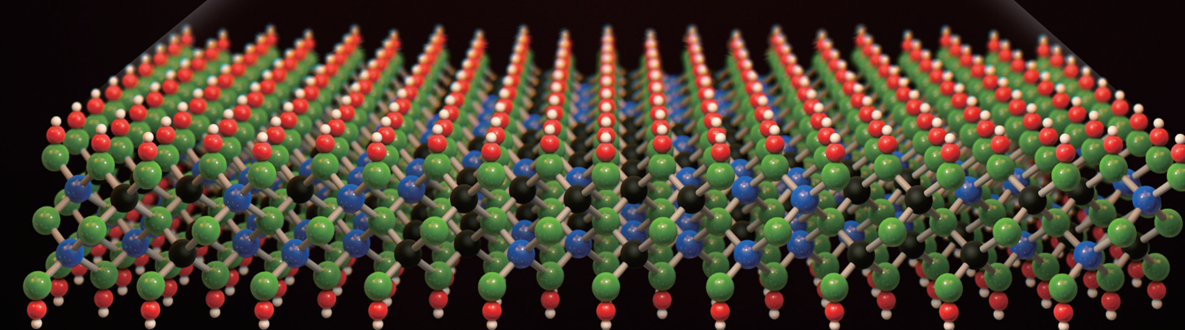
DEC 2020
ISSN 2005-9043
vol. 13(2)
KIST

Leading to tomorrow

KISToday



Blocking More than 99.9% of Electromagnetic Waves... Solution Found from Transition Metal Carbonitride Mxene



Research News

- A nano cleaner that only draws and removes beta-amyloid; the substance that causes dementia
- Transplanting "target signals" into cancer cells: a novel anti-cancer immunotherapy strategy
- Development of artificial intelligence semiconductor technology using electron spin
- Anti-forgery liquid crystal particles made up of multiple photonic shell structure
- High-capacity battery material with DNA from salmon
- Rapid commercialization of "dielectrophoretic tweezers" that catch nano-toxic particles in the atmosphere and water

December. 2020 – vol.13(2)

KISToday

Leading to tomorrow

Korea Institute of Science and Technology

ISSN 2005-9043

5, Hwarang-ro 14-gil, Seongbuk-gu,
Seoul 02792, Republic of Korea
Tel + 82-2-958-6179
www.kist.re.kr/en

Editorial Information

Editor-in-Chief
Hyun Kwang Seok

Editorial Board Members
Il-Joo Cho, Hong Yeol Yoon, Jong-Ho Lee, Hyunjung Yi, Jun-Sik Kim, Ho Seong Jang, Byoung Chan Kim, Hea Jin Lim, Kwi Hyang Han

Managing Editor
Hyun Young Hwang
hyhwang@kist.re.kr
+82-2-958-6179

Cover Story

Materials Architecting Research Center of KIST developed new nanomaterial succeeded in blocking 99.999% of electromagnetic waves

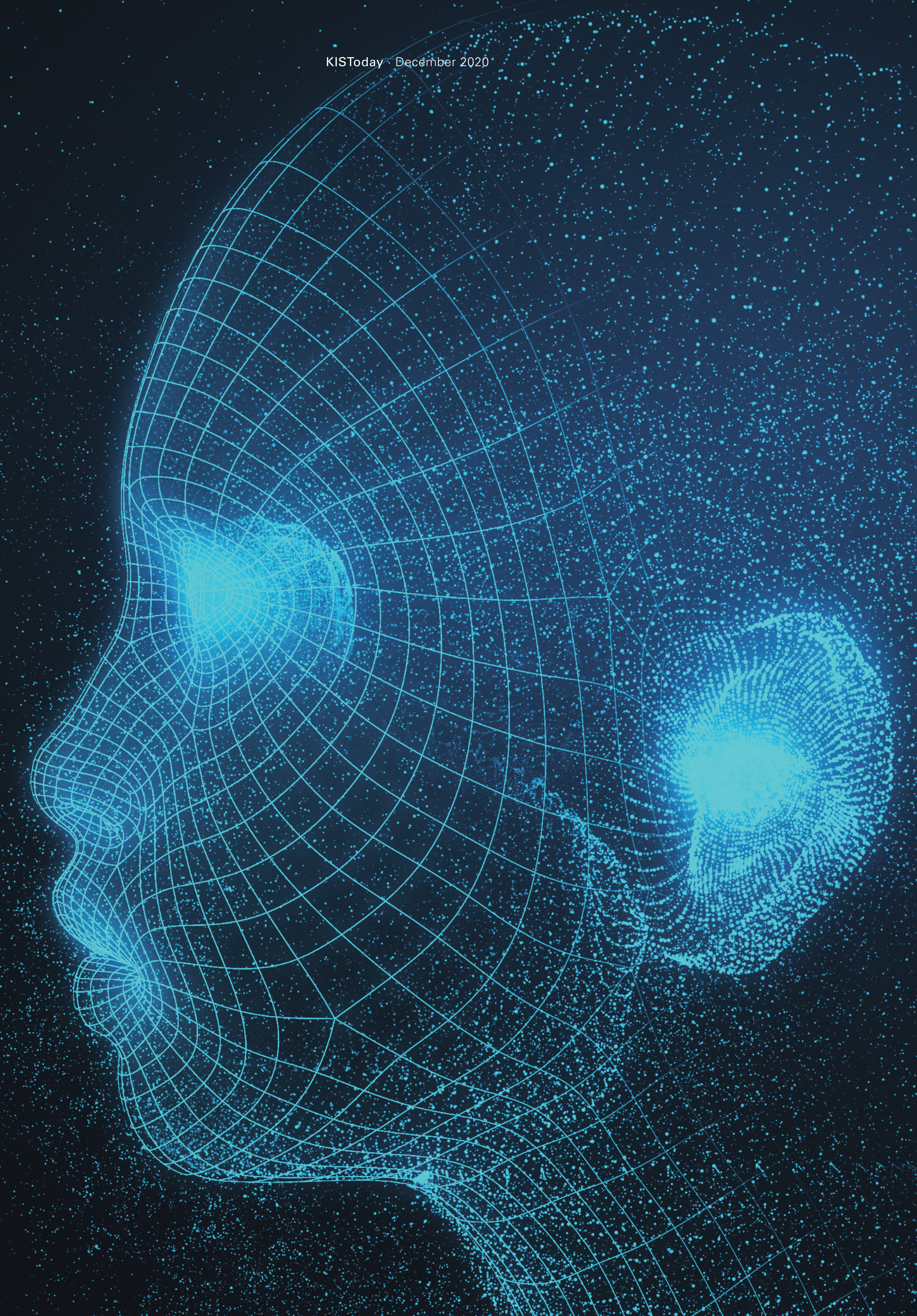
Still Missing, but Holding out Hope

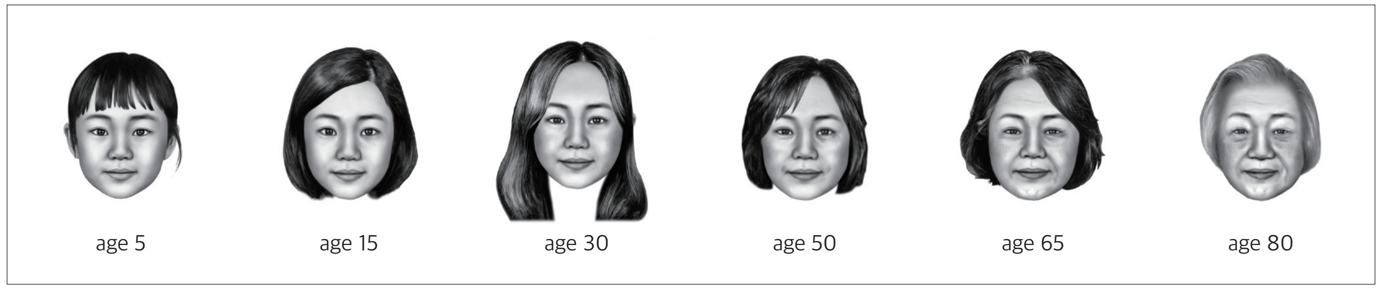
International Missing Children’s Day was designated by President Ronald Reagan in 1983, in the wake of the kidnapping and murder of Etan Patz (six years old at the time) in New York, USA, on May 25, 1979. Later, it was expanded to a worldwide event in which the whole world, including Canada and Europe. Since 2007, South Korea has designated May 25 as the “Korean Missing Children’s Day” and held annual events to raise social interest in the issue of missing children.

This year’s Missing Children’s Day event focused on online promotions of the search for missing children and prevention of child disappearance, in line with the policy of social distancing due to COVID-19. The Korean National Policy Agency produced the “Hope Tape”, which contains the records of children’s photographs at the time of disappearance, distinct features, and age-transformed montages in order to lighten the work of families manually handing out fliers about missing children, and to publicize the issue of missing children. During the campaign, parcels containing the Hope Tape are shipped all over the country, and they are expected to increase citizens’ interest in and reports on children that have been missing for a long time.

“3D Facial Composite Software” for Predicting the Faces of Long Missing

As science and technology have advanced, high-definition CCTV and video systems have become widely used and have contributed significantly to crime investigations and solving missing person cases. However, invisible blind spots still exist, and problems remain, such as improperly recorded videos depending on the surrounding environment.





3D facial composites reflecting the changed according to age

A facial compsite can be an important clue in crime and missing person investigations; however, the existing facial compsite have a technical limitation in that an accurate depiction is difficult for various reasons such as a lack of witness statements, faces being covered with masks, or the witness not seeing the target's face properly from the front. To address this limitation, the Artificial Intelligence and Robot Institute of the Korea Institute of Science and Technology (KIST) has developed "3D facial composite software."

The main characteristics of a 3D facial composite include side recognition, facial appearance transformation, and age progression. Side recognition is a technique for implementing a frontal facial compsite through 3D modeling based on the side information when having the subject's profile as the only available information. In many cases, the information for the subject is not frontal, but it is possible to deduce the frontal information from the profile information based on the facial data of Koreans.

Meanwhile, because the face is not rendered completely accurately in a facial compsite, it should be changed as similarly as possible through modification and compensation through the process of a facial appearance transformation. However, there is a problem of people providing qualitative testimonies based on personal standards, such as "the eyes were more fierce" and "the cheeks were slimmer," instead of providing quantitative testimonies, such as "the eyebrow length was 0.5cm longer" or "the corners of the lips should be raised about 15 degrees." To produce objective indicators based on such qualitative testimonies using the facial appearance transformation technique developed by the research team, a scaled assessment was conducted with approximately 900 people. Furthermore, 234 resulting values were used as the vector values to distinguish the scores for each facial point commonly recognized by viewers. In other words, the developed technology is more efficient than the existing facial composite techniques because an overall facial composite is primarily generated according to the selection criteria of "attractive," "despicable," and so on, and detailed modifications are then made for each facial part.

The greatest advantage of this technology is that it can reflect the changed according to age. In the case of long unsolved or missing person cases, there will be differences in the subject's recorded face from the actual face because a long time has passed since the original incident. If the facial changes according to age can be adjusted and deduced for each year of aging by reflecting the change in facial shape, wrinkles created, pigmentation, and other factors, the scope and possibility of using facial composites can be further increased.

The 3D facial composite technology developed by the team was started with a research project requested by the Korean National Police Agency, and in fact, a few years ago, it played a decisive role in finding a son who had gone missing 38 years earlier and reuniting him with his family. The boy, who was 12 years old at the time of his disappearance, had turned 50 and looked like a completely different person. Nevertheless, the facial composite composed by the research team based on an image taken when he was 12 resembled the face of the 50-year-old missing person and based on a report of an individual who saw the facial composite, the son, who it seemed would be gone forever, was reunited with his family.

The greatest advantage of this technology is that it can reflect the changed according to age. In the case of long unsolved or missing person cases, there will be differences in the subject's recorded face from the actual face because a long time has passed since the original incident.

Although the utilization of 3D facial composites is mainly associated with criminal investigations, the applicability of the core technology for creating 3D facial composites is high in other fields as well.

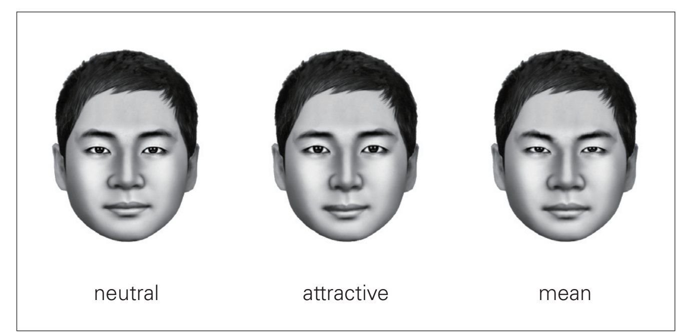
In 2015, which marked the 70th anniversary of Korea's liberation, a facial composite technique was used to console the pain of the divided Korean nation. In a special photography exhibition for separated families, called "Last Wish," the present appearances of family members who were separated 70 years ago were restored and exhibited as photographs to allow the separated families to at least come together in photographic images. The separated families and the audience viewing them were all greatly comforted and impressed.

The usability in the industrial sectors is also excellent. In particular, in the case of the game industry where 3D modeling is frequently used, real avatars are created by accurately reflecting the outer shapes of the models, rather than using simple customization when creating the avatars. As virtual reality (VR) and augmented reality (AR) have evolved, the gap between players and avatars has decreased, and going one step further, a more realistic experience will be provided if aging avatars are created.

The applicability is also high in the beauty industry in that people use different cosmetic products or cosmetic methods when their facial shape changes or wrinkles appear as they get older. Companies can sell customized products by predicting the aging of consumers in advance, and the consumers can prepare appropriate consumption plans for themselves. In other words, aging can be used for anti-aging.

In the future, image processing technologies based on VR, AR, and AI techniques, including a 3D age progression facial composite, are expected to benefit more varying and broader ranges of people. Such a technology that can help many people will be praised as a technology that preemptively responds to the future society.

Dr. Ig-Jae Kim (Director-General of Artificial Intelligence and Robot Institute) explains the principle of 3D facial composite software



Facial composite can be modicated according to the selection criteria of "attractive," "mean" and so on.

A Leap Toward the Future Creating an Innovative R&D model

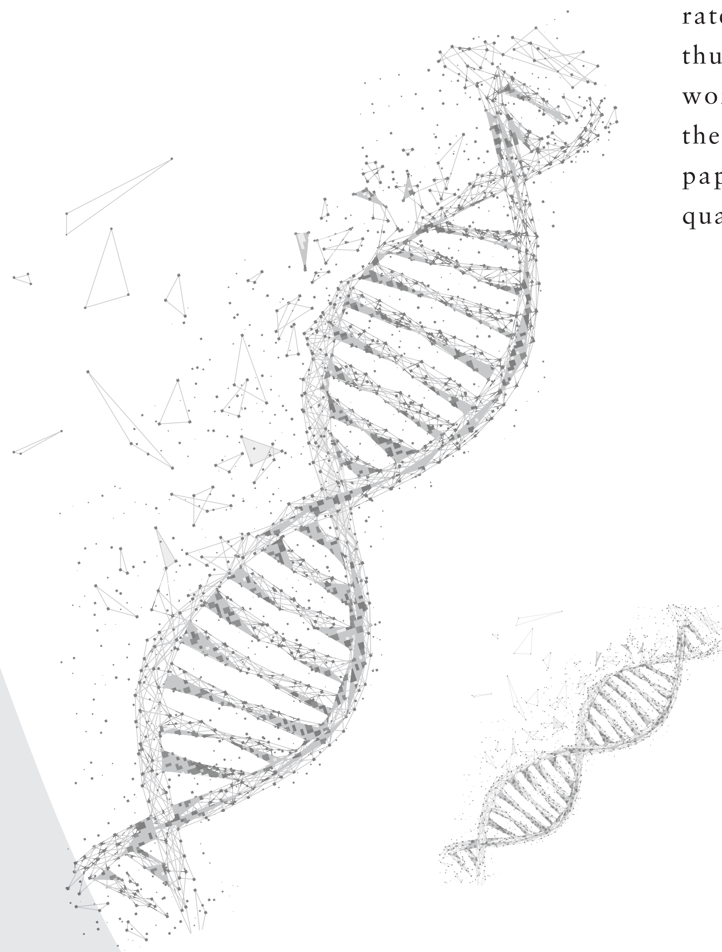
Seok Jin Yoon
25th President of KIST

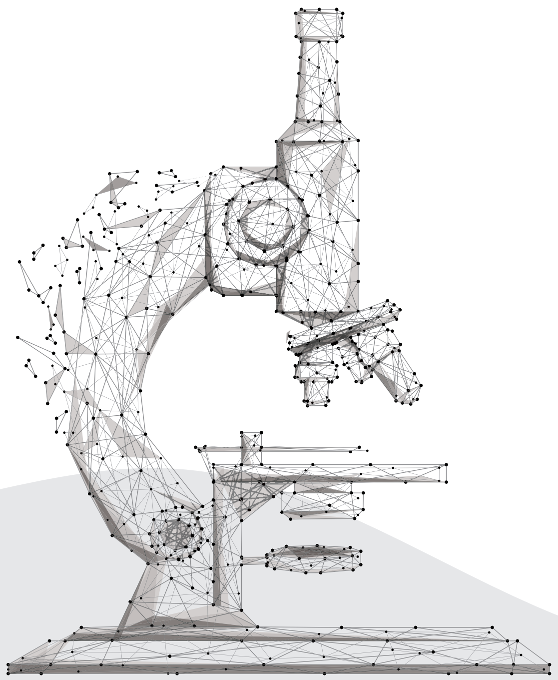
Least developed among developing countries are following the footsteps of South Korea in terms of national growth path. India, Vietnam, Indonesia, and other nations have been putting pressure on South Korea with their ebullient growth, under an already difficult economic situation owing to the presence of China, which has become the world's manufacturing center. To make matters worse, the United States and China are narrowing Korea's position amidst the fight for global technical and economic dominance without considering the catastrophes it might cause, in an attempt to achieve the upper hand in the fourth industrial revolution, which will change the framework of global industry and economy. Japan's targeting of the core components and materials of South Korea's flagship industry is slowing down the South Korean growth as well. Hence, a Korean research and development model (K-R&D) should be commenced to ensure the future competitiveness of the nation.

KIST has presented scientific and technological solutions to national issues by building national R&D platforms, which cannot be achieved by other universities or companies. KIST aims to create large-scale research outcomes with great economic and social ripple effects and discover future growth engines based on science and technology, as well as pursue a centripetal role of national R&D by becoming a hub of open innovation and convergence research.

As of 2018, 4.81% of the gross domestic product (GDP) in Korea was invested in research and development, ranking number 1 in the world in the ratio of investment, surpassing Israel, and the total amount of investment was the fifth highest, after the United States, China, Japan, and Germany.

To achieve this, the establishment of new Korean R&D is essential. The 97% success rate of government R&D, which has long been controversial, is actually an inherent vice of South Korean R&D. The close to 100 success rate of government R&D means that the focus is on short-term performance, thus more challenging and creative research cannot be conducted. To produce world-class research outcomes, it is therefore necessary to boldly eliminate the ranking-focused evaluations that solely focus on the number of published papers and change the research evaluation system from a quantitative to a qualitative one.





To this end, KIST has introduced its "grand challenge to conduct research in uncharted territories, unsolved research, and the world's first attempted research."

Based on such progress at the research level, we should also strive to be a leader in research and development that will support the future society. To this end, KIST has introduced its "grand challenge to conduct research in uncharted territories, unsolved research, and the world's first attempted research." The goal is to foster 10 world-class research teams by 2030 through the Reformed K-Lab Project, which recognizes and rewards challenging failures as diligent efforts. At the same time, it is hoped that an organizational culture without fear of failure will be permanently settled in KIST.

Finally, there is one more desired blueprint for the future of KIST, i.e., to create an "on-site industry cooperation model," in which the research outcomes of the government-funded research institutes can be directly linked to the outcomes of industry. In the 10 stages ranging from basic source technology to industrialization, the typical government-funded research institutes and companies are stalled at stage 4 or 5, without passing through the so-called "Death Valley." If the commercialization of the source technology is achieved in stage 8 or 9, beyond the Death Valley, based on the new on-site cooperation model, a virtuous cycle of industry–university research cooperation will be possible.

Although I have been the leader of KIST for less than a year, I hope that the future I am currently dreaming about will become the cornerstone of the progress made by KIST 10 to 20 years in the future. Furthermore, I hope that this will help build an ecosystem for R&D industry and research innovation.

Synergistic Haze Enhancement by Nitrate Uptake into Transported Particles

Haze pollution is affected by local air pollutants, regional transport of background particles and precursors, atmospheric chemistry related to secondary aerosol formation, and meteorological conditions conducive to physical, dynamical, and chemical processes. In the large, populated and industrialized areas like the Asian continental outflow region, the combination of regional transport and local stagnation often exacerbates urban haze pollution. This study reveals the synergistic effect of remote and local sources on urban haze pollution in the downwind region and provides insight into the nonlinearity of domestic and foreign contributions to receptor $PM_{2.5}$ concentrations in numerical air quality models.

Jin Young Kim

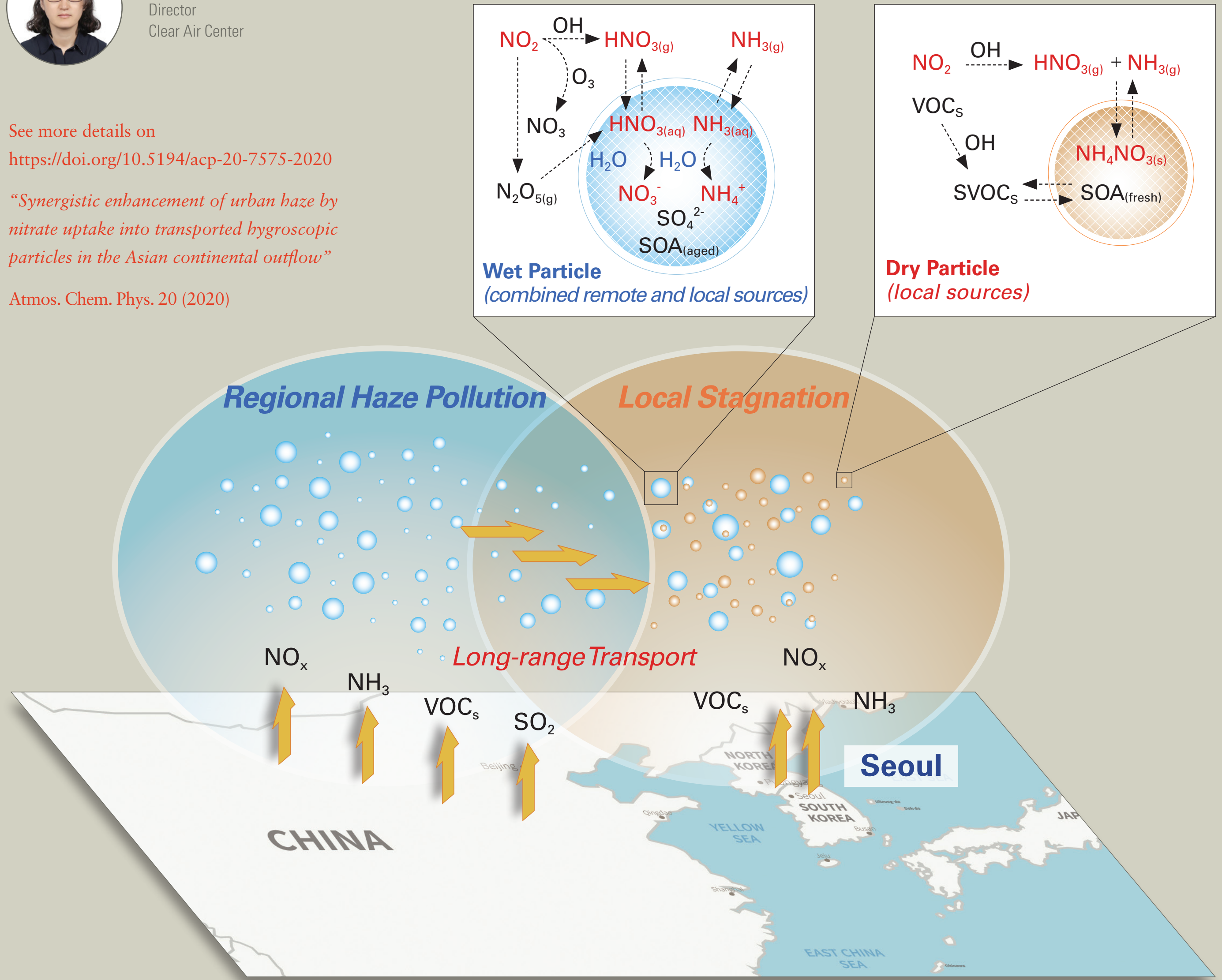
Director

Clear Air Center

See more details on https://doi.org/10.5194/acp-20-7575-2020

"Synergistic enhancement of urban haze by nitrate uptake into transported hygroscopic particles in the Asian continental outflow"

Atmos. Chem. Phys. 20 (2020)



Materials Science Stands at the Center of Breakthrough in the Future

“Materials” have been treated as the most important things in the history of mankind. The classification of the Stone Age, Bronze Age, and Iron Age divides the history of mankind based on the materials used at the time, which suggests that the materials are the key factors in human history.

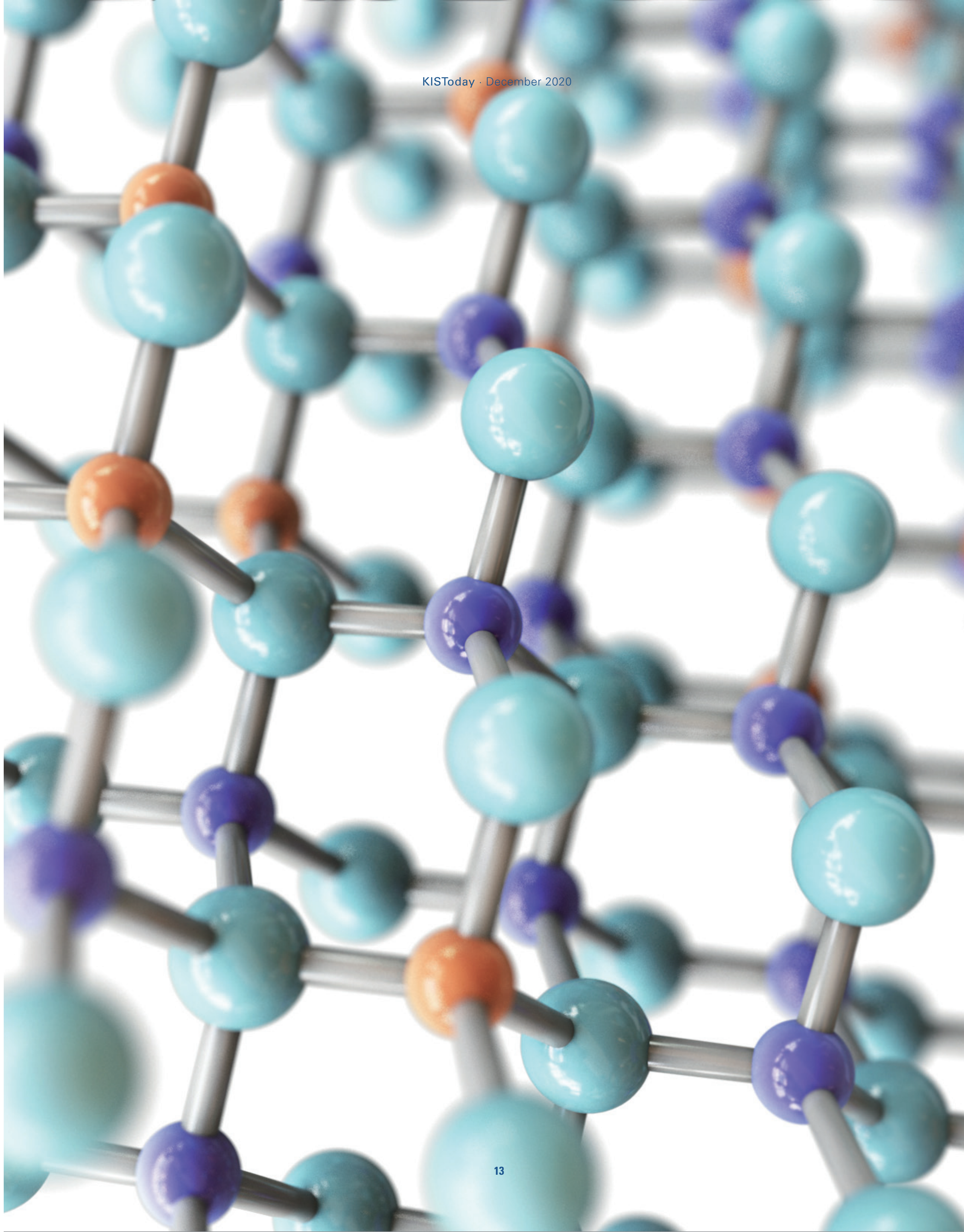
With the rapid evolution of science and technology, and the emergence of a plethora of changes in human life, it has become more important to develop new materials to respond to these changes. Accordingly, people’s interest in innovative new materials is increasing.

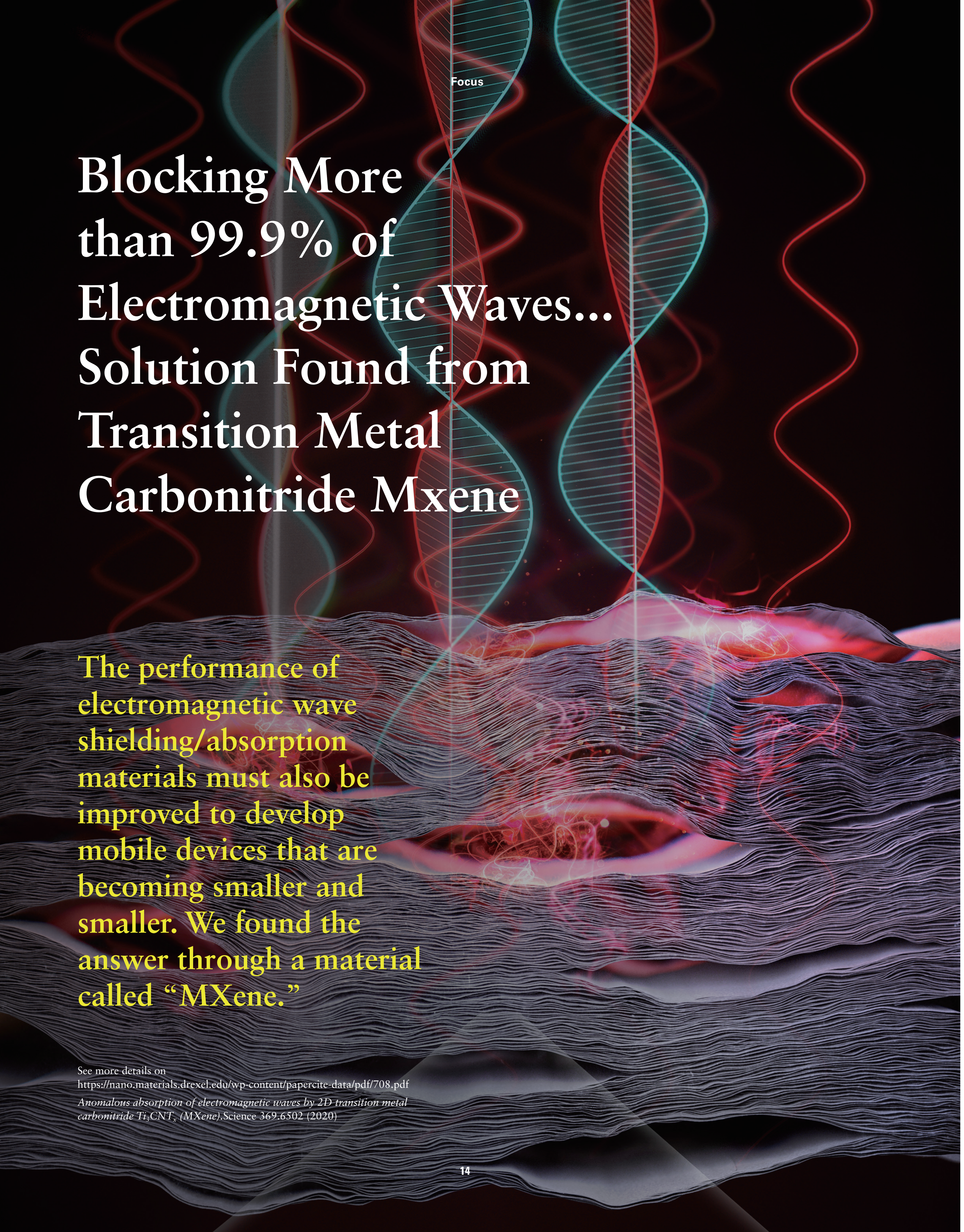
Even if a new material is developed, many problems and limitations have to be overcome before commercialization. Therefore, the commercialization of new materials is a long-term project that requires at least 20-30 years from the development of the source technology to commercialization. However, once a material is developed successfully, the developer can dominate the market for a long time, and as a result, its economic impact will be huge.

In fact, the blue light-emitting diode (LED) developed in the mid-1990s is a prime example. Japan developed the blue LED and created new industries related to LED lighting. Furthermore, they dominated the world market and produced a Nobel Prize winners in physics in 2014. That is, an innovative material sparked revolutionary changes.

As the countries around the world, including the United States, Japan, and China, immerse themselves in the development of future materials, emphasis is being placed on the importance of interdisciplinary convergence research and advancements in these fields, such as big data and computational science, to support research and development for future materials. In fact, in an effort to develop materials to unearth new properties, researchers are conducting convergence studies with novel research, such as big data and computational science.

In an effort to develop materials to unearth new properties, researchers are conducting convergence studies with novel research, such as big data and computational science.





Blocking More than 99.9% of Electromagnetic Waves... Solution Found from Transition Metal Carbonitride Mxene

The performance of electromagnetic wave shielding/absorption materials must also be improved to develop mobile devices that are becoming smaller and smaller. We found the answer through a material called "MXene."

See more details on
https://nano.materials.drexel.edu/wp-content/papercite-data/pdf/708.pdf
Anomalous absorption of electromagnetic waves by 2D transition metal carbonitride Ti_3CNT_x (MXene).Science 369.6502 (2020)

Chong Min Koo
Principal Researcher
Materials Architecting Research Center

When you hear a buzzing sound from a cell phone, this is due to electromagnetic interference (EMI). EMI is a major societal concern due to its detrimental impacts on advanced high-tech electronic devices as well as the human beings. We found the answer through a material called "MXene." It is expected to be used not only for electronic and communication devices but also for defense technology.

Research group of Dr. Chong Min Koo who studies "electromagnetic shielding/absorbing materials," at Materials Architecting Research Center, KIST, developed a new nanomaterial that overcomes existing limitations. This material succeeded in blocking 99.999999% of electromagnetic waves at a thickness of about 40 μm, similar to a single hair follicle's thickness.

Curiosity led to an amazing discovery. A researcher, inspired from literature, applied moderate-temperature heat treatment to a material named "transition metal carbonitride Ti_3CNT_x MXene". The outstanding performance achieved was difficult to explain by the existing theory of electromagnetism. With repetition of results over a period of two years, Dr. Koo said, "I was as happy as discovering a pearl in the mud. I hope that this will open the door for not only electromagnetic shielding and absorbing but also a wide range of other electronic applications."

This year, the discovery was published in prestigious journal of Science on July 24th. The research team collaborated with Professor Myung Ki Kim of Korea University's KU-KIST Graduate School of Converging Science and Technology and Professor Yury Gogotsi of Drexel University, United States.

The need to develop electromagnetic shielding/absorbing materials is a pressing matter as the size of electronic devices become smaller and smaller.

Electronic devices, such as cell phones, laptops, and TVs that we use everyday are composed of several elements. These devices generate undesirable electromagnetic waves during their operation. Due to the electromagnetic induction effect in a closed proximity, an interference arising from the unwanted electromagnetic waves causes malfunctioning and failure of these devices. Therefore, it's essential to develop an electromagnetic shielding/absorbing material for safety of the devices and human health.

In particular, as compacted and lightweight electronic devices are preferred in recent years, an electromagnetic wave shielding/absorbing material with an excellent performance is an important issue. Dr. Koo emphasized the importance of research and development saying that "the shorter the distance between materials, more they are influenced by the electromagnetic waves. Therefore, thin and light-weight shielding materials need to be developed for the advanced electronic devices."

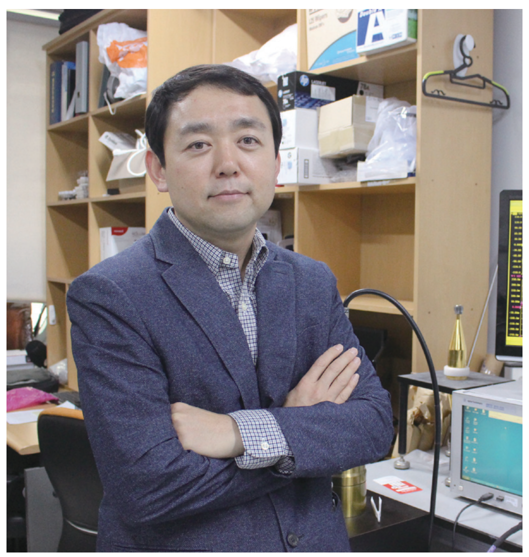
Conventional electromagnetic shielding materials are made of metals with excellent electrical conductivity. However, these are heavy, expensive, and unstable due to corrosion, making it challenging to apply flexible coatings and unsuitable for their use in highly integrated electronic communication devices. In particular, as metals have reflective properties rather than absorption, there is a significant concern that the reflected waves can damage the surrounding circuits and cause secondary pollution.

As the research team began developing electromagnetic wave absorbing materials, among various materials, the group focused on "MXenes" which are lighter and cheaper than metals, yet have electrical conductivity comparable to that of metals. MXenes also allow easy solution printing processing for thin coatings. The $Ti_3C_2T_x$ MXene nanomaterial was developed in 2016 for EMI shielding. It was an excellent material with 92 dB shielding effectiveness at 45 μm thickness, similar to that of a human hair. Notwithstanding, there was a need to strengthen the absorption technology further for compacted 5G electronics.

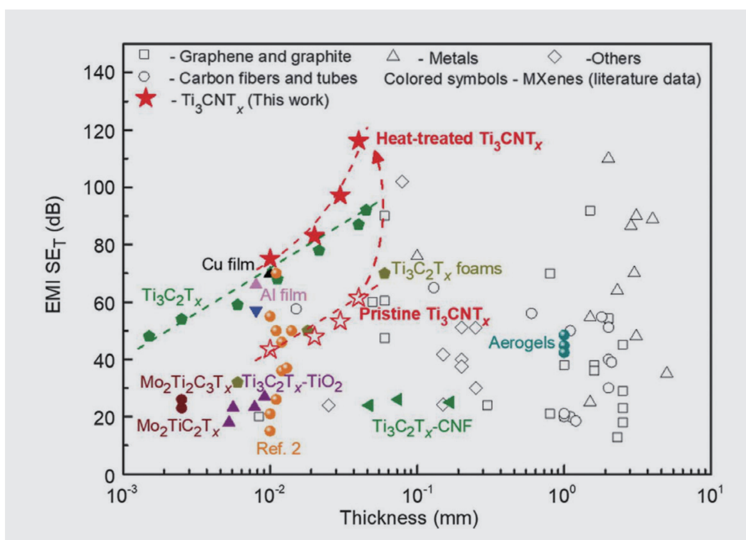
Dr. Koo predicted that the technology could be used as an electromagnetic wave shielding/absorbing material for highly integrated mobile electronic and communication devices.

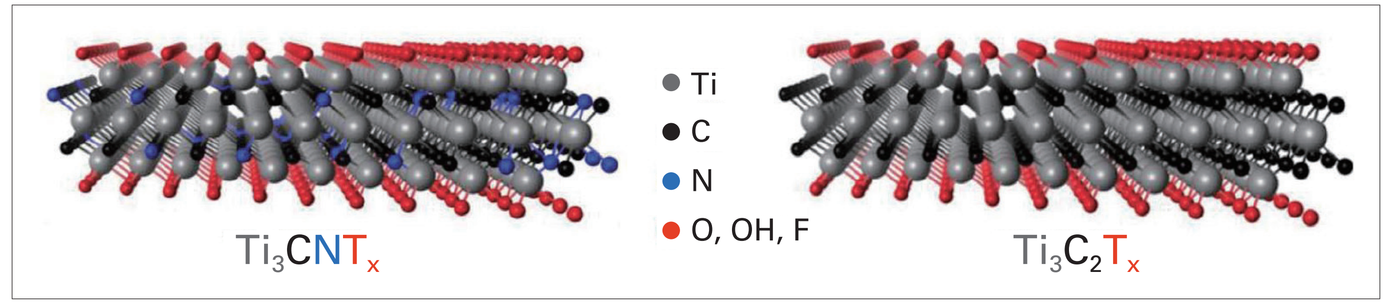
Therefore, the research team recently developed a Ti_3CNT_x MXene nanomaterial that can solve the reflection problem. Made-up of titanium, carbon, and nitrogen elements; this material has confirmed a high electromagnetic wave shielding performance of more than 116 dB at 40 μm thickness, the highest among all synthetic materials reported to date. As 10 dB means 90% shielding, 20dB means 99% shielding, and 30 dB means 99.9%shielding; a 116 dB is a shielding rate of over 99.99999999%.

Surprisingly, the newly developed Ti_3CNT_x MXene revealed the anomalously improved absorption in electromagnetic waves due to strong multiple reflections inside the porous structure. A combination of meta-material



Comparison of EMI shielding effectiveness (SE_T) of reported shielding materials. Red star symbol represent EMI SE_T of annealed Ti_3CNT_x films. Notably, at the comparable thickness, our annealed Ti_3CNT_x MXene lies well above all the other reported materials.





Schematic representation of the Ti_3CNT_x and $Ti_3C_2T_x$ MXenes. T_x represents surface terminations (–OH, –O, and –F)

like structure, high porosity and additional polarization losses resulted the maximum absorption of electromagnetic waves inside the porous structure.

This material, Ti_3CNT_x, was developed by chemical etching of aluminum atoms (Al) from Ti_3AlCN. The chemical reactions produced nanometer thin two-dimensional (2D) flakes of Ti_3CNT_x in an aqueous dispersion. This dispersion can be directly used to coat large area of electronic components. In this work, freestanding films of different thickness were made by vacuum filtration of the dispersion. The obtained films were heat treated at different annealing temperatures. The mild heat treatment at 250 °C and 350 °C dramatically improved the EMI shielding and absorption performance of Ti_3CNT_x films. Upon analysis, it was found that the unique layered structure and meta-structure formation improve the absorption characteristics of Ti_3CNT_x films. Herein, the present research results realize excellent electromagnetic wave absorption characteristics even at very low film thicknesses.

Dr.Koo predicted that the technology could be used as an electromagnetic wave shielding/absorbing material for highly integrated 5G mobile electronic and communication devices. Moreover, it was expected that it could be used for military applications such as shielding of electromagnetic pulse (EMP) attacks that neutralize all the electronic devices. Or stealth technology making it challenging to detect aircraft and missiles early by radar with its strong electromagnetic wave absorption capability. The research team is developing a high-performance thin shielding coating application technology that can enhance the electromagnetic shielding performance of a concrete wall and/or building.

However, he said, "The use in highly integrated electronic devices such as mobile phones is likely to be the fastest among the various technologies. Further research is being conducted on material processing technologies for simple processes so that companies can use them quickly."

Also, according to the researchers, the MXene material has an excellent ability to convert electrical energy into heat. Therefore, it is expected that various applications such as heating technology that resolves internal and external temperature differences or other technology that utilizes electrical conductivity will be possible.

Meanwhile, the research team is preparing to publish a book on the subject of "2D Materials for Electromagnetic Shielding." It has been approved by Wiley, a world-renowned academic publisher, and will be published in early 2021.

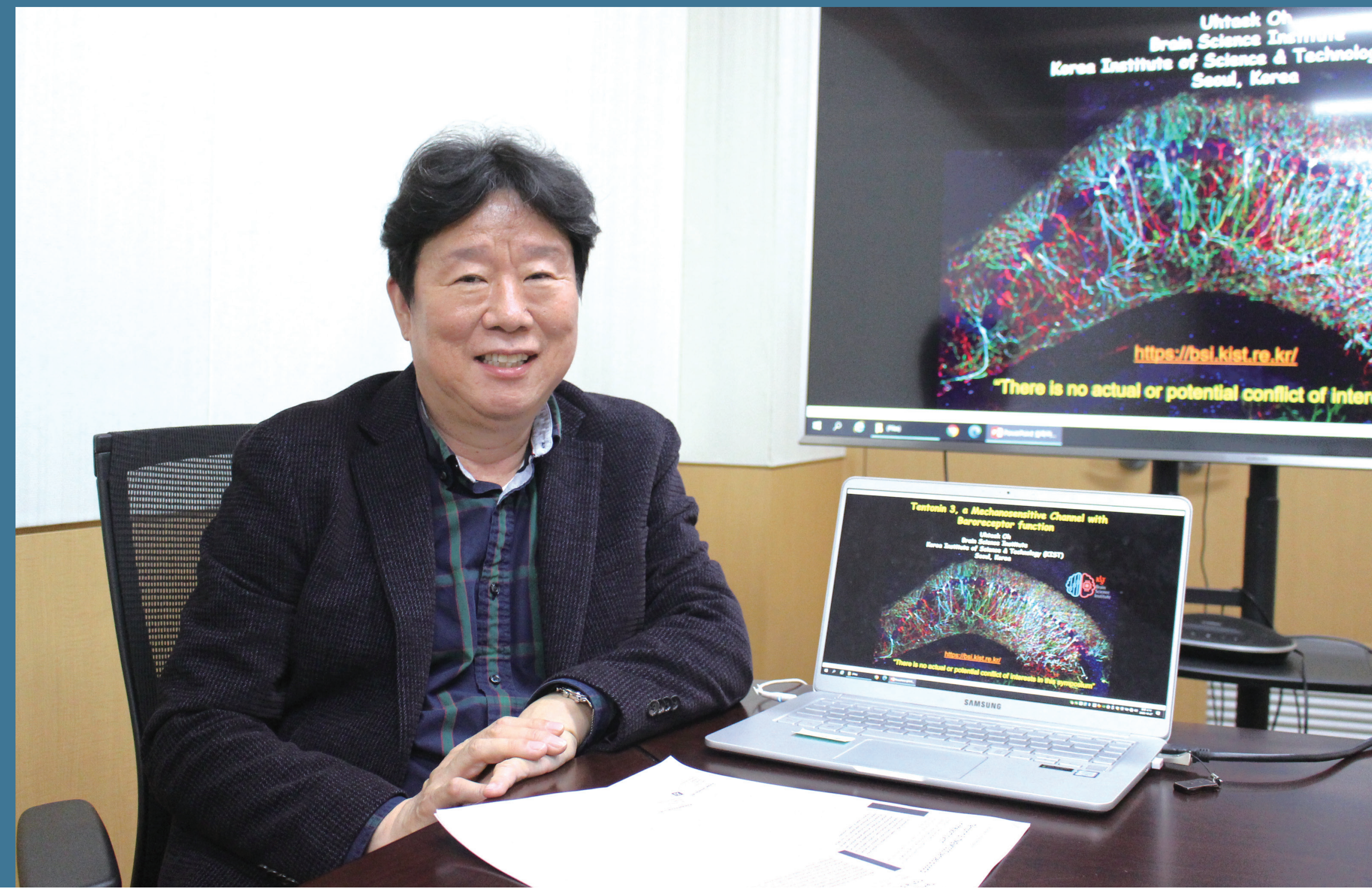
Documentary Film "*Evaporated*"

In April 2000, Joon-won Choi, who was 6 years old at the time, was last seen playing with friends near her home, and never returned. Her family immediately began searching the area and distributed fliers across the nation to find traces of Joon-won but to this date still has not found her. Twenty years later, based on the missing case of Joon-won Choi, the documentary film *Evaporated* was released, which is South Korea's first film dealing with long-term issue of missing children.

The movie *Evaporated* reexamines the psychology and life of the family of the missing child, focusing on Joon-won's father who has been attempting to find her for the past 20 years. This film depicts a father who has abandoned his normal life to focus only on finding the traces of his daughter, who always seems to be within reach if only he could search just a little longer; Joon-won's older sister who was pushed out of the center of the family because of her missing sister; and the pain and grief of a mother who lost her daughter. In other words, as the title suggests, this movie shows what have "*Evaporated*" from the members of the family owing to the disappearance of Joon-won.

In *Evaporated*, "3D facial composite software*" was used tocreate the estimated current image of 28 year-old Joon-won to help the family continuously search for her.

*Developed by Dr. Ig-Jae Kim
(Director-General of Artificial Intelligence and Robot Institute)



Research Result Found the Causing Factors of Hypertension

01

Untaek Oh
Director-General
Brain Science Institute

See more details on
https://doi.org/10.1172/JCI133798.

"Tentonin 3/TMEM150C senses blood pressure changes in the aortic arch." *The Journal of Clinical Investigation* 130.7. (2020)

After the initial discovery of Tentonin 3, the research team of Dr. Uhtaek Oh, KIST identified its role in blood pressure control, which has been an existing problem for decades. The team expects to better understand high blood pressure-related diseases and develop treatments for such ailments.

"Like potatoes hanging from stalks, research outcomes sometimes appear one after another. For instance, after Tentonin 3 was first discovered in 2016 as a mechanosensor, we extended our research on baroreceptor function that precisely regulates the blood pressure change. This outcome began with the efforts of younger researchers who volunteered to conduct the research to find a gene for mechanosensitive channel, for which there was no guarantee when the results would be derived. We are looking forward to seeing how new potato stalks will be found based on this achievement."

Uhtaek Oh, the Director-General of Brain Science Institute, KIST, who is an authority in the field of neuroscience in South Korea, compared the research results to the harvesting of potatoes. He used this expression because his first discovery of several channel genes such as Anoctamin 1 and Tentonin 3 are involved in important functions of our body. "Research is always exciting and heart-pounding," he said, based on 30 years of research experience in a single field of neuroscience, which includes the molecular mechanism of pain development, pain-related ion channels, and novel ion channel gene cloning.

He has recently made another interesting, heart-pounding achievement. He has revealed that Tentonin 3, a mechanosensitive channel reported in a paper in 2016, acts as a molecular sensor that precisely controls the blood pressure. It is expected to be a cornerstone of understanding blood pressure-related diseases such as hypertension and developing treatments. The research paper was published in the Journal of Clinical Investigation (JCI), U.S.A.

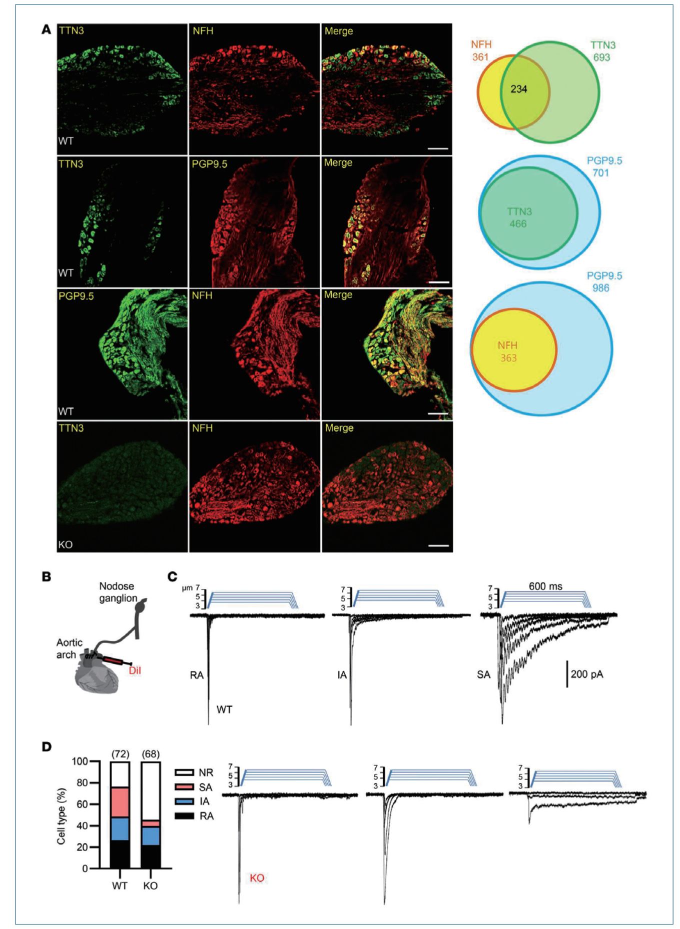
Blood pressure is in disarray without Tentonin 3: This solves a difficult problem that has been puzzling researchers for decades

Human bodies have flowing microcurrents. This is because bioelectric signals are generated as the ions pass through the ion channels formed in the cell membranes surrounding the cells. The electrical excitement of cells by ion channels enables heartbeat, hormone secretion, sensation, and movement. A failure of ion channels can lead to serious illnesses because they control every small part of our bodies.

Among the ion channels, those that are usually closed but have opened through mechanical stimulation are called "mechanosensitive channels." The mechanosensitive channels help one feel a mechanical stimulation applied from the outside when hitting or touching an object, as an example. Thanks to mechanosensitive channels, you can feel whether an object in your hand is a 500 or 100 Korean won coin, soft down fluff, or slippery glass. Moreover, such channels are needed to detect internal stimulations such as a degree of muscle contraction, movement of the bones, expansion of the lungs, and the ups and downs of blood pressure.

However, there have not been many mechanosensitive channels discovered compared to various mechanical stimuli. There are only two known types: "PIEZO1 and PIEZO2," discovered by an overseas research team, and "Tentonin 3," discovered by Dr. Oh's team in 2016. PIEZO 1 and 2 are known to be responsible for the tactile sensation of the skin. They are possessed by all animals, from humans to lugworms. By contrast, Tentonin 3 has been interpreted as a mechanosensitive channel that has developed and evolved in vertebrates only.

> Like potatoes hanging from stalks, research outcomes sometimes appear one after another.



TTN3 is responsible for SA MA currents in aortic arch–projecting NG neurons.

The research team that discovered Tentonin 3 began their study with the hypothesis that the nerve fascicles around the aorta act as a blood pressure sensor. They believed that "since the heart pumps strongly to the aorta, where blood pressure is sensed by baroreceptors, there must be a molecular pressure sensor in the aorta."

In fact, they discovered through research that a large quantity of Tentonin 3 exists at the nerve ends of baroreceptors in the aorta. In particular, the research team confirmed that the nerves manifesting Tentonin 3 cover the aorta completely. As a result, they confirmed that the blood pressure detection ability is extremely low in mice lacking Tentonin 3.

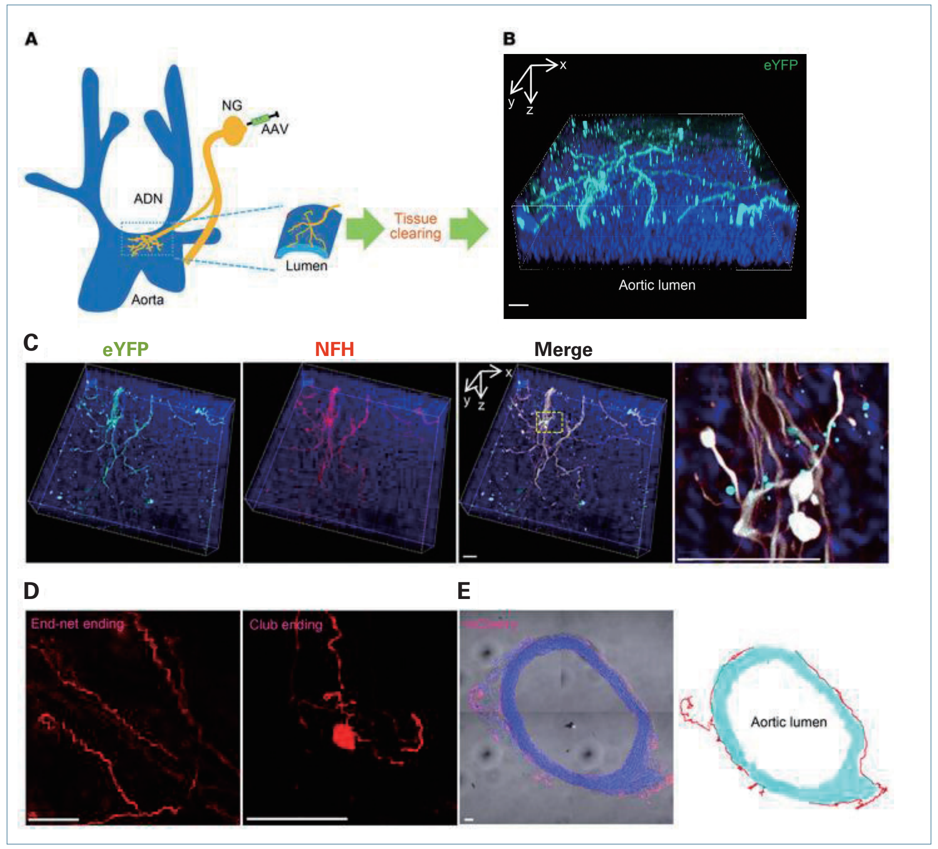
Dr. Oh stated that, "in the results, the Tentonin 3 gene-removed mice showed a significant decrease in the blood pressure detection ability with a rapid increase in blood pressure and heart rates, unlike in the regular mice." He then explained that "when the Tentonin 3 genes are expressed again in the Tentonin 3-removed mice, the blood pressure and heart rate returned to normal, just like healthy mice."

Our body maintains health by controlling the blood pressure on its own, but the molecular sensor that acts as a sensor detecting the blood pressure has not been clearly identified. If the blood pressure is not regulated properly, causing hypertension, it may lead to strokes and heart attacks. If the blood pressure drops suddenly due to bleeding, etc., blood cannot be supplied to major organs, damaging the organs, which is more dangerous. This discovery is an example of solving the puzzle regarding the blood pressure detecting molecular sensor, which had been an unsolved problem for decades.

"As our achievement, we discovered Tentonin 3 as the gene required for a baroreceptor reflex to increase or decrease the blood pressure. We have expanded the range of physiological understanding of the blood pressure detection system in animals." Dr. Oh said, "this study will serve a significant role in laying the groundwork for the treatment of hypertension caused by erroneous heart blood pressure detection."

"Long-awaited achievement-thanks to the younger researchers who joined actively"

This study was made possible because of the efforts of several younger researchers who had been working together in the same lab since the time Dr. Oh was serving as a professor at Seoul National University. While introducing his research, he expressed his gratitude to many researchers including Dr. Gyu-Sang Hong (currently a Senior researcher of KIST), Dr. Lu Huan Jun (currently a professor at Nantong University), and Dr. Byung-joon Lee,



TTN3 is present in the nerve terminals of the ADN.

In particular, "the discovery of Tentonin 3 had led to this research achievement," he said, noting the effort of Gyu-Sang Hong, PhD, who participated enthusiastically in the early stage of research.

According to Dr. Oh, in 2015, which was a few years after the discovery of mechanical channels (PIEZO 1 and 2) by an overseas research team, he found a list that likely facilitated the discovery of another mechanical channel. He was a professor at Seoul National University at the time and had many discussions with his students; however, the large amount of work was a stumbling block. At the time, nobody wanted to analyze the gene sequences, which might take more than a year to accomplish, because they already had many other research projects and their graduation schedule could be affected.

Dr. Hong who was a student at the time also turned it down, but after a week of contemplation, he came to see Dr. Oh and said, "I will give it a try." If the luck had not been on their side, the mechanosensitive channel could have been at the bottom of the list, never to be seen. Luckily, however, Hong succeeded in finding the mechanical channel on the fourth list provided during a 2 month period.

He stated, "as the ions go in and out, the electric currents were confirmed after mechanical stimulation. Because it was a really long-awaited result, I was extremely happy. Based on this research, we were able to produce other results as well."

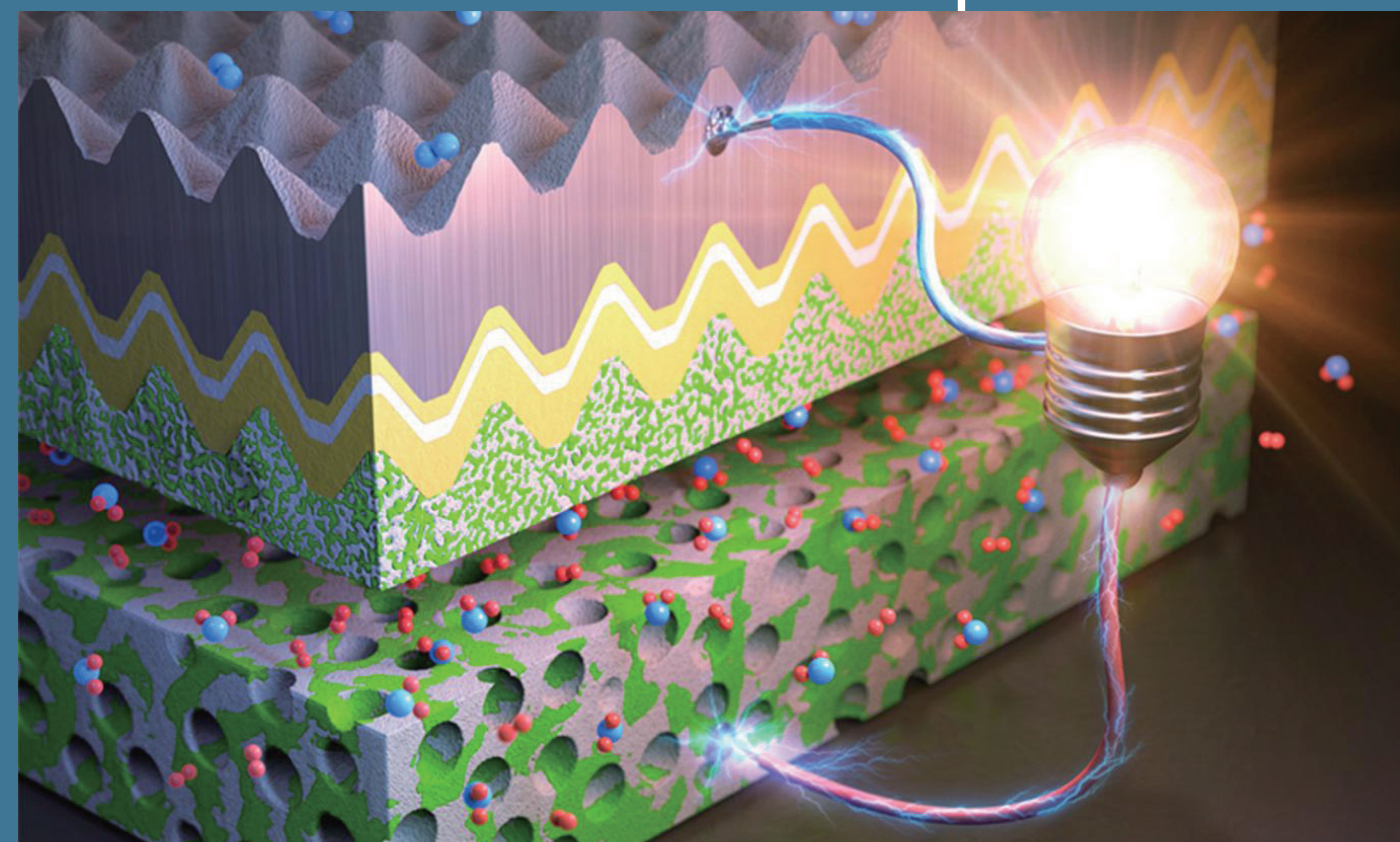
Dr. Oh wants to make better discoveries with younger researchers based on the studies he has conducted over the past 30 years. He added, "We are also continuously pursuing follow-up studies on Anoctamin 1 discovered in 2008. We will continue to examine aspects that may be related to the special parts or core functions of the brain, and strive to solve the mysteries of brain through studies on the changes and functions."

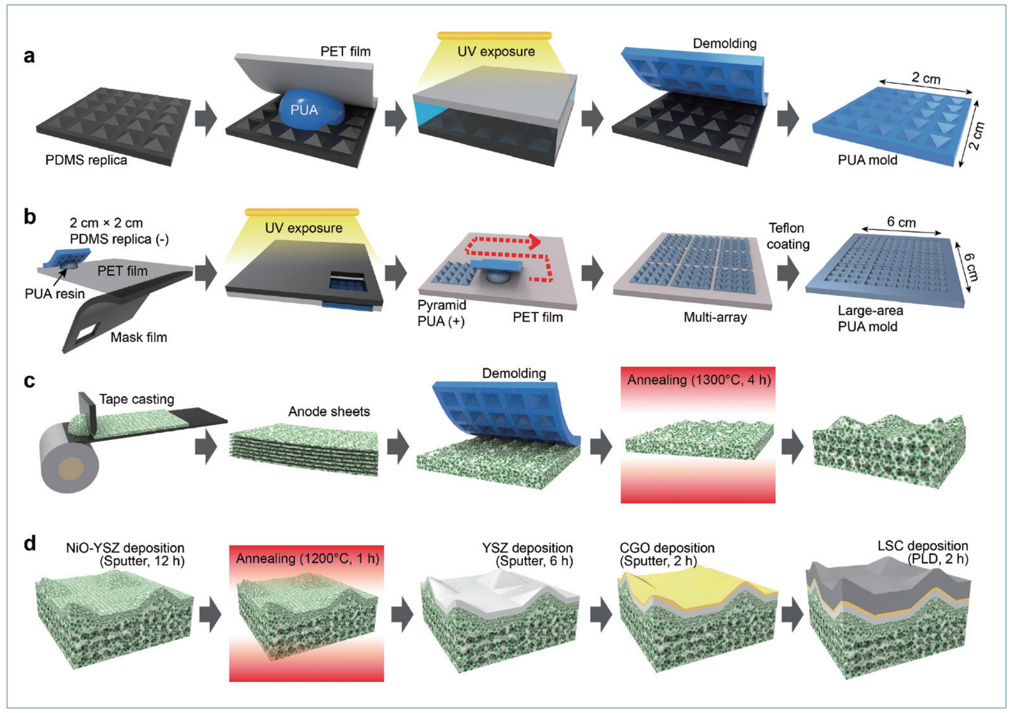
02

3D Interface Architecturing: 50% Performance Increase in Solid Oxide Fuel Cells

Hyoungchul Kim
Principal Researcher
Center of Energy Materials Research

See more details on https://doi.org/10.1039/D0EE00870B
"Multiscale structured low-temperature solid oxide fuel cells with 13 W power at 500℃"
Energy & Environmental Science
13.10: 3459–3468 (2020)





Schematic illustrations regarding the (a) preparation of a small PUA mold from a PDMS replica, (b) preparation of large-area PUM mold (c) molding process to fabricate a 3D patterned substrate, and (d) deposition of several thin-film layers.

"I think the technology commercialization is the ultimate goal of technology development that makes the original technology more valuable. I will continue to pursue the technology commercialization by responding to solving the given technical issues while also faithfully understanding the basic principles.

Dr. Hyoungchul Kim, a principal research scientist of the Center for Energy Materials Research, has worked at the National Research Institute not only to write outstanding journal papers, but also to do more practically meaningful research that can meet the national agenda. To commercialize the research results, it is necessary to go through a very difficult and complex process for a very long period of time. However, if that is the major role of the National Research Institute, researchers should strive to commercialize the technology required by the country and community. Dr. Kim said, "As long as I belong here to KIST, I really want to do research that can contribute to my country or my community."

Dr. Kim recently succeeded in fabricating a three-dimensionally architectured solid oxide fuel cell (3D-SOFC) as a high-performance energy conversion device pertaining to power output, long-term stability, and large-size scalability. This is the result of a collaboration work with the research group of Professor Mansoo Choi of Seoul National University, who was once an advisor and is now a research partner. The 3D-SOFC fabricated from this study has improved the cell performance by more than 50% compared to the conventional SOFCs. In addition, the relatively low operating temperature of 3D-SOFC made it possible to overcome the long-term stability issue of the conventional SOFC, and in fact, the cell can keep the stable performance without serious deterioration even after a long term test run over 500 hours.

Just like craftsmen baking potteries, Dr. Kim's research group fabricated a 3D-SOFC

This research result was published in 'Energy & Environmental Science', a prestige international journal in the field of energy and environment. Dr. Kim said "Just as craftsmen who make ceramic potteries, bake them in a kiln, and break them if they are not perfect, we fabricated a 3D-SOFC. Now further research is on the way to commercialize this technology."

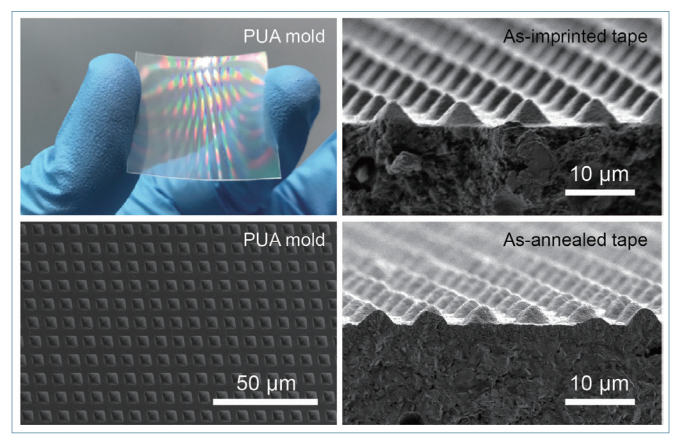
The 3D-SOFC technology delivering a record-high power output of 13 W per single cell at 500℃ is highly to be used as a power pack technology for mobile and transportation in the future.

Nowadays, a SOFC investigated by Dr. Kim has been attracting attentions as a next-generation fuel cell due to its high energy efficiency and fuel flexibility without using precious metal catalysts. However, it needs high operating temperature over 750℃ for efficient electrochemical reaction because ceramics, a major component of SOFC, are barely activated as efficient ion conductors only at high temperatures. Such high-temperature operation of SOFC poses a number of technical problems in terms of materials, processes and economics, acting as one of the major obstacles to SOFC commercialization.

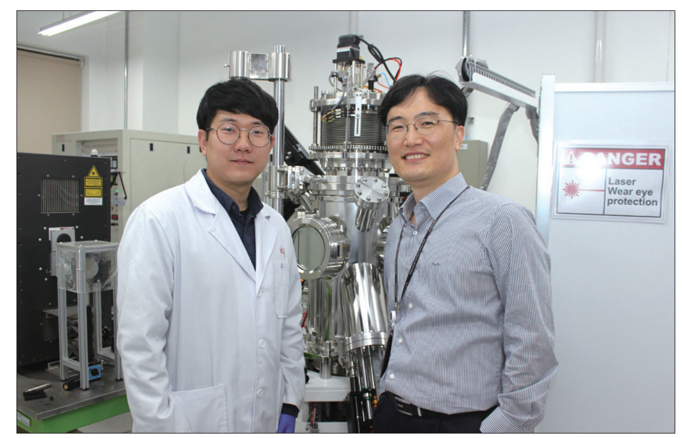
Dr. Kim's group developed a very unique solid-state interfacial engineering skill that can be applied regardless of material type. Based on the developed technology including 3D microstructure patterning process on ceramic substrates, an ideal interfacial structure for high-performance low-temperature SOFCs has been implemented.

First, Dr. Kim's group made an anode substrate with raw ceramic powders, molded it into a substrate with a 3D structure, sintered at high temperature in an electric furnace as like baking a ceramic pottery in a kiln, and then deposited several thin-film layers of electrolytes and electrodes to fabricate SOFC having multiscale 3D structures. In this stage, if the patterned anode substrate is sintered at high temperature as usual without any consideration, the micro-pattern shape cannot be maintained. Dr. Kim's group solve this problem by adjusting the powder rearrangement through the optimal polymer network configuration and

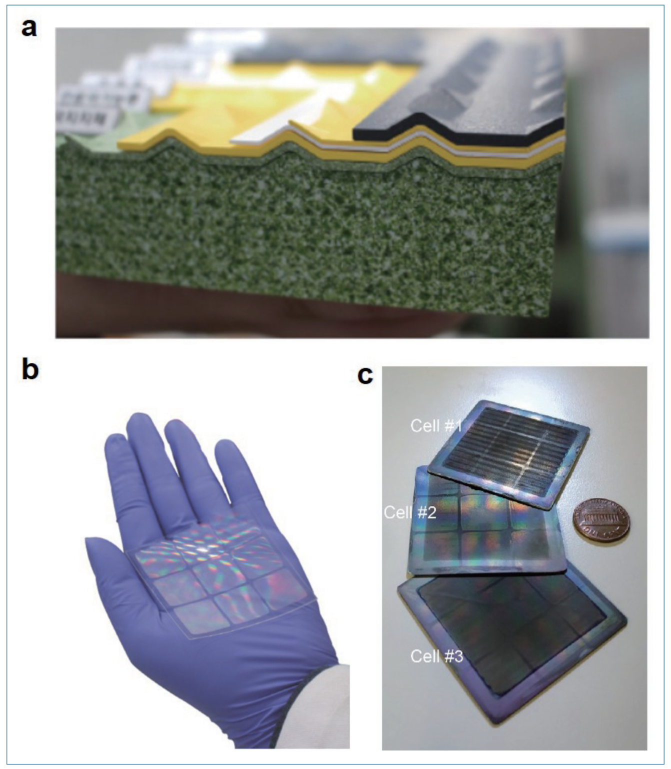
Images of a PUA mold (left), as-imprinted anode substrates (top-right), and as-annealed anode substrates (bottom-right).



Dr. Sung Soo Shin (left) and Dr. Hyoungchul Kim (right) developed an innovative 3D-SOFC having superior power performance and negligible cell degradation at low temperature.



Dr. Kim's research group plans to go one step closer to commercialization by lowering the operating temperature more. Dr. Kim said, "When the operating temperature is lowered a little further, we can use cheaper and more stable materials than before."



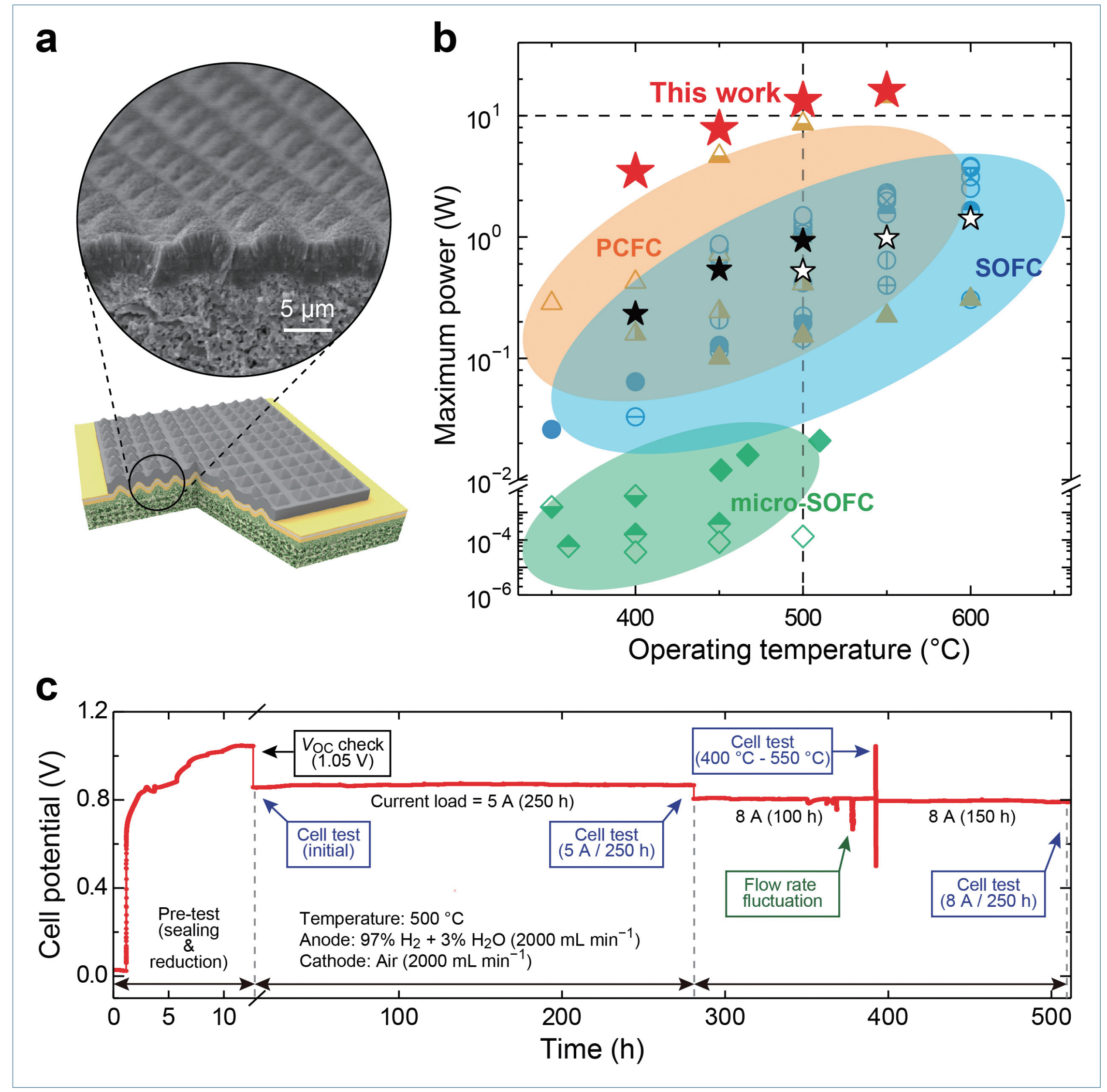
Images of the (a) cutaway model showing 3D interface structures, (b) large-scale PUA mold, and (c) three large-area 3D SOFCs after electrochemical performance tests.

controlling the imprinting pressure. Dr. Kim said "The pyramidal shape is transferred using a polymer mold, just as the shape of a goldfish engraved on the lid is copied when baking a goldfish bread." The subsequent thin-film deposition process makes it possible to realize a nanoscale electrode microstructure that can maintain its electrocatalytic activity even below 600℃, thereby enabling the final 3D-SOFC can achieve the world's highest output of 13 W at 500℃.

Previous studies on 3D-SOFCs have low power performance due to the thick electrolyte layer or small electrode active area. In contrast, Dr. Kim's new technology was applicable to SOFCs with 4cm × 4cm. In particular, a 3D structure increases the interface area, increasing the ion transfer, and reducing the electrode reaction resistance, resulting in a 50% higher power performance than the conventional SOFCs. Additionally, while generating the world's highest output of 13 W at an operating temperature of 500℃, there was almost no performance degradation even during long-term test for 500 hours.

Dr. Kim said, "The 3D-SOFC technology based on large-area ceramic micro-patterning and vacuum deposition processes, which has been verified for commercialization through this study, is highly to be used as a power pack technology for mobile or transportation such as drones and vehicles in the future."

Since it has been recognized for its academic value by publishing a paper in a prestige international journal, the next step is of course commercialization. According



(a) Cross-sectional SEM and schematic images of a 3D SOFC cell. (b) Comparison of the total power performance in this work with that of the previously reported ceramic fuel cells. (c) Long-term stability test results of a large-area 3D SOFC at 500℃.

to Dr. Kim, the operating temperature of 3D-SOFC need to be lowered to 500℃ or less which is more suitable for expanding its application to the mobile or transportation market where next-generation energy devices using thin-film technology can be more competitive. Dr. Kim's research group plans to go one step closer to commercialization by lowering the operating temperature more. Dr. Kim said, "When the operating temperature is lowered a little further, we can use cheaper and more stable materials than before. In particular, if the operating temperature is reduced to ~350℃, well-known stainless steel, not expensive high-temperature alloy, can be used as an interconnector." And he said "We will do further research in the direction of having the same performance even at much lower temperature."

KIST School, a Global Center for Fostering Human Resources of Science and Technology

Since its establishment in 1966, KIST has been developing creative source technologies required for the nation's future growth engine; strengthening the convergence technologies to successfully conduct national projects according to the demands of various fields such as energy, environment, national defense, and bio-industry; and playing a central role in industry-university cooperation to increase the strengths of each other through the role of linking the industry and universities.

KIST School has been operating several educational programs as a way to nurture talents. International Research and Development Academy, IRDA was one of KIST education programs. It started in 2001 with 21 students from 5 countries, 3 years later, University of Science and Technology (UST), UST was established and IRDA and UST merged.In partnership with UST, KIST established the KIST School in partnership with the

University of Science and Technology (UST), KIST established the KIST School in March 2017 as the basic foundation of industry-university cooperation because they recognized the need for fostering excellent human resources in science. Accordingly, as a hub education institute for the ecosystem of science and technology innovation, the KIST School aims to foster talented students in national science and technology, who will become the future global leaders in the scientific and technological research areas.

Based on its accumulated research capacity and cutting-edge science and technology infrastructure, KIST provides systematic research and educational opportunities to young researchers of KIST School. The three convergence majors, namely, Bio-Medical Science & Technology, Energy & Environment Technology and Nano & Information Technology based on field research-oriented convergence science and technology curriculums. Furthermore, the curriculums are linked with Convergence science solving social problem and technology research capabilities and advanced research infrastructure, which are the strengths of KIST, aiming to educate master's and PhD program students in science and technology who will lead the future society.

The KIST School selects outstanding students with high potential for full scholarships and training grants, and in addition, provides differentiated educational benefits whereby the students can directly participate in various research projects and learn practical skills of science and technology on-site. Furthermore, approximately 200 faculty members carefully selected from a pool of around 600 PhD level researchers in KIST are top professors in South Korea who have been producing innovative research outcomes, and they provide students with high-level lectures and experimentation opportunities.

As global campus, KIST offers several unique graduate-level programs to help students, both domestic and foreign, gain the knowledge and practical research experience that will equip them for success as scientists and engineers in specialized S&T fields. Accordingly the school has been attracting future talent from 28 countries around the world and producing global leaders in science and technology to build a global cooperation network in the fields of science and technology.

Professor Chairul Hudaya (President of Sumbawa University of Technology in Indonesia)

Professor Chairul Hudaya, who took his PhD course at the KIST School, was appointed as the president of Sumbawa University of Technology in Indonesia last February, 2020. After graduating from the Department of Electronical Engineering at the University of Indonesia in 2006, President Hudaya studied in South Korea and graduated from Seoul National University with a master's Afterwards, he received his doctorate in February 2016 in energy & environment technology from the KIST. Right after receiving Ph.D. he has been appointed as an assistant professor of University of Indonesia in 2016. And he became the president in only 4 years after being appointed as a professorT School. As a professor, President Hudaya has achieved outstanding results. For example, after being appointed as an assistant professor in the Department of Electrical Engineering at the University of Indonesia in 2016, he was selected as a recipient of the "2017 Young Scientists and Technologists Award" by the ASEAN and received the Best Teaching Professor Award at the University of Indonesia.

Ultimately, the KIST School has a goal of finding pioneers around the world who will overcome global challenges together. To achieve this goal, it provides research-oriented education in the new convergence technology fields that can preemptively respond to the rapidly changing future environment, and uses the advanced research infrastructure of KIST to foster global leaders of science and technology. By planning for a better future for the next 10 to 20 years rather than just 1 year in advance, the KIST School will continue to lead in producing potential science and technology leaders who will create scientific and technological outcomes for all of humankind.

Research News. 01

Bio/Medical

A nano cleaner that only draws and removes beta-amyloid; the substance that causes dementia

See more details on
https://doi.org/10.1002/adfm.201910475
"Silica Nanodepletors: Targeting and Clearing Alzheimer's β-Amyloid Plaques." Advanced Functional Materials 30.15: 1910475.(2020)

Joonseok Lee
Senior Researcher
Molecular Recognition Research Center

Beta-amyloid protein, known as the primary cause of dementia, tends to aggregate in the brain. When this protein is excessively aggregated, it kills nerve cells and destroys synapses, accelerating Alzheimer's disease progression. Therefore, to prevent such aggregation, studies using antibodies and inhibitors to block the production of beta-amyloid proteins or prevent the generated proteins from clumping with each other have been conducted in various fields. However, effective treatment for dementia has not yet been developed.

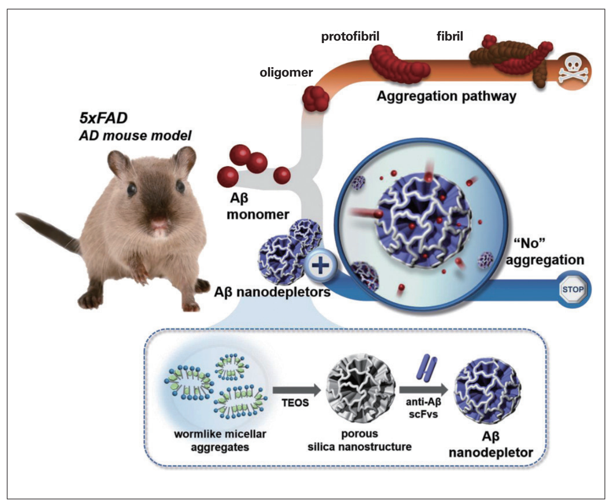
Dr. Joonseok Lee's team from the KIST Molecular Recognition Research Center focused on a strategy to prevent the generation of toxic substances through a novel approach by suctioning and removing the produced beta-amyloid protein in comparison to the conventional method. Additionally, through joint research with Professor Chan Beom Park's team of the Department of Advanced Materials Engineering at KAIST and the National Research Institute of Argon, a nanostructure that selectively suctions and removes beta-amyloid protein, considered to be the leading cause of dementia, was developed.

However, to efficiently suck and remove a specific protein such as beta-amyloid, a substance with beta-amyloid selectivity like an antibody is required. Unfortunately, conventional antibodies have a disadvantage in that their stability is deficient in the body and can bind to other molecules, and have low efficiency. To overcome these limitations, the research team designed nanoparticles with huge pores to fabricate nanostructures with large surface areas. Moreover, a mini-antibody (scFv), which has high selectivity for a target substance and can be drawn with higher efficiency, is attached to the construct to select and adsorb the target substance; beta-amyloid protein.

As a result, the "nano cleaner" developed by the research team effectively adsorbed beta-amyloid protein, blocking their abnormal aggregation by more than 80%, and alleviating neurotoxicity. Further, the research team proved its effect through animal experiments, demonstrating its potential as a future anti-amyloid inhibitor.

The nano cleaner enables the inhibition of aggregation of neurotoxic substances based on beta-amyloid or tau proteins' suctioning. If the application range is expanded in the future, it is expected to contribute to disease prevention and health promotion as a nano cleaner that can selectively remove various harmful substances in the body.

Schematic illustration of removing the producted beta-amyloid protein



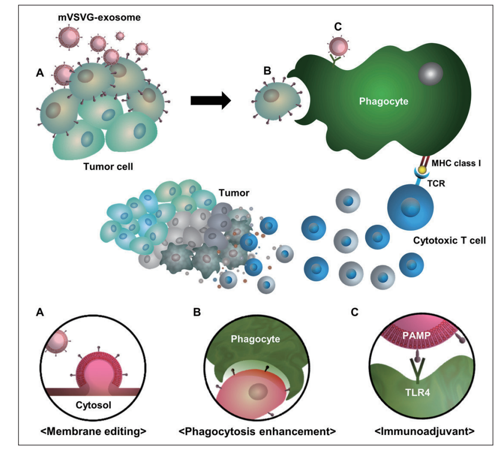
Since the advent of "immune-oncology drugs" that induce immune cells in the body to eliminate cancer cells, the global trend of cancer treatment strategies is rapidly changing. Anti-cancer immunotherapy is a treatment that effectively responds to cancer through the formation of cancer-specific immunity. It has surprising clinical practice effects while solving the side effects and limitations of existing anti-cancer therapies (chemotherapy, surgery, radiation therapy, etc.). However, as cancer cells can conceal themselves from immune cells, even these immune-oncology drugs have limitations in that they are only effective in some cancer patients.

The research team of Dr. InSan Kim and Dr. Yoosoo Yang of KIST's Center for Theragnosis succeeded in developing a nature-derived nanoparticle that can activate immune cells in the body in various cancer tumors effectively. As well, overcome the above limitations, and establish anti-cancer immunotherapy technology that can be active in multiple tumors.

The anti-cancer immunity nanoparticles developed by the research team can specifically fuse with cancer cells to transmit (transplant) dangerous markers, namely, "target signals," to cancer cells' surface. Cancer cells exposed to this "target signal" can no longer hide from the immune cells of our body, and the immune cells recognize cancer cells as "enemies" and "eat" them easily. The activated immune cells in the body can efficiently eliminate cancer by amplifying the immune response against cancer.

The research team developed a technology that uses exosomes, nano-sized particles released by cells, to deliver a "target signal" protein specifically to cancer cells surface in acidic tumor microenvironments. When this protein is implanted, the immune evasion ability that cancer cells initially possess is neutralized. Therefore, the nanoparticles can eliminate cancer by generating excellent anti-cancer immunity in various breast cancer, colon cancer, and lymphoma tumors.

Furthermore, combined treatment of this nanoparticle with immune checkpoint blockades (PDL1 inhibitors) can induce memory immunity against cancer and prevent a recurrence. Dr. In-San Kim said, "the development of this nanoparticle that can induce the enhancement of the 'enemy' signal of cancer cells in the body can be expected to be used as next-generation anti-cancer immunotherapy that can overcome the limitations of existing anti-cancer immunotherapy methods."



Schematic illustration of mVSVG-Exo–mediated tumor xenogenization Strategy

Yoosoo Yang
Senior Researcher
Center for Theragnosis

In-San Kim
Principal Researcher
Center for Theragnosis

Research News. 02

Bio/Medical

Transplanting "target signals" into cancer cells: a novel anti-cancer immunotherapy strategy

See more details on
https://doi.org/10.1126/sciadv.aaz2083
"Xenogenization of tumor cells by fusogenic exosomes in tumor microenvironment ignites and propagates antitumor immunity."
Science advances, 6.27: eaaz2083. (2020)

Research News. 03

Material/Systems

Development of artificial intelligence semiconductor technology using electron spin

See more details on
https://doi.org/10.1038/s41928-020-0385-0
"Skyrmion-based artificial synapses for neuromorphic computing."
Nature Electronics, 3.3: 148-155. (2020)

Competition is fierce for the development of artificial intelligence (AI) semiconductor technology, which is the core technology of the fourth industrial revolution. With the advancement of AI technology, ultra-low-power AI-only semiconductors need is rapidly rising as the computing power increases exponentially.

Dr. Hyunsu Ju of KIST's Center of Opto-Electronic Materials and Devices and Dr. Joonyeon Chang, the Director-General of the KIST Gangneung Institute of Natural Products, conducted joint research with Dr. SungHoon Woo of IBM. The study developed core technology for low-power neuromorphic computing devices using the swirl-shaped nano-spin structure, the skyrmion.

"Skyrmion" is a spin structure arranged in a spiral shape and has the advantages of having unique structural stability, small size in the order of nanometers. It is easy to create and control, making it very useful for application to the next-generation electronic devices. Additionally, each skyrmion has its electrical resistance. Change in resistance depending on the number of skyrmions can be adjusted and measured in an analog manner. Due to such excellent characteristics, interest in developing an artificial synaptic device based on skyrmion has been high. However, owing to the technical difficulty of electrically controlling skyrmion, so far, it has only been predicted theoretically.

The research team conceived that the synaptic weight could be changed by controlling the number of skyrmions on the same principle as neurotransmitters. They found a method to electrically control the skyrmion electronic device that is proposed only conceptually. The device was manufactured for the first time based on this method. It has high durability when operating at a lower voltage than conventional synaptic devices.

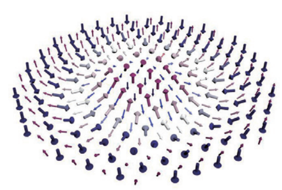
The research team corroborated that the recognition rate was relatively high, at 90% when the handwritten numeric pattern (MNIST) recognition learning was performed using this artificial synaptic device. Existing artificial synaptic devices required hundreds of thousands of repetitive learning to obtain a similar level of recognition rate, but this could be achieved in skyrmion-based artificial synaptic devices by only learning 15,000 times. Wherein reducing the power consumption of devices required for recognition by more than 10 times.

To the best of our knowledge, this study's result is the world's first implementation of a skyrmion-based artificial synaptic device, which was previously presented only as a theory. By controlling the synaptic weight according to the number of electrically controlled skyrmions, it most closely mimics the human brain that controls the synaptic weight by the neurotransmitter amount. Moreover, this study's new approach using skyrmion suggests a novel method for research in this field. It presents a new generation of materials or neuromorphic devices based on novel devices.

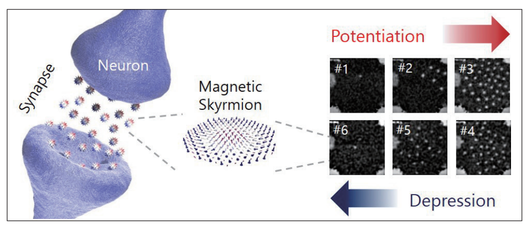
Hyunsu Ju
Senior Researcher
Center of Opto-Electronic Materials and Devices

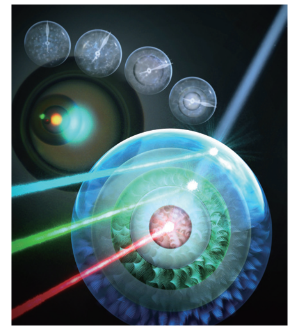
Joonyeon Chang
Director-General
Gangneung Institute of Natural Products

Schematic diagram of magnetic skyrmion, topologically protected spin texture.

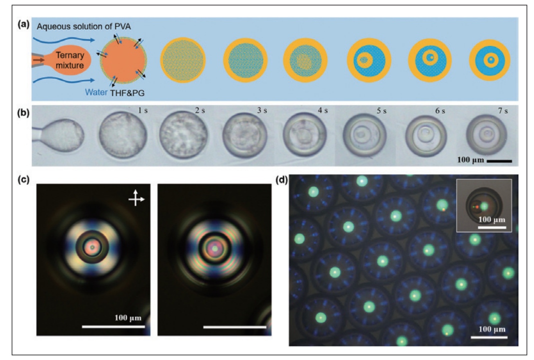


Artificial synaptic behavior implemented with magnetic skyrmion devices





A schematic diagram and photo of photonic multishells



Multiple emulsion drops containing cholesteric liquid crystal through phase separation process and their reflection colors

Research News. 04

Material/Systems

Anti-forgery liquid crystal particles made up of multiple photonic shell structure

See more details on
https://doi.org/10.1002/adma.202002166.
"Photonic Multishells Composed of Cholesteric Liquid Crystals Designed by Controlled Phase Separation in Emulsion Drops."
Advanced Materials, 2002166. (2020)

Sangseok Lee
Researcher
Functional Composite Materials Research Center

The team of Dr. Sangseok Lee at KIST Jeonbuk Institute of Advanced Composite Material developed an anti-forgery material. The material can replace color conversion ink in banknotes and IDs through joint research with Professor ShinHyun Kim's team of the Department of Biochemical Engineering at KAIST.

When a specific additive is mixed with a liquid crystal material commonly used in a display device, liquid crystal molecules spontaneously rotate to form a spiral structure. Such material is referred to as cholesteric liquid crystal. It is a photonic crystal material that displays color by selectively reflecting light in a specific wavelength range by a structure even if no pigment is added. Further, the reflected light has a circular polarization property that rotates in a spiral shape while drawing a circle. Thus, the color may appear or disappear according to conditions. Therefore, it may be utilized in technology for preventing forgery and alteration using light.

If a cholesteric liquid crystal with such optical properties is made into a repetitive structure, a material having two or more reflective colors can be developed. Furthermore, liquid crystal particles with various reflective colors through multiple layers can be applied as a sophisticated anti-forgery material. However, to create a material composed of several layers, it was necessary to repeatedly stack layers one by one using a carefully designed device, leading to a technology-need to solve this complex process.

The research team found homogeneous ternary mixtures of the oil-friendly liquid crystals, water-friendly organic alcohol, and co-solvent. At this time, the co-solvent, organic alcohol, and water molecules were exchanged through the interface of the fine droplets, and accordingly, the equilibrium of the ternary mixtures was changed. The change of the composition induced the phase separation into an oil-friendly layer and a water-friendly layer, resulting in the formation of a multi-layered core-shell structure.

Like the Russian doll Matryoshka, multiple core-shell structures are produced in a highly controlled manner, where the multiplicity is controlled up to 5 by adjusting the initial composition of the drops. Dr. Lee said, "This achievement is expected to be utilized as a functional ink that can impart unique optical properties as liquid crystal particles can easily have multiple layers."

Research News. 05

Energy/Environment

High-capacity battery material with DNA from salmon

See more details on
https://doi.org/10.1002/aenm.201903658
"Ecofriendly Chemical Activation of Overlithiated Layered Oxides by DNA-Wrapped Carbon Nanotubes."
Advanced Energy Materials,10.9: 1903658.(2020)

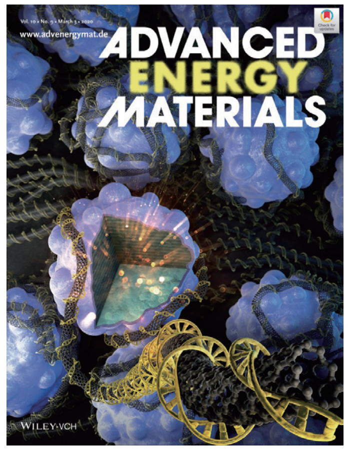
Recently, a Korean joint research team developed a next-generation high-capacity cathode material. The KIST research team led by Dr. Kyung Yoon Chung, head of the Center for Energy Storage Research, and Dr. Wonyoung Chang, principal researcher at the Center for Energy Storage Research, collaborated with the research team of Prof. Sang-Young Lee (Professor at the Ulsan National Institute of Science and Technology (UNIST). They have developed a high-performance cathode material by stabilizing the surface of over-lithiated layered oxides (OLOs), using DNA from salmon.

Over-lithiated layered oxides (OLOs) have been attracting attention for a long time as next-generation cathode materials owing to their high reversible capacity of 250 mAh/g compared to 160 mAh/g of existing commercialized materials. They can enhance the energy storage capacity of batteries by more than 50%. However, OLOs have a major drawback in that, during charge/discharge cycling, the transition metal-oxygen layers where the lithium is located in between can collapse and swell, rendering the battery unusable.

Using transmission electron microscopy, the research team at KIST analyzed changes in the crystallographic structure of different parts of the surface and interior of the OLOs. The results of the analysis confirmed that the transition metal-oxygen layers start to collapse at the surface of the electrodes after battery operation. Accordingly, the joint research team used DNA from salmon with excellent affinity for lithium ions to control the surface structure of OLO, which was the main cause of the material collapse. However, there was a problem; the salmon DNA often tended to aggregate in aqueous solutions. To overcome this issue, the research team synthesized carbon nanotubes (CNTs) and combined them with salmon DNA. The DNA/CNT combined mixture was uniformly arranged and attached to the OLO surface, resulting in the development of new oxides.

Moreover, by employing the integrated high-degree analysis method, the KIST research team found that the electrochemical characteristics of OLOs and its structural stability were enhanced with the application of the mixture. This method investigates a range of factors, from individual particles to electrodes. The results of the in situ X-ray-based analysis confirmed that the structural collapse of the electrode oxides was restrained during charge/discharge cycling. A structural change analysis was also conducted to confirm that the batteries were stable even when overheated.

This study differs from other existing attempts based on synthesized materials in that it uses DNA, which is the primary material of living organisms, and introduces a new direction for the development of high-capacity battery materials. It is of great significance that the design factors for high energy density and safe cathode materials have been presented through the advanced integrated analysis method.



The article were featured on the cover of *Advanced Energy Materials* (2020)

Wonyoung Chang
Principal Researcher
Center for Energy Storage Research

Kyung Yoon Chung
Head
Center for Energy Storage Research

Research News. 06

Energy/Environment

Rapid commercialization of "dielectrophoretic tweezers" that catch nano-toxic particles in the atmosphere and water

See more details on
https://doi.org/10.1038/s41467-020-16630-w
"Precise capture and dynamic relocation of nanoparticulate biomolecules through dielectrophoretic enhancement by vertical nanogap architectures."
Nature Communications, 11.1: 1-9.(2020)

Dr. Yong-Sang Ryu of the KIST Sensor System Research Center developed a source technology that effectively controls fine dust and fine plastics, which are the main culprit of toxicity in the human body and disturbance of the earth's ecosystem. The source technology was developed through joint research with Professor Sin-Doo Lee's team of the Department of Electrical and Information Engineering at Seoul National University.

The research team revealed that it had developed a "nanogap electrode" that efficiently captures ultra-fine suspended particles in a fluid at the level of 20 nanometers (nm), which is 1/1000 of the thickness of a hair follicle. The research team also succeeded in using the electrode in selective enrichment and location control experiments of extracellular vesicles (exosomes) and dementia proteins (beta-amyloid), recently attracting attention as new drug development and new markers for cancer diagnosis.

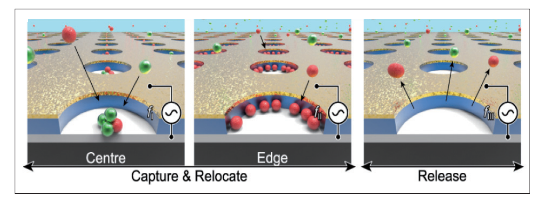
Academia worldwide has been making great efforts to develop a technology that can manipulate nano-scale particles without damage. The optical tweezers technology that won the 2018 Nobel Prize in Physics is representative of this. However, beyond the individual level of movement and measurement, commercialization, much craved by the industry, has been slow. There were obvious technical limitations in making the mechanism for capturing, sorting, purifying, and concentrating particles below 100 nm to a large area and a large capacity in a general atmospheric and water environment.

The research team succeeded in making a large area of nanogap electrodes that enable the 'dielectrophoretic tweezer' technology through particle concentration and purification experiments in centimeters (cm). Dielectrophoresis is a technology that applies a wavelength that vibrates hundreds to thousands of times per second to two electrodes to form a non-uniform electric field around the electrode, thereby attracting or repelling particles around the electric field to the electrode.

The research team experimented with various electrode structures to find a technique that uses a typical semiconductor process instead of expensive equipment and found that asymmetric electrodes in a vertical arrangement generate a dielectrophoretic force more than 10 times greater than that of a conventional horizontal arrangement. This achievement is even more meaningful as it can be applied as a technology for selective purification of nano-sized particles regardless of type or environment in the future. Dr. Yong-Sang Ryu of KIST expressed the significance of the study, saying, "Based on this, we hope that we will be able to contribute to solving various social problems and improving the quality of life for humanity as a whole."

Yong-Sang Ryu
Senior Researcher
Sensor System Research Center

Dielectrophoretic and AC electro-osmotic characterization on VNE(Vertical Nanogap Electrode).



“We Will Create an Immersive Environment for Researchers to Achieve Regional Development.”

Jin Sang Kim
Director-General
KIST Jeonbuk Institute of Advanced Composite Materials

Jin Sang Kim, the new Director-General of the Jeonbuk Institute of Advanced Composite Materials

In August 2020, Dr. Kim was appointed as the KIST's new head, the Jeonbuk Institute of Advanced Composite Materials. Dr. Kim has devoted himself to the research of electronic materials for over 30 years and led to new semiconductor materials and devices. This is why he was selected as the right person in the Jeonbuk branch established to achieve the cornerstone of economic development through the development of carbon-related composite material technology.

As soon as he arrived, he had one-on-one interviews with all employees and heard the research site's voice. He listened to the concerns accumulated over the years, from requests for replacement of outdated facilities to improve the research environment and difficulties in research. After the interviews, he went through, again and again, the voices of the researchers compressed in A4 sheets. He had a feeling of confidence following these conversations and thought, “I can do it together with these people”.

He said, “I had a lot of worries about how to run the research institute, but I felt reassured that the talented researchers were working hard for the future in our KIST Jeonbuk.” He showed his confidence in managing the institute by adding, “Above all, I gained the trust that these people can do it.”

Two joint projects with the Jeonbuk Institute remain as excellent practice cases

“I built a relationship with KIST Jeonbuk Institute by doing two joint projects. I wanted to immerse myself in research in a quiet place, and I arrived here. I think it was meant to be.”

We always dream of a future where we can develop carbon-based composite materials to make electric wires, automobile cables, power transmission lines, and so on, and commercialize them.

a panoraic view of KIST Jeonbuk Institute

Director-General Kim conducted joint research with the Jeonbuk Institute while serving as the head of the Moon Exploration Research Project Promotion Team and head of the R&D project team customized for the security site. The Jeonbuk Institute, where research on combining the strengths of two or more materials to create a more synergistic effect is being conducted, was a partner he wanted to work together. Lightweight materials for space travel were researched jointly, and together they also developed an ultra-lightweight foldable shield to protect police officers. Police officers are using these shields and are considered an excellent case among the research team's projects. They were also recently donated to Nigeria.

The Jeonbuk Institute has developed a technology that can recover more than 95% of carbon fiber by treating carbon fiber reinforced plastic (CFRP) at an eco-friendly and low-cost level. This was transferred to a company. Further, a technology for synthesizing boron nitride was developed, a two-dimensional substance composed of two elements (nitrogen and boron) into a single crystal, and was published in the famous international journal, Science.

The “waste plastic into carbon by upcycling technology” he mentioned is expected to be used in high-value-added carbon resource conversion technology from waste plastics, which are increasing due to Covid-19.

“As the time spend at home increased due to Covid-19, the consumption of food delivery and the use of disposables increased. We have confirmed that graphite and carbon can be extracted from plastics and used as electrode materials, so we will improve them with low-cost process technology to help solve social problems that may arise from non-face-to-face activities.”

Lastly, there is something he wants to achieve while in office. It is a research institute where researchers can settle down and work hard. He said, “Because the Jeonbuk Institute office is located in an area far from the metropolitan area, there is indeed high researcher turnover. There are many young researchers, but I will try to operate the institution so that they can become leader-level researchers.”

He added, “I always dream of a future where we can develop carbon-based composite materials to make electric wires, automobile cables, power transmission lines, and so on, and commercialize them. I will create a good research environment where researchers can achieve success.”

From KIST to VKIST, through My Eyes

Tran Tuan Thanh
Head
Division of R&D coordination(VKIST)

In 2011, when I first came to KIST as a young man, everything was new to me. I had no idea that, 9 years later, I would be a staff member at VKIST. These days, I collaborate with KIST staff on the construction of VKIST, which is being built step-by-step according to KIST's methodology. It is an honor and a pleasure to be taking part in this project - I certainly never imagined anything like it!

As a student at KIST, I was also introduced to the "Miracle on the Han River" and the tireless, indomitable spirit of the Korean people. Now, Korea has become one of the most developed countries in the world: one of only seven nations to join the 30-50 club. Throughout the country's economic transformation, KIST was a driving force that made the Korean "miracle" possible.

Many of my colleagues at VKIST are specialists from KIST. Not only do we work together, we are good friends, as well. I particularly wish to thank Mr. Joo Yong Chul, Mr. Won very wise men, and Mr. Jung Jiwon, Mr. Sa, an incredibly hard worker. And a very special thanks to the founding president of VKIST, Dr. Kum Dongwha, who previously served as president of KIST and is truly a great president. I have learned a great deal of knowledge and skills from each of them, who are working very hard for VKIST at Vietnam.

In my eyes, KIST is a premier research institute that aims to improve quality of life for everyone and create a better future. From its launch in 1966, KIST has continually been at the forefront of Korean development, and their success stories go hand-in-hand. KIST is the result of strong leadership,

VKIST members in the 1st membership training on November 2020.

Creating new industries and achieving growth is important as it is directly linked to employment.

a panoramic view of VKIST

effective policy, and passionate researchers. In its early stages, KIST prided itself on being a "laboratory that never sleeps", reflecting the dedication and commitment of its pioneering scientists and researchers.

In 2019, when I returned to KIST as a VKIST staff member participating in the VKIST – 1st Capacity Building Program, I understood how essential it was for me to digest as much knowledge and experience as possible from KIST's experts in order to ensure VKIST's smooth establishment.

VKIST is taking its first step toward building its R&D capacities. Our mission is to lead applied R&D on advanced technologies pertaining to Vietnamese industries and sustainable economic development. VKIST aims to become a leader among technical solution providers for market winners, meaning that its R&D activities are aligned with bridging the gap between meeting Vietnam's technological needs and offering practical market solutions.

The first task will be the successful and timely completion of the VKIST ODA project. Building a solid foundation is essential for VKIST's sustainable future growth. To accomplish this, VKIST must work to organize and improve every aspect of its management. Capacity-building will be aligned with the construction of an operating system (OS), personnel development, and the procurement of needed equipment.

Currently, we are in the progress of finishing the building construction, getting equipment for laboratories, and recruiting administration staff and researchers as well. Everything is moving forward and I am very happy to see we are growing up every day.

I believe that with the support from KIST, the VKIST Project will prove a great success, becoming the definitive example of successful cooperation between Vietnam and Korea—and not just in terms of S&T. I can see myself ten years from now telling my family how proud I am to have been a part of this special moment in history.

Just as KIST did for Korea, VKIST is expected to play a leading role in accelerating Vietnam's industrialization process and paving the way for the Fourth Industrial Revolution.

Delegators in the VKIST Midterm Workshop in June 2020

The Inauguration Ceremony of KIST's 25th President, Dr. Seok Jin Yoon

On July 20, 2020, the inauguration ceremony of KIST's 25th president was held at KIST headquarters in Seongbuk-gu, Seoul. This event was broadcast live online with only the people in major positions in attendance due to the coronavirus (COVID-19) pandemic.

Since its establishment in 1966, KIST, the first comprehensive research institute in Korea, has been leading Korea's science and technology research paradigm and has been a driving force behind economic development. While it already possesses accumulated research capabilities and a solid human network and infrastructure, at the inauguration of its new president it announced the direction of future development.

At the ceremony, Dr. Seok Jin Yoon, who was inaugurated as the 25th president, said that he would prioritize the "establishment of a research system that responds to global agendas and national issues" as the first direction of development for KIST. He announced that he will take on numerous tasks relating to national issues such as overcoming dementia, infectious diseases, and fine dust particles in the hopes of finding ultimate solutions. In addition, he emphasized the role of a "research institute that presents new growth engines" for not only technology in materials, parts, and equipment , but also future core technologies that can compete in the world. Lastly, he expressed plans to further strengthen the "research institute that presents new growth engines" , which strives for convergence and cooperation with universities, research institutes, and companies while conducting world-class research.

KIST's 25th President promised to "present a vision that all members can relate to and participate in, and by breaking down the rigid formality and opening the doors to the director's office, and opening hearts and ears to members with sincere communication."

Joint Cooperation in the Anti-Doping Program by KIST and KADA

The KIST Doping Control Center was established in 1984 to conduct sports doping analysis for the 1986 Asian Games and the 1988 Olympics that were both hosted in Seoul. Additionally, doping analysis at the 2014 Asian Games held in Incheon and the 2018 Winter Olympics held in Pyeongchang, as well as other related doping analysis tasks, were performed exclusively by the KIST Doping Control Center. The center gets recertified by the World Anti-Doping Organization (WADA) every year, and doping test sample analysis and new research for developing analysis methods are carried out.

KADA, the Korean Anti-doping Agency, and the KIST Doping Control Center, which is an internationally recognized doping analysis testing agency, recognize the importance of strategic cooperation to successfully perform anti-doping tasks regulated by WADA.

To strengthen the cooperation between these two groups, on February 25, 2020, a Memorandum of Understanding (MOU) for strategic joint cooperation in the anti-doping program was signed by both organizations.

Through this agreement, the two organizations vowed to do the following: quickly identify standards and norms determined by WADA and international organizations and promptly identify research trends; share information and trends relating to international organizations and support participation in related projects; promote joint research and cooperative projects through mutual cooperation; cooperate in sample analysis-related information and support doping test materials, while preparing and organizing sports competitions; promote a sense of community through mutual exchanges; and establish and operate business councils for each field of cooperation.

KIST and KADA have been working together for a long time on the issue of "sports anti-doping." Through the signing ceremony, KIST, as the only WADA-accredited doping analysis testing institution in Korea, will continue to make efforts to protect the health of athletes, promote fair competition, and contribute to enhancing the nation's status through international business.

Through this anti-doping program agreement, KIST complies with the standards of the World Anti-Doping Organization and of international organizations, and through joint projects with the Doping Control Center utilizing cutting-edge equipment and technology, international cooperation and professional talent, KIST looks forward to making a significant contribution to the anti-doping field and becoming a world leader in the field.

Establishment of the Industry-Research Cooperation Promotion Group to respond to export restrictions

Trade conflicts and export restrictions have recently emerged as hot topics in the world of science and technology. Accordingly, KIST established the "K-Club Material, Parts, and Equipment Industry-Research Cooperation Promotion Group" centering on 30 member companies related to subsidiaries, departments, and heads within the K-Club, a family company. This Group will respond to the government's materials, parts, and equipment support policies, develop joint Research and Development (R&D) tasks, and promote converging R&D support projects that reflect the unique characteristics of a convergent research center.

Based on the established promotion team, the KIST Innovation Business Cooperation Center will derive R&D tasks based on technology consumers and will actively support additional requests for successful results. To this end, KIST has announced that it is planning to open up the material, parts, and equipment platform and various kinds of equipment (manufacturing equipment and analysis equipment) built by KIST to the promotion team to establish an optimal promotion system that can result in visible results in a short period of time.

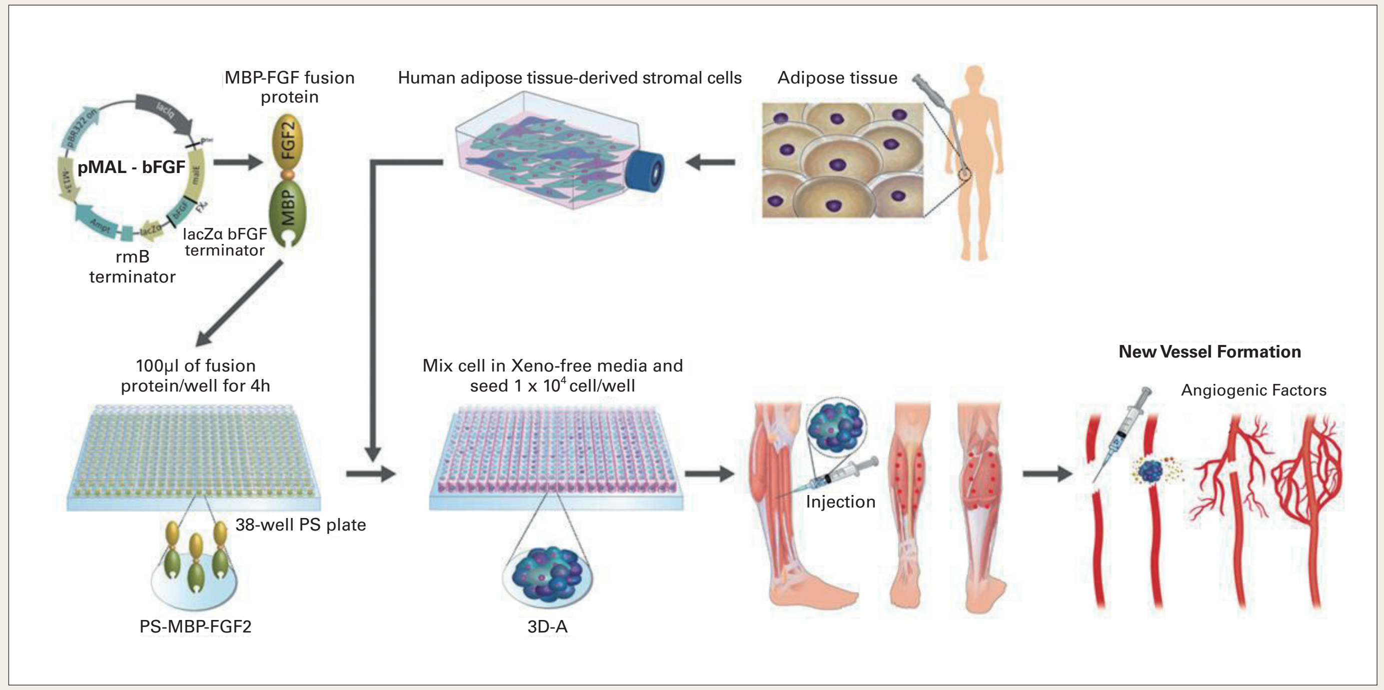
In addition, to support materials, parts, and equipment companies, KIST plans to form a special response TF comprised of researchers related to 100 core materials, parts, and equipment, to provide unique R&D support. Centering on the established promotion team and TF, we plan to actively respond to the government's material, parts, and equipment support policies.

Additionally, KIST is planning to identify members of other innovative companies related to it, other than K-Club member companies, and among them, the "Linking Lab" will be installed to focus on companies that have a large impact on performance and support them with human and physical infrastructure.

Clinical approval for treatment of critical limb ischemia using stem cells

Dr. Sang-Heon Kim's team at the Biomaterials Research Center announced that it has received approval from the Ministry of Food and Drug Safety for a clinical trial of a cell therapy for critical limb ischemia, a type of cardiovascular disease.

Critical limb ischemia refers to a serious state of peripheral arterial disease caused by the blockage of major blood vessels that supply blood to the lower extremities such as the thighs, calves, and feet. Peripheral arterial disease is exacerbated by various factors including smoking, high blood pressure, and diabetes, and it may progress to severe limb ischemia in which ulcers appear or toes become necrotic.



Schematic illustration of Spheroid-shaped stem cell therapy for critical limb ischemia

Currently, there is no treatment for peripheral arterial obstruction diseases such as critical limb ischemia. There is arterial bypass grafting and percutaneous angioplasty for the treatment of this disease, but there are risks such as the ones inherent in surgery and decreased treatment efficiency. "Stem cell three-dimensional microstructure technology," which can overcome the limitations of the current treatment technologies and may improve ischemia-related symptoms, is different from existing cell therapy technology.

Dr. Kim's team developed a new physiologically active protein that stem cells can adhere to in order to develop a treatment for critical limb ischemia, and cultured the stem cells into a three-dimensional spheroid by simply coating this protein in a culture dish. A spheroid refers to a circular aggregate of cells in which a number of cells unite in a lump form.

When cultured spheroids are mixed and injected into the affected area of a person with critical limb ischemia, the injection can treat the pain and necrosis of the affected area through suppression of inflammation and blood vessel generation.

The researchers administered the candidate stem cell therapy to mice with blood vessels that had been completely removed and observed various regenerative effects. As a result, compared to the existing methods, the researchers demonstrated that stem cells injected in vivo had a higher engraftment rate and angiogenesis. In addition, fibrosis due to inflammation was suppressed, and excellent tissue regeneration ability was confirmed.

Dr. Kim explained, "The three-dimensional microstructure of stem cells is the closest to commercialization as a therapeutic agent as it uses adult stem cells that have a simple manufacturing process, excellent cell engraftment rate and angiogenesis, and are somewhat easy to license. He added, "It can be applied not only to adult stem cells but also to various cells derived from reverse differentiation embryonic stem cells, and it can be used as a source technology for diverse occasions."

Development of anti-fog goggles and masks with strong resistance

Development of anti-fog goggles for medical staff responding to the coronavirus (COVID-19) pandemic and masks made with a material with improved resistance to virus-containing droplets (saliva) has begun.

Based on technology that maximizes the moisture properties of the original material by controlling its surface structure in nano units (1 billionth of a meter), Dr. Myoung-Woon Moon research team at KIST's Extreme Materials Technology Research Center is developing a mask made with a material with improved resistance to virus-containing droplets (saliva) and that prevents fogging-up of goggles that can be used as personal protective equipment (PPE).

When the glass surface of the goggles is nanostructured to exhibit super-hydrophilicity, since water vapor spreads in the form of a thin film rather than a droplet, fogging does not occur. Thus, the inconvenience experienced by medical staff who wear goggles for a long time can be minimized.

In addition, unlike conventional anti-fog agents that thinly coat the glass surface with a hydrophilic material, there is no risk of evaporation even during sterilization for medical devices that are reused, so it is excellent in terms of durability.

Maximizing the water repellency of the outer material of the mask makes it difficult for droplets containing the virus to be in contact with the mask, and it can suppress the spread of droplets on the surface into the mask, greatly improving the resistance of masks used by medical staff.

The researchers plan to conduct follow-up research to improve aspects of performance such as durability, and produce prototypes in collaboration with related companies.

Introducing KIST's New Members

KIST provides great collaboration opportunities, tackling and conquering difficult problems in our society and inspires multidisciplinary and convergence research.

Eunjung Kim
Senior Researcher
Natural Product Informatics Research Center

I joined KIST in August this year. As an applied mathematics major, I have developed mathematical models to better understand and treat incurable diseases such as cancers. By combining mathematical modeling and statistical analysis with clinical and experimental data, I have addressed problems in carcinogenesis and anti-cancer treatment, collaborating closely with clinicians and basic scientists.

KIST provides great collaboration opportunities, tackling and conquering difficult problems in our society and inspires multidisciplinary and convergence research. I'm immensely passionate about my research and fully committed to a scientist career at the interface of mathematical modeling and biological research. Given the nature of my work, a highly interdisciplinary environment is critical for the success of my research. KIST provides multidisciplinary team science opportunities and my goal is to contribute to improving natural product research translation from source to clinical trials. Therefore I think KIST is the place to make my dream come true.

At KIST, I'm developing research programs by collaborating with biologists and chemists to create mathematical models to understand i) underlying mechanisms of multiple targets of a natural product and ii) interaction mechanisms of microbial communities in the human gut.

I developed an interest in the researcher's path during the course of my academic achievement, and I was greatly influenced by my supervising professor, Takao Someya. The biggest lesson that I learned from him was his philosophy on research and his expertise as a researcher.

Wonryung Lee
Senior Researcher
Biomaterials Research Center

During my degree course, I was working on the development of a bioelectric signal sensing platform. After graduating, I worked on biochemical sensor research at the KIST, as a postdoc in place of military service. At the time, I felt the limitation of conducting research alone, and recognized the need to collaborate with experts in biological research. Coincidently, the Biomaterials Research Center at the KIST was starting to conduct related research and I joined it with a strong interest in this field.

Prior to joining the KIST, I conducted research in a limited field of biophysical sensors. There are many biochemical monitoring experts in the Biomaterials Research Center, and I would like to gain expertise in the biochemical monitoring field through collaborative research. Furthermore, I would like to develop bio-information device platforms with general expertise in biophysical and biochemical sensors.

I developed an interest in the researcher's path during the course of my academic achievement, and I was greatly influenced by my supervising professor, Takao Someya. The biggest lesson that I learned from him was his philosophy on research and his expertise as a researcher. He advised me that I should not cling to results; I will eventually obtain results with time if I focus on research with my expertise.

I would like to act as a bridge connecting researchers from diverse fields and perform collaborated research to shift the paradigm of AOP-based alternative animal experiments.

Indong Jeon
Senior Researcher
KIST Europe

As a bio engineer with more than ten years of research experience in both university and research institutes, I have been interested in alternative animal experiments. During my stay as a post-doc at KIST and the University of Oxford, I learned how to create an optimized bio compatibility assessment for materials and molecules and mastered various cell-based evaluation techniques for toxicity, viability, and biomarker detection. I applied to KIST-EU to make my dream come true in Europe, where the field of alternatives to animal experiments is strong.

The animal experiment is generally considered as the standard for evaluating the safety of drugs and cosmetics. However, experimental errors and incorrect interpretation of test results can arise from animal testing due to interspecies differences in metabolism and pharmacological/toxicological response. Therefore, Adverse Outcome Pathway (AOP)-based alternative testing methods are becoming the new mainstream tools for evaluating hazardous chemicals and their mixture. Here, I would like to act as a bridge connecting researchers from diverse fields and perform collaborated research to shift the paradigm of AOP-based alternative animal experiments. I would like to create an experimental model for a more accurate prediction about how different organisms react to a chemical under different circumstances and design alternative animal experiments with improved accuracy to represent relevant human adverse effects or environmental organisms, which would be faster and cost-effective. I believe that my multidisciplinary expertise and KIST-EU's professionalism will unquestionably create a synergy in designing new alternative animal experiments beyond the limitation of currently used animal testing.

Thes scientists who have inspired me the most are the ones I privilege of working with Dr. Hyun-Kwang Seok, Dr. Yu-Chan Kim, and Dr. Hojeong Jeon who are my post-doc supervisors when I was working in the Biomaterials Research Center at KIST (2014 -2017). It was amazing to see their decades of work becoming recognized at such a high level. They all were a trailblazer, and they have been a model for me.

While working as a postdoc at Harvard, I was convinced that the KIST offered the best environment for producing robots with a high level of perfection, and decided to join the KIST.

Kahye Song
Senior Researcher Center for Intelligent and Interactive Robotics

During my graduate studies, I built a soft actuator and thought intensively about areas to which it could be applied. Fortunately, I worked as a postdoctoral researcher at KIST to develop soft robotics/wearable robotics, and I was impressed by how the admirable research fellow and senior researchers cooperated to make robots. Afterwards, while working as a postdoc at Harvard, I was convinced that the KIST offered the best environment for producing robots with a high level of perfection, and decided to join the KIST.

I am a scientist working on soft wearable robotics. While wearable robotics have the potential to expand the scope of human strength beyond the limitations of physics and the human body, they can also open the way for disadvantaged people to enjoy an extremely ordinary life. It is my desire to pursue research that helps more people live safely and comfortably.

As a beginning researcher, I acknowledge my lack of certain capabilities and experience. I have been gaining experience and learning research competence and personal character by interacting with all the scientists I have met. In particular, I have learned patience and persistence from my supervising professor, and humility, a challenging spirit, and consideration for others from the researchers in the research center.

Recruitment

KIST is looking forward to recruit creative and passionate research talent both in Korea and from abroad to continue our move to a position of preeminence in global research.

• **When & How to Apply**
Please refer to the details on below websites
http://www.kist.re.kr
http://onest-kist.saramin.co.kr

Categories and Specific Area of Research

Brain Science Institute

· Examine brain function and cause of disease; utilize mapping of functional-structural connection in neural circuits
· Computational neuroscience
· Neural stem cell application
· Microsensors, MEMS, Brain Engineering and Microsystems
· Brain Disease/Neurochemical Imaging and Therapeutics

Biomedical Research Division

· Analysis and application of medical big data
· Rehabilitation technology for overcoming disabilities
· Electric/optical sensors for implantable devices
· Targeted anticancer agents and cancer immunotherapy

Clean Energy Institute

· Material and system technology for hydride/fuel cell
· Hydrogen storage material and module technology
· Solid state electrochemical thin film process and engineering technology
· Synthesis of advanced secondary cell liquid electrolytes, separators, battery engineering and production, electrode material technology

Post-Silicon Semiconductor Institute

· Quantum Computing, Quantum Communication, Quantum Information Theory
· High speed electronic device/nonlinear photoelectric device, optical data control/analysis/design
· Spin device using nano spin dynamics and spin trajectory
· Neuromorphic semiconducting material/devices/system

Artificial Intelligence and Robotics Institute

· Technology and system technology for intelligent robots (control/recognition/human robot interaction, etc.)
· Atmospheric environmental science related to fine dust
· Medical robot system technology
· 2D/3D video and media technology
· AI core technology

Advanced Materials Research Division

· Photonics materials and devices for optical control
· Biomarker detection technology based on omics and antibody engineering
· Cancer immunotherapy and medicinal chemistry
· Materials for extreme physical properties and extreme environments(energy, environment, structure)
· Multiscale organic-inorganic hybrid catalyst active material

National Agenda Research Division

· Technology and system technology for intelligent robots (control/recognition/human robot interaction, etc.)
· Atmospheric environmental science related to fine dust
· Medical robot system technology
· 2D/3D video and media technology
· AI core technology

KIST Gangneung* (*Must be able to work in Gangneung)

· Identify and verify the efficacy and mechanism of natural substances based on omics data
· Bioinformatics for the application of precision medicine to natural materials
· Analysis of changes in the signal transduction system in vivo induced by natural products (mRNA/protein)
· Smart Farm AI Control and Modeling

KIST Jeonbuk* (*Must be able to work in Wanju)

· High temperature carbon composite material manufacturing technology
· Synthesis and mechanical molding/physical analysis of thermoplastic/thermosetting polymer resins
· Polymer synthesis and analysis
· Multi-scale modeling of structural composite materials