THE KIST, Making New History

GREEN CITY TECHNOLOGY INSTITUTE

ANNUAL REPORT

2016

Korea Institute of Science and Technology

Contents

Green City Technology Institute

ANNUAL REPORT 2016

G
Greetings

Greetings

Welcome to the Green City Technology Institute at the Korea Institute of Science and Technology (KIST). Currently, about 50% of the world's population resides in urban areas, up from less than 10% in the 18th century. The urban population is expected to reach almost 70% in the near future, increasing the importance of cities as residential areas. In order to address a wide range of potential issues associated with urban life a variety of factors such as the environment, energy, and health should be considered.

Our institute consists of 241 researchers, including 52 primary faculty members who specialize in those areas and undertake continual R&D activities to improve the quality of urban life. We believe all our research should help focus on making life better for everyone, and the overarching goal of our institute is to establish "Green Cities" where sustainable usage of natural resources like "clean" water, air, and energy is realized. We hope you enjoy learning about our current research activities and our vision for the future.

Thank you for your interest, and we hope you have a prosperous 2017!

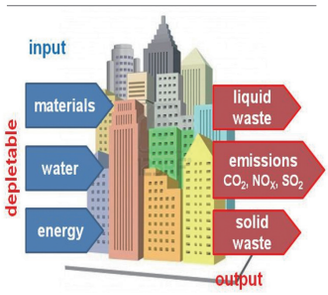
Best regards,

Director-general of GCTI
Dr. Lee, Seockheon

Green City

A Green City is an eco-friendly city where humans live in harmony with nature by virtually eliminating carbon emissions through a dramatic reduction of greenhouse gases thanks to a convergence of natural resources, highly-efficient energy, and information technologies.

As-is



Linear metabolism

*Green City Technology

To-be

Cyclic metabolism

Report Summany

Vision and Mission of GCTI

Although the main factors of the green city may include ecological land, architecture, transportation, water, air, and energy, the Green City Technology Institute (GCTI) mainly focuses on resolving environmental and energy problems affecting welfare and climate change. The vision of GCTI is to realize worldwide R&D leadership on environmental technologies related to wastewater treatment and air quality control, as well as technologies related to energy storage and urban energy systems.

GCT's Realization of an eco-friendly and self-sustainable Green City

Supplying Comprehensive solutions for the realization of a Green City through the convergence of core technologies

- Providing the fundamental technologies for green energy and environment
- Application of core technologies to a preliminary Green City
- Commercialization of green technology through communications
- Resolving national and global agendas for water, air, and energy

Environmental Control Technology

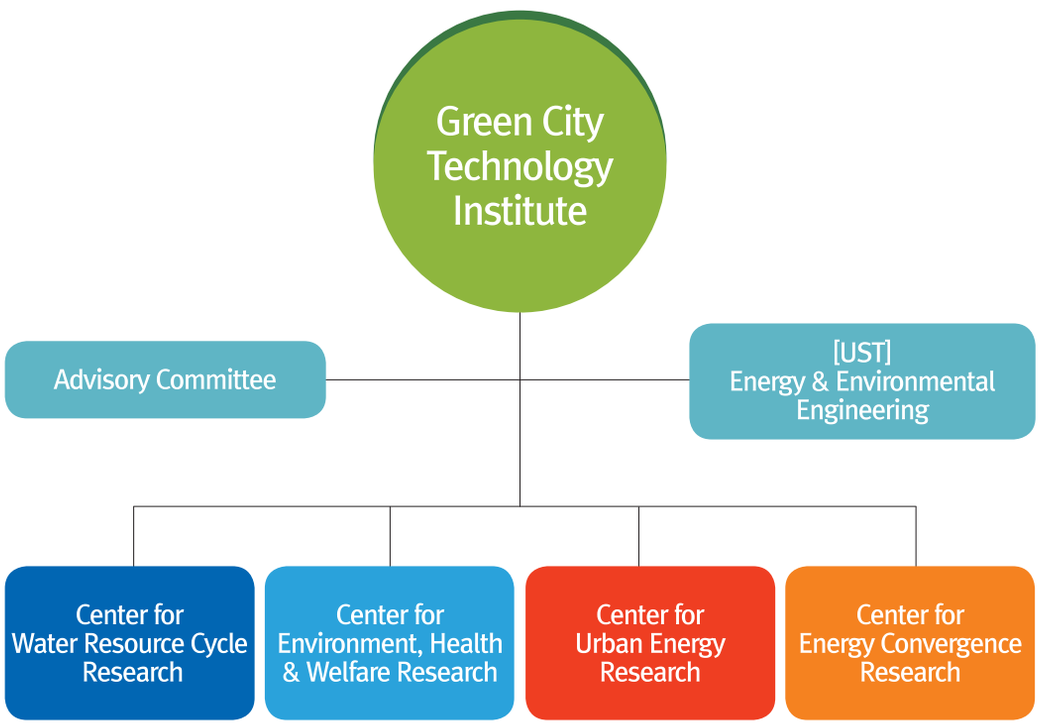
〉water resource cycle tech.
〉air purifying tech.
〉risk mechanism tech.

Low-carbon Energy Technology

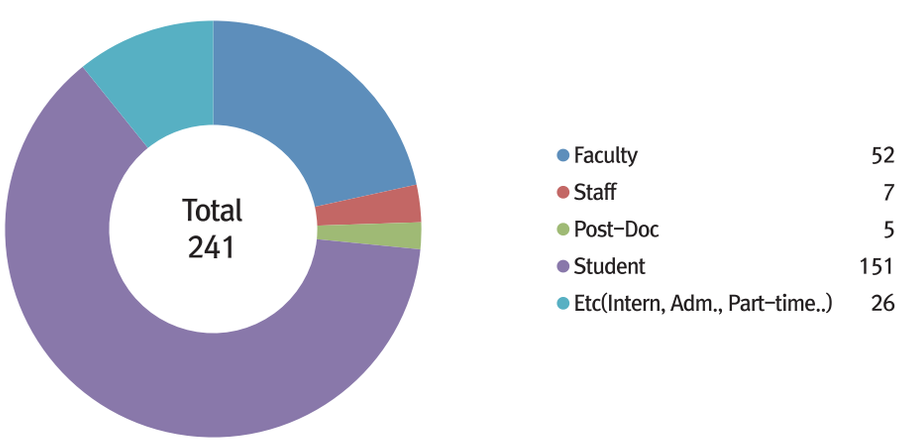
〉energy storage tech.
〉energy system tech.
〉energy convergence tech.

Organization

GCTI was founded in 2012 and now consists of four research centers : the Center for Water Resource Cycle Research, the Center for Environment, Health, and Welfare Research, the Center for Urban Energy System Research, and the Center for Energy Convergence Research. We also operate the Energy and Environmental Engineering Program at the United University of Science and Technology, and this program currently involves the participation of that 52 professors and 151 MS and Ph.D. students now belong to.

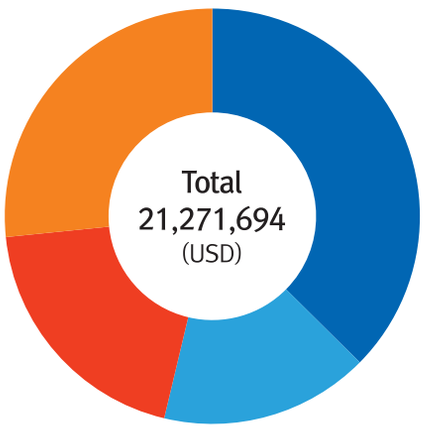


Manpower



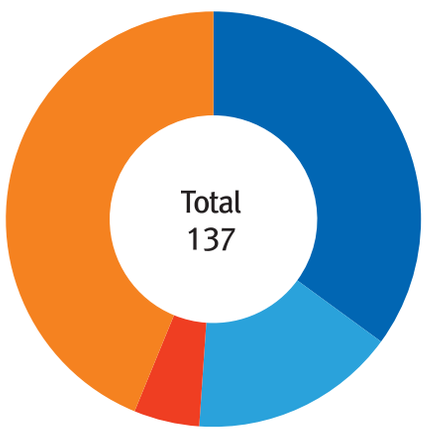
Performance

Grants



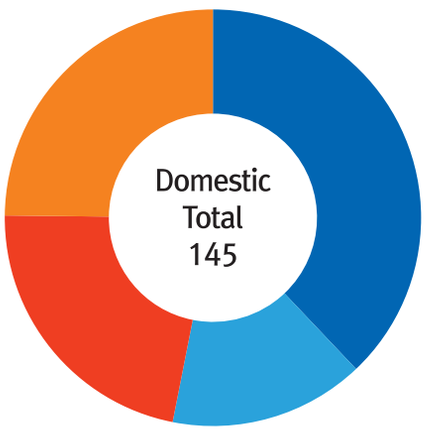
Water Resources Cycle	7,961,143
Environment, Health and Welfare	3,467,736
Urban Energy	4,184,562
Energy Convergence	5,658,253

Publication (SCI, SCIE)

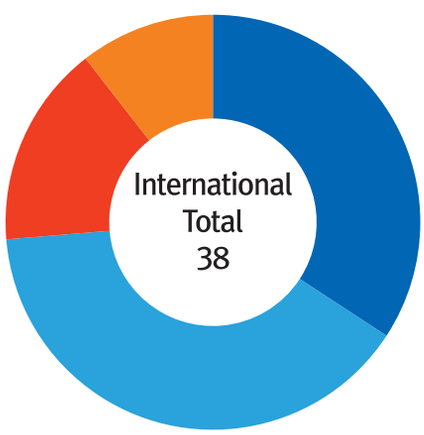


Water Resources Cycle	48
Environment, Health and Welfare	22
Urban Energy	7
Energy Convergence	60

Intellectual Property

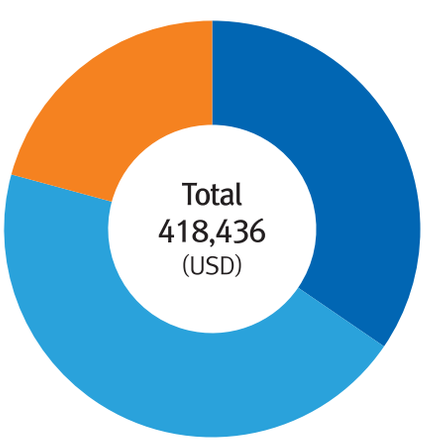


Water Resources Cycle	55
Environment, Health and Welfare	22
Urban Energy	32
Energy Convergence	36



Water Resources Cycle	13
Environment, Health and Welfare	15
Urban Energy	6
Energy Convergence	4

Technology Transfers



Water Resources Cycle	144,522
Environment, Health and Welfare	186,957
Urban Energy	0
Energy Convergence	86,957

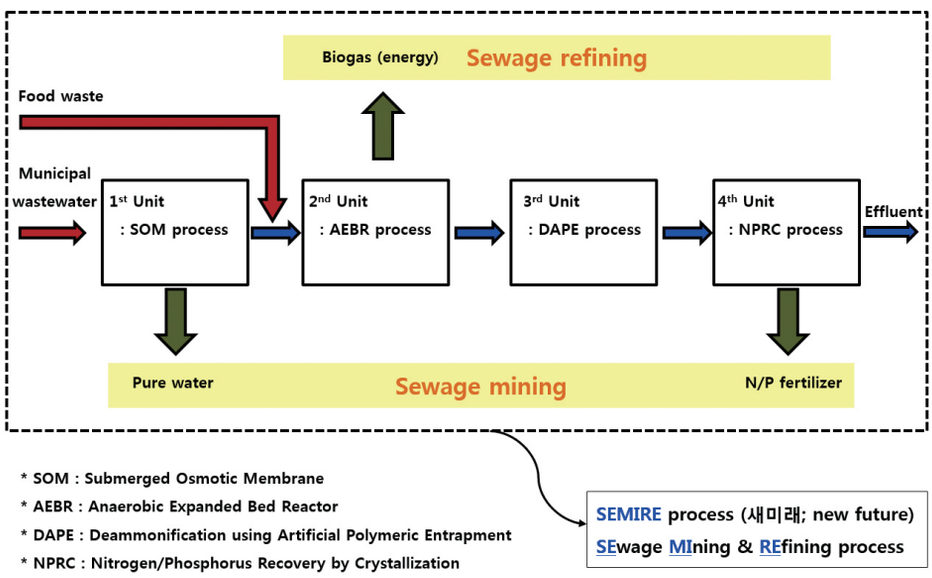
Research Program

I. Future Fundamental Research Program

1. Development of Decentralized Water Recycling System

Dr. Lee, Seockheon (P.I.), Dr. Chung, Yun Chul, Dr. Lee, Sang Hyup, Dr. Lee, Young Haeng, Dr. Choi, Jae Woo, Dr. Bae, Hyo Kwan
Dr. Park, Chanhyuk and Dr. Jeong, Seongpil

The conventional environmental technology still requires intensive energy despite the several technology developments assisted by the large research funds. Considering the worldwide energy limitation, the paradigm shift in wastewater treatment should lead to the efficient water reuse and energy recovery system for the wastewater treating facilities. Leading countries including USA, EU and Japan already started to develop the core technologies to replace the conventional technologies such as activated sludge process. The most representative novel technologies are membrane separation for water reuse, anaerobic treatment for energy recovery and N/P recovery processes. In addition to the anaerobic treatment, nitrogen source should be treated in a energy-efficient way. Thus, in this research, core technologies for 1) wastewater concentration using membrane separation, 2) Integrated biogas production process, 3) biological wastewater treatment of concentrated nitrogen source, 4) production of reclaimed water, and 5) N/P recovery processes were developed.



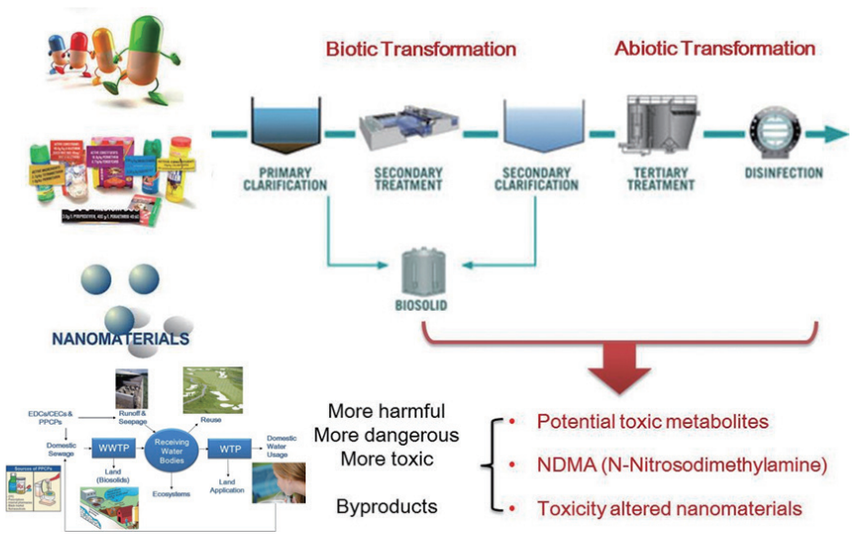
〈 A schematic representing the decentralized water reuse system 〉

2. Development of Micropollutants Management Technologies in Urban Water Cycles

Dr. Song, Kyung Guen (P.I.), Dr. Ahn, Kyu Hong, Dr. Park, Wan Chul, Dr. Hong, Seock Won, Dr. Lee, Seunghak
Dr. Cho, Kangwoo, and Dr. Kim, Eun Ju

Along with changes in human way of life and advances in analytic techniques, there has been growing concern for emerging contaminants (POPs, PPCPs, EDCs) whose direct toxicity and indirect effects (anti-disinfectants super bacteria) are of growing concerns. In this regards, we seek towards control and management technologies for unregulated emerging contaminants, particulary to secure safety in water reuse system. The specific research areas include the following topics.

- The treatment efficiencies of pharmaceutical micropollutants in an anaerobic membrane bioreactor were tested under different operational conditions and the operating factors influencing the performance of MBR were identified.
- We monitor the biodegradation metabolites and pathway of pharmaceuticals and evaluate the toxicity of those micropollutants on zebrafish using its wavelength recognition and activity.
- We assess the changes in material properties of metal oxide NPs in wastewater treatment plant and their potential environmental risk.
- The kinetics of N-nitrosodimethylamine (NDMA) formation during chloramination of pharmaceuticals were investigated depending on the pharmaceutical precursors and reaction conditions.



〈 A schematic representing the micropollutants management system 〉

3. Development of Next-Generation Urban Hazardous Pollutant Diagonsis, Control, and Prediction System

Dr. Kim, Jin Young, (P.I.) Dr. Bae, Gwi-Nam, Dr. Jurng, Jong Soo, Dr. Lee, Seung-Bok, Dr. Kim, Byoung Chan, Dr. Jung, Jae Hee, Dr. Kim, Hwa Jin, and Dr. Oh, Youngtak

This research project aims to develop efficient future-generation fine particle pollutants diagnosis system for enhanced human health and well-being. This includes developing fundamental technolgies of urban/indoor air pollution monitoring and modeling, urban hazardous pollutants diagnosis and control, integrated risk assessment and prediction system, and integrated network technology for managing urban environment conditions. Technological objectives are developing portable $PM_{2.5}$ measuring analysis system (with 10% standard deviation), on-line sensor kit for hazardous biomolecule detection (2 h detection sensitivity), on-site heavy-metal detection kit (Pd ~ 0.1 ug/g level), and DNA chip for potential health-hazard prediction (over 10 genome maps). Current air pollutants diagnosis system relies on limited information of particles such as concentration, and particle size, but next-generation diagnosis and prediction system needs more information for efficient promotion of human health against hazardous pollutants.

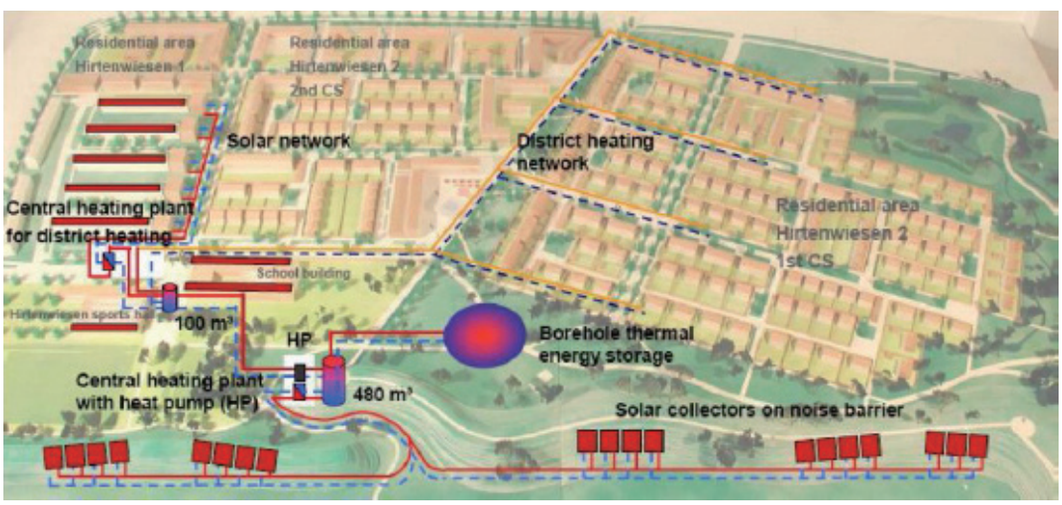
	Hazardous pollutants (new)	Fine particles (current)
Size	$\leq 2.5\ \mu m$	$\leq 2.5\ \mu m$
Hazard	composition $\rangle$ total concentration	total concentration $\gg$ composition
Base	mass, chemicals, biomolecules, heavy-metals	mass
Environment	indoor/outdoor	outdoor only

With new hazardous pollutants categorization, portable $PM_{2.5}$ detection system will be developed which provides not only conventional particle size and concentration, but also the types of pollutants and appropriate means to counter-measure. With various hazardous pollutants, detection of potential pathogenic biomolecule will be enhanced based on optics-driven sensitivity and selectivity. In addition, numerous heavy metal pollutants will be monitored selectively though complex of acidic nano-particle. Finally, specific diagnosis system of hazardous pollutants informing potential and chrnoic effect and human health assessment will be developed.

4. Development of Elementary Technologies for Low Temperature-Thermal Grid

Dr. Lee, Yong bok (P.I.), Dr. Lee, Dae-Young, Dr. Kim, Chang Ho, Dr. Kim, Kwang Ho, Dr. Choi, Ung Su, Dr. Kim, Seo Young, Dr. Choi, Hang Cheol, Dr. Han, Hung-Gu, Dr. Jeon, Jae Hak, Dr. Cho, Bok Hee, Dr. Kong, Hosung, Dr. Lee, Yoon Pyo, Dr. Karng, Sarng Woo, Dr. Shin, Youhwan, and Dr. Choi, Sun

Aiming to develop low temperature-thermal grid in smart cities, in this research, it is anticipated to develop several elementary technologies, i.e. Thermal battery technology, Thermal storage materials, Low-temp HVAC systems, and Low-temp Power generation systems. Starting from 2012-2013, the concept, Smart Thermal Grids has been defined in several european countries. Smart Thermal Grids can play an important role in the future Smart Cities by ensuring a reliable and affordable heating and cooling supply to various customers with low-carbon and renewable energy carriers, such as waste heat, waste-to-energy, solar thermal, biomass, and geothermal energy. Technical elements of smart thermal grids cover thermal generation include small-scale low-carbon heating and cooling systems, CHP, and novel approaches for producing domestic hot water, thermal storage technologies, and innovative network. Based-upon expertise of participating researchers in this project, we aim to focus on the development of 1) Bulk-scale, encapsulated, high-k phase change materials, 2) Heat storage tank, 3) Low-temp heat-driven power generation systems, and 4) Low-grade thermal source-based hybrid desiccant cooling systems.

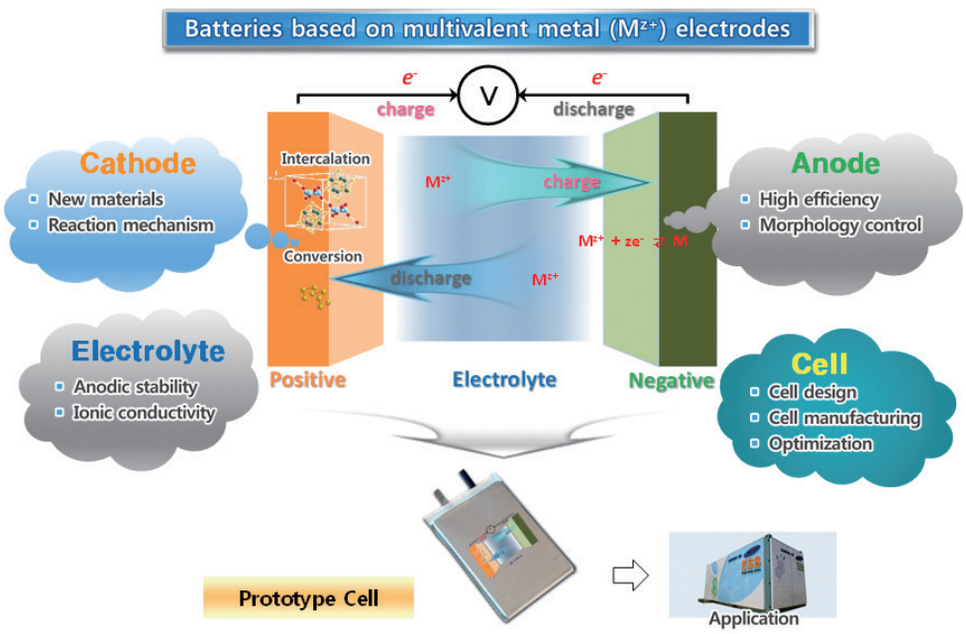


〈Blueprint of low-temperature thermal grid〉

5. Development of Fundamental Technology for the Next-Generation Battery, Employing Multivalent Metal Electrodes

Dr. Oh, Si Hyoung (P.I.), Dr. Cho, Byung Won, Dr. Choi, Won Chang, Dr. Chang, Wonyoung, Dr. Lee, Hwa Young, and Dr. Kim, Chang Sam

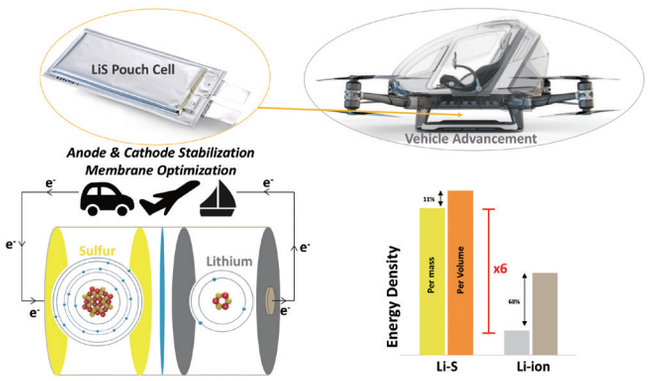
Recently, the demands for new Energy Storage Systems(ESS) to cope with growing global markets for the Electric Vehicles(EV) and for the efficient energy management and backup power of large buildings have been rocketing world-wide. For the successful application to these markets, it is necessary for the new battery system to meet more strict requirements on their performance, safety, and cost-competitiveness than conventional LIB. Among those needs, safety and cost-effectiveness are one of key hurdles to leap over when it comes to considering batteries for the commercial large-scale ESS. The energy storage systems based on multivalent metal electrodes provides an ideal alternative for LIB in these areas. The multivalent metals such as magnesium (2.33%), aluminium(8.23%) and zinc(0.007%) are abundant in the earth's crust and thus batteries utilizing these metals can be potentially constructed in much lower price than LIB. Most of all, typical multivalent metals are more chemically-inert and thus more safe than lithium. Their electrochemical deposition of metals does not involve dangerous dendrite formation contrary to Li. In this project, we aim at developing fundamental core technologies for cathodes, anodes, electrolytes and cell technologies for batteries employing multivalent metal electrodes.



〈 A schematic representing the material and cell technologies for batteries with multivalent metal electrode 〉

6. Development of Key Technologies and Pouch Cells for Li–S Battery

Dr. Cho, Won Il (P.I.), Dr. Lee, Joong Kee, Dr. Ha, Heung Yong, Dr. Nah, In Wook, and Hwang, Jinyeon



〈Schematic of lithium sulfur battery and its applicable area〉

The scope of this research is building foundations for core-technologies and pragmatic approaches to develop lithium sulfur (LiS) system that can surpass current lithium ion battery technologies. The LiS system holds invaluable properties that make LiS battery stands out among various types of secondary batteries. First, lithium metal anode is highly attractive as it is lightweight and possesses the most electropositive property. Additionally, the low density of lithium metal (0.534 g cm^{-3}) leads to the highest specific capacity value of 3860 mAh g^{-1}. Second, among various cathode materials, sulfur stands out as a highly attractive candidate due to its high energy density of 2500 $Whkg^{-1}$. The redox reaction 16 Li + S_8 〈---〉 8 Li_2S occurs spontaneously and is fully reversible. Also, sulfur is cost effective ($0.148 kg^{-1}, Qatar Sulphur Price) and earth abundant, which provides an additional incentive for the development of LiS electrochemical storage technology. Hence, the LiS system is considered as one of the most promising platforms for next generation of lithium ion battery.

However, the development of a practical LiS rechargeable battery has been hindered by fundamental problems associated with multiple transport and thermodynamics. First, sulfur suffers from poor electrical conductivity ($5x10^{-30}$ S cm^{-1} at R.T.) and produces a discharge product (Li_2S) that has an insulating characteristic. Second, the volume of sulfur increases by ~80% when it is fully lithiated. Furthermore, the redox reaction product, Li_2S, is always accompanied by the formation of various intermediate lithium polysulfides (LPS = Li_2S_n, $2 \leq n \leq 8$), which leads to challenges in active material loss and reutilization. LPS are highly soluble in organic electrolytes and therefore cause the loss of active materials in the cathode. Once in the electrolyte, the LPS species can diffuse through the separator and reach the Li anode, establishing an internal shuttling pathway between the lithium anode and sulfur cathode. During this process, the active materials in both electrodes are continuously consumed by the LPS reacting with the Li metal. Also, uneven deposition of lithium on the lithium anode during cycling leads to dendrite formation and proliferation which cause degradation of an electrolyte system and arise safety concerns if internally short circuited. As a result, rapid capacity fading, poor cycling lifetime, and low coulombic efficiency are observed in the usual LiS system.

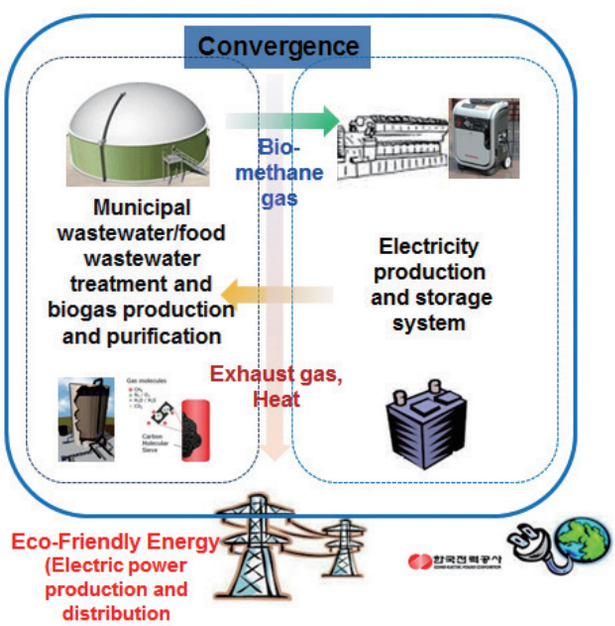
To overcome aforementioned prominent challenges in LiS system, key technologies for stabilizing lithium anode & sulfur cathode and optimizing separators are developed throughout this research project. Also, the construction of LiS pouch cell facility including dry-room and pouch equipment is currently in progress to further conduct essential LiS research to increase the practicality and popularization of LiS batteries. The development of this high-energy density LiS pouch cells would be able to significantly contribute to advancement in energy fields academically and industrially.

II. Flagship Research Program

1. Development of Core Environment and Energy Technology for Municipal Wastewater Treatment Plant

Dr. Lee, Young Haeng (P.I.) Dr. Choi, Jae Young, Dr. Song, Kyung Geun, Dr. Park, Chanhyuk, Dr. Jurng, Jong Soo, Dr. Shin, Youhwan, Dr. Choi, Sun, Dr. Lee, Joong Kee

After overcoming several oil crisis, the development of renewable energy source became the national agenda. Recently, Korea's central and local governments have been actively pursuing nation-wide projects to create Eco-Friendly Energy Towns, which are designed to return profits to the residents by combining the production of renewable energy. The goal of this flagship project is to develop core environment and energy technologies for "wastewater to eco-friendly energy" production in municipal wastewater treatment plant (MWTP). Main research topics are biogas production from municipal wastewater and food wastewater, energy-saving biogas purification and separation, electric power production and storage. In this project, we are aiming at the development of an efficient, cost-effective, convenient convergence system for renewable energy production in MWTP, which are directly and practically applicable to Eco-Friendly Energy Towns.



〈Schematic of wastewater treatment plant〉

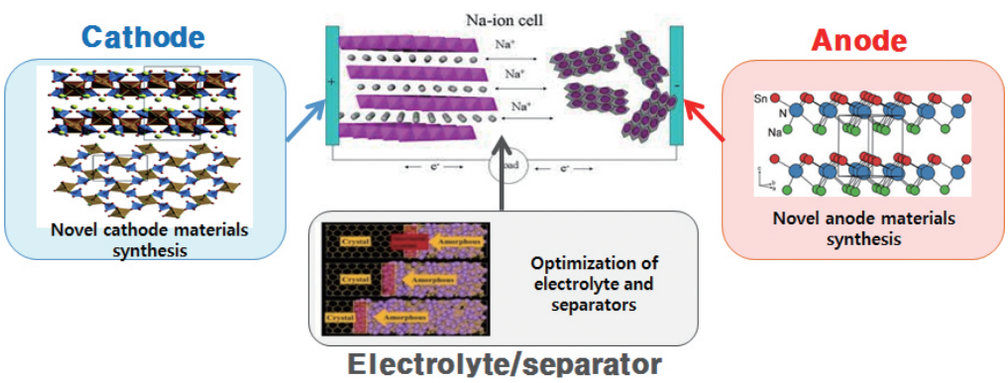
2. Development of Core Technologies for Sodium Ion Batteries as Beyond Lithium Ion Batteries

Dr. Chung, Kyung Yoon (P.I.), Dr. Chang, Wonyoung, Dr. Choi, Won Chang, Dr. Kim, Chang Sam, and Dr. Jung, Hun-Gi

This research is to develop core technologies for the sodium ion batteries. The sodium ion batteries are considered as a possible candidate for the replacement of state-of-the-art lithium ion batteries. As the secondary batteries expands its application into large scale batteries such as electric vehicles and energy storage systems, it is expected that there will be a shortage in the lithium sources. Further more, lithium ion batteries are still expensive for the large scale application. Thus, it is necessary to develop cost competitive battery system without resource problems. Sodium ion batteries are one of the strong candidate in this aspect.

For the development of the sodium ion batteries, it is very important to develop a four major components in the battery cells, which are cathode, anode, electrolyte and separators. In this project, we focus on the synthesis of novel cathode and anode materials and optimization of electrolyte and separators. For this purpose, we adopted computational cellulation to predict the thermodynamic properties of the materials. Also, we investigate the reaction and degradation mechanisms of the cell components using the in situ analytical techniques.

The research outcome is anticipated to enable the commercialization of the sodium ion batteries, which leads to the application of sodium ion batteries to the energy storage systems. Eventually, the accomplishment of the goals of this research leads to national energy welfare for all the residents.



〈 Schematic diagram of the research for novel sodium-ion battery 〉

Major Achievements

Outstanding Publications in Major Journals

- S. Jeong *et al*., Advanced organic and biological analysis of dual media filtration used as a pretreatment in a full-scale seawater desalination plant, Desalination, 385, 83 (2016)
- C. M. Chung *et al*., Alleviation of membrane fouling in a submerged membrane bioreactor with electrochemical oxidation mediated by in-situ free chlorine generation, Water Research, 96, 52 (2016)
- Y. J. Ko *et al*., Chromate adsorption mechanism on nanodiamond-derived onion-like carbon, J. Hazard. Mater., 320, 368 (2016)
- J. Han *et al*., Effect of nitrogen doping on titanium carbonitride-derived adsorbents used for arsenic removal, J. Hazard. Mater., 302, 375 (2016)
- H. C. Kim *et al*., Evaluating integrated strategies for robust treatment of high saline piggery wastewater, Water Research, 89, 222 (2016)
- Y. Cha *et al*., Modeling spatiotemporal bacterial variability with meteorological and watershed land-use characteristics, Water Research, 100, 306 (2016)
- S. Jeong *et al*., Modification of bi-composite membrane support layer by macro puncture for membrane distillation application, Desalination, 385, 106-116 (2016)
- S. Jeong *et al*., Nanostructured PVDF membrane for MD application by an O_2 and CF_4 plasma treatment, Desalination, 399, 178 (2016)
- R. Aryapratama *et al*., Performance evaluation of hollow fiber air gap membrane distillation module with multiple cooling channels, Desalination, 385, 58 (2016)
- S. K. Jeon *et al*., Potential risks of TiO_2 and ZnO nanoparticles released from sunscreens into outdoor swimming pools, Journal of hazardous materials, 317, 312 (2016)
- K. Cho *et al*., Simultaneous dechlorination and disinfection using vacuum UV irradiation for SWRO process, Desalination, 398, 22 (2016)
- K. Cho *et al*., Simultaneous dechlorination and disinfection using vacuum UV irradiation for SWRO process, Desalination, 398, 22 (2016)
- Y. B. Lim *et al*., Photochemical organonitrate formation in wet aerosols, Atmos. Chem. Phys., 16,12631 (2016)
- M. Y. Song *et al*., An aptamer cocktail-functionalized photocatalyst with enhanced antibacterial efficiency towards target bacteria, J. Hazard. Mater. 318, 247 (2016)
- B. Lee *et al*., Efficient protein digestion using highly-stable and reproducible trypsin coatings on magnetic nanofibers, Chem. Eng. J., 288, 770 (2016)
- V. T. Nguyen *et al*., Highly sensitive sandwich-type SPR based detection of whole H5Nx viruses using a pair of aptamers, Biosens. Bioelectron., 86, 293 (2016)
- J. H. Jung *et al*., Real-time bacterial microcolony counting using on-chip microscopy, Sci. Rep., 6, 21473 (2016)
- Y. Oh *et al*., Divalent Fe atom coordination in two-dimensional microporous graphitic carbon nitride, ACS Appl. Mater. Inter., 8, 25438 (2016)
- U. S. Choi *et al*., CeO_2-covered nanofiber for highly efficient removal of phosphorus from aqueous solution, J. Hazard Mater., 307, 91 (2016).
- Y. B. Lee *et al*., Effects of eccentricity and vibration response on high-speed rigid rotor supported by hybrid foil-magnetic bearing, J. MECH. ENG SCI: Proc IMechE, 230, 994 (2016).
- Y. Shin et al., Synthesis of strontium titanate nanoparticles using supercritical water, Ceramic International, 42, 17853 (2016).
- A-Y. Kim *et al*., Oxidation-resistant hybrid metal oxides/metal nanodots/silver nanowires for high performance flexible transparent heaters, *Nanoscale*, 8, 3307 (2016)
- S. Kim *et al*., Layered-Layered-spinel cathode materials prepared by a high-energy ball-milling process forlithium-ion batteries, *ACS Appl. Mater. Interfaces*, 8, 363 (2016)
- S. H. Oh *et al*., Maximum catalytic activity of Pt_3M in Li-O_2 batteries: M=group V transition metals, *Nano Energy*, 27, 1 (2016)

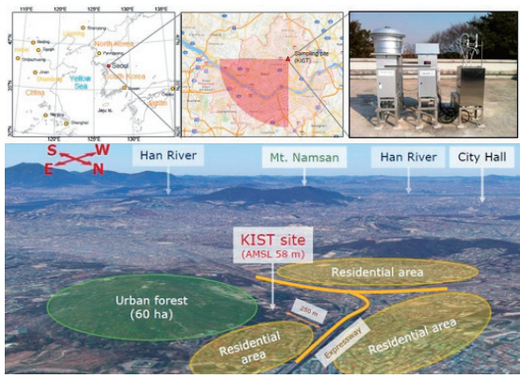
Technology Transfer

- Dr. Hong, Seok Won, 『Development of copper recovery technology for ecotoxicity reduction of semiconductor wastewater』, loyalty: ₩31,200,000 (2016)
- Dr. Lee, Sang-Hyup, 『Alginate bead impregnated bubble and photocatalyst method for the same』, loyalty: ₩75,000,000 (2016)
- Dr. Lee, Sang-Hyup, 『Water purification aparatus having double-pipe』, loyalty: ₩40,000,000 (2016)
- Dr. Lee, Sang-Hyup, 『Apparatus and method for cultivating micro-algae applied ozone oxidation』, loyalty: ₩20,000,000 (2016)
- Dr. Jurng, Jongsoo 『Catalyst filter technology comprising nano metallic catalyst sprayed on the surface of support』, loyalty: ₩53,700,000 (2016)

Major Technology Development Featured in the Press

- Dr. Lee, Sang Hyup, 『Development of coagulant for the cyanobacteria removal in drinking water source』 (2016)

- Dr. Kim, Jin Young, 『The assessment of fine dust particle (PM2.5) source.. "28+α % contribution from China』 (2016)



- Dr. Chung, Kyung Yoon, 『Development of electrode materials which can increase the energy density up to150%』, (Digital Times, Oct. 25, 2016)

디지털타임스 2016년 10월 25일 화요일

IT·과학 10면

KIST, 에너지 저장 1.5배↑ 이차전지 전극 소재 개발

국내 연구진이 전력난 해결 수단으로 주목받고 있는 '에너지저장시스템(ESS)'에 활용할 수 있는 저비용·고효율 이차전지 전극 소재를 개발했다.

한국과학기술연구원(KIST) 에너지융합연구단 정경윤 박사(사진) 팀은 금속유기구조체 소재 중 하나인 '프러시안 블루 아날로그' 구조를 기반으로 철과 바나듐 전이금속을 도입한 새로운 전극 소재를 개발했다고 24일 밝혔다.

금속유기구조체는 유기 결합 분자에 금속이온이 결합된 3차원 결정구조체로, 내부에 수많은 나노 기공이 있다. 연구팀이 개발한 철·바나듐 프러시안 블루 아날로그 소재는 비용은 낮고 수율은 높은 공법으로 개발됐으며, 기존 같은 소재와 비교해 에너지 저장용량이 150% 이상 높다. 또 높은 충·방전 효율과 출력 특성을 실험을 통해 확인했다. 남도영기자 namdo0@

- Dr. Cho, Won Il, 『New coating technique of separator for high performance of Li-S batteries』 (Arirang TV, Dec. 2, 2016)

Awards

- Dr. Lee, Yong-bok, was awarded for National R&D 100 awards for 『Development of smart-bearing and its execution technology in harsh-extreme environment』 (2016)

Exhibition

- Dr. Lee, Yong-bok, was awarded for National R&D 100 awards for 『Development of smart-bearing and its execution technology in harsh-extreme environment』 (2016)

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2. Specified Results

(1) Grants

● KIST / Development of Innovative Equipment for Disinfection of Infectious virus / ₩150,000,000 / PI: Lee, Kang Bong

● KIST/ Development of Unmanned Disinfection Equipment responding to Infectious Diseases / ₩842,424,000/ PI: Lee, Kang Bong

● Korea Environmental Industry Technology Institute / Development of on-site detection method for bioaerosol and hazardous heavy metals in fine particulate matters and particulate matters in real time / ₩335,000,000 / PI: Lee, Kang Bong

● Korea Association of University, Research Institute and Industry/Development of mass production technology of functional nanoparticles / ₩191,500,000/ PI : Lee, Kang Bong

● Korea Environmental Industry Technology Institute / Development of site management and evaluation of accessibility for heavy metals in soil at abandoned mine area/ ₩320,000,000/ PI : Choi, Jae Young

● Ministry of Science, ICT and Future Planning/Developement of Smartphone-Incorporated External High Power Battery Pack for Mobile Energy/ ₩170,000,000/ PI : Kweon, Soon-Cheol

(2) Publications

● J. Lee, Y. S. Nam, J. Min, K.-B. Lee, and Y. Lee, TOF-SIMS analysis of red color inks of writing and printing tools on questioned documents, J. Forensic Sci., 61(3), 815-822 (2016) (IF = 1.322)

● M. Kim, J. Lee, and Y. Lee, Structural and compositional analyses of Cu(In,Ga)Se2 thin film solar cells with different cell performances, J. Vac. Sci. Technol. B, 34(3), 03H121-1-6 (2016) (IF = 1.398)

● H.-S. Lee, K.-M. Choi, E. J., Won, M.-T. Thi Phan, S. Y. Lee, D.-J. Shin, S. Chun, G. Park, S.-K. Kim, K.-B. Lee, H.-J. Lee, and D. Cho, Protein stability changes of the novel p.Arg180Cys mutant A glycosyltransferase resulted in a weak A phenotype, Vox Sanguinis, 111, 441-444 (2016) (IF = 2.628)

- M.-K. Ji, H.-S. Yun, B. S. Hwang, A. N. Kabra, B.-H. Jeon, and J. Choi, Mixotrophic cultivation of Nephroselmis sp. using industrial wastewater for enhanced microalgal biomass production, Ecological Engineering, 95, 527-533 (2016) (IF = 2.740)
- H.-S. Yun, M.-K. Ji, Y.-T. Park, E.-S. Salama, and J. Choi, Microalga, Acutodesmus obliquus KGE 30 as a potential candidate for CO2 mitigation and biodiesel production, Environ. Sci. Pollut. Res. 23, 17831-17839 (2016) (IF = 2.760)
- S. Lee, Y.-S. Nam, S.-H. Choi, Y. Lee, and K.-B. Lee, Highly sensitive photometric determination of cyanide based on selective etching of gold nanorods, Microchim. Acta, 185, 3035-3041 (2016) (IF = 4.831)
- S. Lee, Y.-S. Nam, H.-J. Lee, Y. Lee, and K.-B. Lee, Highly selective colorimetric detection of Zn(II) ions using label-free silver nanoparticles, Sensors and Actuators, 8(237), 643-651 (2016) (IF = 4.758)
- J.-H. Hwang, A. N. Kabra, M.-K. Ji, J. Choi, M. W. El-Dalatony, and B.-H. Jeon, Enhancement of continuous fermentative bioethanol production using combined treatment of mixed microalgal biomass, Algal Research, 17, 14-20 (2016) (IF = 4.694)
- M. Kim, J. Lee, H. Kim, K.-B. Lee, and Y. Lee, Effect of the impurity incorporation on the performance of Cu(In,Ga)Se2 semiconductor solar cells, J. Nanosci. Nanotechnol., 16, 10748-10752 (2016) (IF = 1.338)
- J.-Q. Xiong, M. B. Kurade, R. A. I. Abou-Shanab, M.-K. Ji, J. Choi, J. O. Kim, and B.-H. Jeon, Biodegradation of carbamazepine using freshwater microalgae Chlamydomonas mexicana and Scenedesmus obliquus and the determination of its metabolic fate, Bioresource Technology, 205, 183-190 (2016) (IF = 4.917)
- K. M. Kim, Y.-S. Nam, I. W. Nah, Y. Lee, and K.-B. Lee, Glutathione functionalized gold nanoparticles for colorimetric detection of didecyldimethylammonium chloride, J. Nanosci. Nanotechnol., 16, 11191-11200 (2016) (IF = 1.338)

(3) Intellectual Property

1) Patents(Registered)

- Surface modified nanoparticles, preparation method thereof, the colormetric detection sensor of copper ions (ii) and the colormetric detection method, KR 10-1681110 (Lee, Kang Bong)
- Surface modified nanoparticles, and colorimetric detection sensor for zinc ion using the same, KR 10-1681114 (Lee, Kang Bong)
- Novel strain of nephroselmis sp. Kge2 and method for increasing fatty acid concentration in the strain, KR 10-1680048 (Choi, Jae Young)
- Colorimetric detection method on mercury ion(ii) and ornanic mercury using gold nanoparticles functionalized with polyethylene imine, KR 10-1677562 (Lee, Kang Bong)
- Colorimetric detection sensor and method for ferric ion using gold nanoparticles functionalized with glycol chitosan, KR 10-1675347 (Lee, Kang Bong)
- Method of identifying cements using x-ray fluorescence and x-ray diffraction, KR 10-1652913 (Lee, Kang Bong)
- Novel strain of microractinium and adxorbent of heavy metals using the same, KR 10-1624174 (Choi, Jae Young)
- Novel strain of microractinium sp. Kge33 and adxorbent of heavy metals using the same, KR 10-1624176(Choi, Jae Young)
- Method of identifying cements using isotope ratio mass spectrometer, KR 10-1600888 (Lee, Kang Bong)
- Surface modified-nanoparticles, preparation method thereof and colorimetric detection method of lead ions, KR 10-1578691 (Lee, Kang Bong)

2) Patents(Pending)

- Selective Colorimetric Detection Method of Cr6+ ions through Size-Control of Label-Free Gold Nanoparticles, US15/224,195 (Lee, Kang Bong)
- Colorimetric detection technology of cyanide anion by etching of gold nanorods, US15/357169 (Lee, Kang Bong)
- A method for producing valuarble materials by usingNephroselmis sp. KGE 8 microalgae, KR 2016-0002102 (Choi, Jae Young)
- Manufacturing technology for fluorescence sensor and its kit on hydrogen sulfide using silica nanoparticles modified with azidocoumarin, KR 2016-0041747(Lee, Kang Bong)
- Measuring Apparatus for Gas Flow using CO2, Tracer Gas Concentration Measurement Method, KR 2016-0072475 (Lee, Kang Bong)
- Development of Efficient H2O2 Evaporator System using Ceramic Preheater and Optimized Heating Bar, KR 2016-0086781 (Lee, Kang Bong)
- An adsorbent for removal of hydrogen sulfide using float derived from tailing and method for preparing the same, KR 2016-0144642 (Choi, Jae Young)
- Method development to monitor authenticity of erectile dysfunction drugs using ftir spectra and principal component analysis, KR 2016-0138248 (Lee, Kang Bong)
- Evaporator device for sterilant, KR 2016-0100104 (Lee, Kang Bong)
- A simple sterilization equipment using hydrogen peroxide vapor, KR 2016-0150234 (Lee, Kang Bong)
- External battery pack for emergency-driving electric vehicle, KR 2016-0144724 (Kweon, Soon-Cheol)

(4) Technology Transfers

Name of the Transferred Technology	Loyalty[KRW]	P.I.
Virus Disinfection Technology	300,000,000	Lee, Kang Bong

》Overview of Transferred Technology
- Hydrogen Peroxide Vapor (HPV) generator for virus sterilization.
- Equipment for hydrogen peroxide decomposition
- Graphene sensor for measurement of hydrogen peroxide concentration
- MnO_2 nanoparticle catalyst for hydrogen peroxide decomposition

》Expectation Effect
- Effective sterilization of contagious viruses such as MERS, Evola, etc.
- Efficient disinfection of hospital rooms and public places.

01

Center for Water Resource Cycle Research

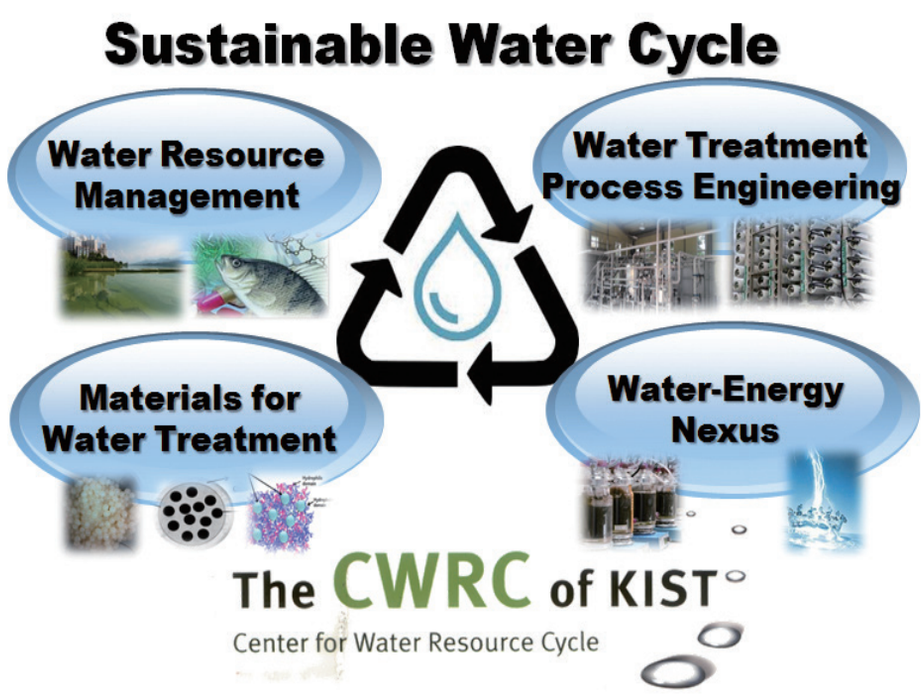
01 Center for Water Resource Cycle Research

Mission

Establishment of Sustainable Water Resource and Water Cycle

The Center for Water Resource Cycle (CWRC) made clear a vision for sustainable growth via conducting national agendas such as maintaining clean water, securing stable water resources, and developing environmental technologies for commercialization and technology transfers. Due to the technical needs for a rapidly growing global water market, experts in the CWRC are working together in many fields, including membrane separation, nano-material, advanced oxidation, environmental analysis, and desalination. In order to develop cutting-edge water technologies for water environment and become one of the world's leading research centers, the CWRC is cooperating with governments, companies, and international experts to achieve global collaboration.

Dr. Lee, Seockheon
Head of the Center for Water Resource Cycle Research



Research Areas

I. Water Resource Management

Main research topics

- Algae (source) control
- Emerging contaminants control
- Nutrient (N, P) and pathogens control

Regarding the livabilities in developed area, the presence of eutrophication related with global warming is widely recognized as the major environmental problem (color, order, and toxicity). In addition, major cities are facing emerging contaminants (POPs, PPCPs, EDCs) whose direct toxicity and indirect effects (anti-disinfectants super bacteria) are of growing concerns. For public contributions, we focus on the scientific research on the environmental fates of emerging contaminants. In parallel, technical developments are being made for control of algal bloom and emerging contaminants. Controls of the source of eutrophication (N, P) and pathogens are investigated for beneficial effects both on the developed area and sanitation in the developing world.

II. Process Engineering for a Sustainable Water Cycle

Main research topics

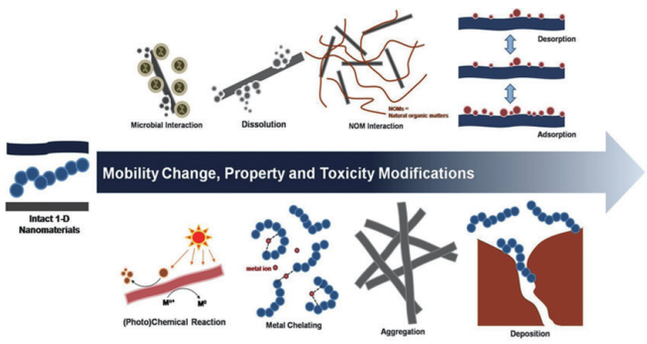
- Membrane bio-reactor, biological nutrient removal process
- Forward osmosis, Membrane distillation process
- Chemical/biological fouling control in membrane process
- Anamox-partial nitritation

The process engineering for water reuse works on water treatment directly related to water production in order to increase water supply in the vicinity of urbanized and industrialized areas. Our center focuses on the development of cutting edge technologies for the future and enhancement of conventional technologies. Managing the balanced between science and engineering, our center has been contributing to technology transfer in the process engineering research area. The technologies developed in the past have been commercializd and adapted in some industries.

Ⅲ. Application and Implication of Environmental Nano-Materials

• Main research topics

- Nanomaterials-based sorbents and catalysts
- Fate and transport of nanomaterials in water/subsurface environment



Water treatment technology based on nano-materials is a fast growing technology. The principal aim is to investigate potential applications of nano-materials and assessing their implications to the water environment. In addition, we concentrate on ideas and problems concerning current knowledge on nano-materials, such as uncertain risks caused by nano-materials to human health and the water environment. For properly assessing the risk of ENMs, their fate and transport in the environment reflecting the exposure potential to the receptors are carefully examined along with their toxicity.

Ⅳ. Energy Saving / Harvesting Environmental Technology

• Main research topics

- Biogas production from organic wastes
- Energy harvesting photo/electro-catalysts
- Anaerobic membrane bio-reactor (AnMBR)

Securing and saving energy is very important. Water and energy is intrinsically linked, to produce clean water and energy. After overcoming several oil crises, the energy-saving process and development of renewable energy source became the national agenda. Our center carries out research projects focused on bioenergy production from organic wastes for sustainable energy production as well as for waste reduction and treatment.

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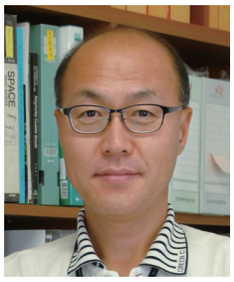

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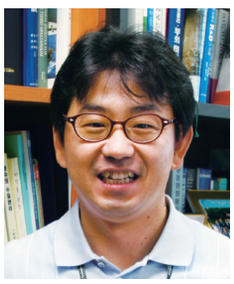

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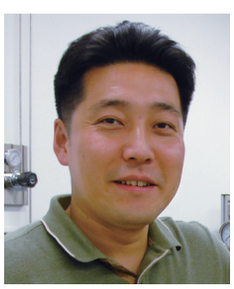

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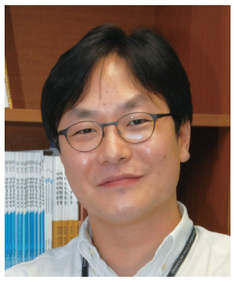

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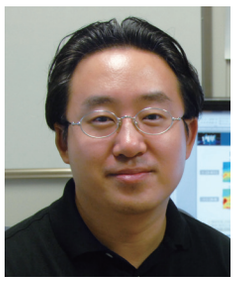

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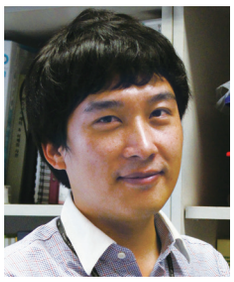

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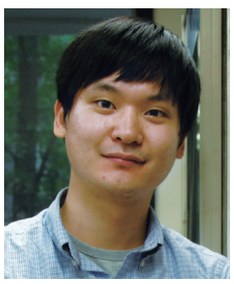

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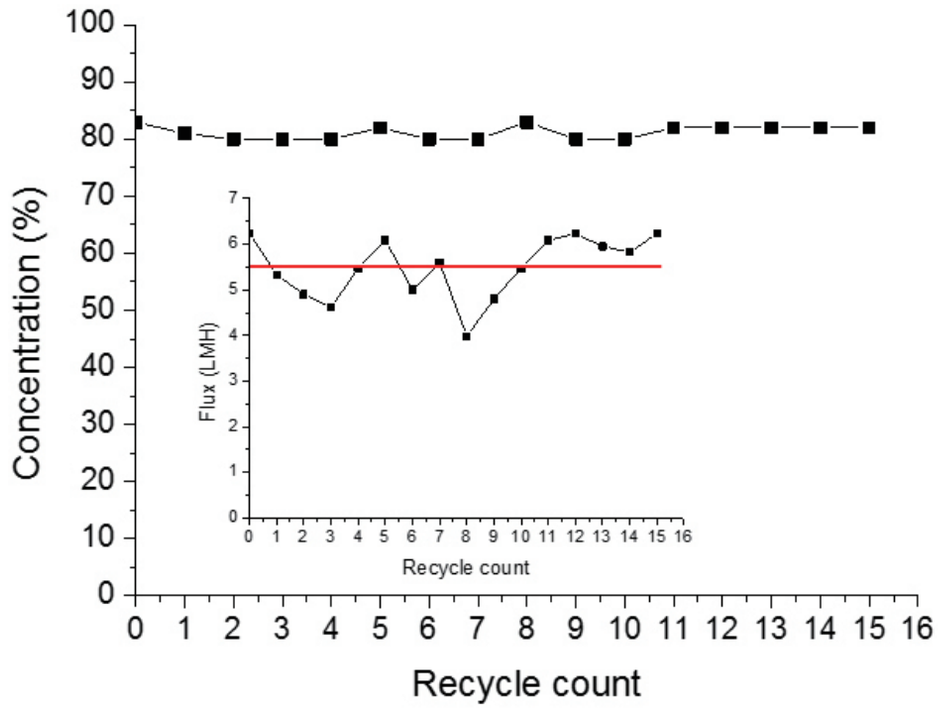
2. R&D Highlights

Development of decentralized water reuse system–organic draw solute based submerged osmotic membrane process for the concentration of the municipal wastewater (Dr. Lee, Seockheon)

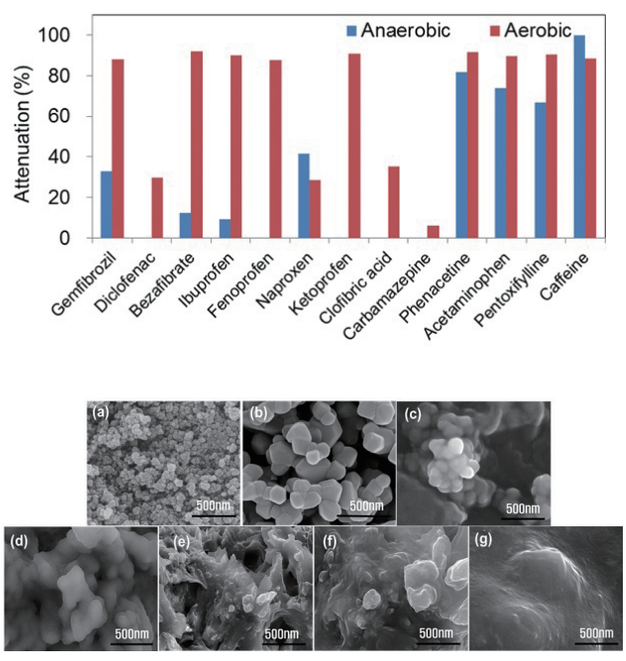
It has been required to develop an energy efficient FO (forward osmosis) process for the wastewater treatment. We suggested a novel organic draw solute, MSG (monosodium glutamate) for the concentration of the wastewater by using the submerged osmotic membrane (SOM) process. Stable concentration of the wastewater was achieved up to concentration rate 80 % by the SOM process with MSG as draw solution. The MSG draw solute showed a dramatic decrease in reverse salt flux (Js/Jw) and similar water flux compared to NaCl draw solute at the same concentration. Moreover, the MSG draw solute in the range of 0.004–0.015 mol/L enhanced methanogens growth and increased methane production. This suggests that MSG draw solute for the SOM process to concentrate wastewater can be an additionally beneficial to the following biogas production process.



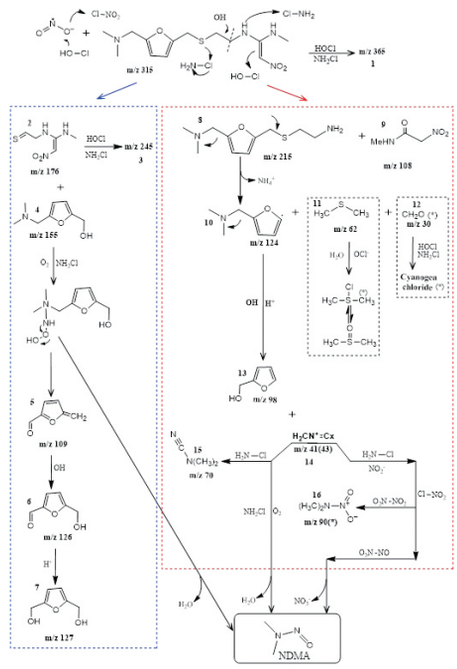
〈 The concentration rate of the SOM process by using the municipal wastewater
Recycle count: the number of intermittent batch tests by using one membrane continuously with the washing process 〉

Development of micropollutants management technologies in urban water cycle (Dr. Song, Kyung Guen)

The occurrence of micropollutants (also termed as emerging contaminants), including pharmaceuticals and nanoparticles (NPs) in the aquatic environment has become a worldwide issue of increasing environmental concenrn. However, current wastewater treatment plants (WWTPs) are not specifically designed to eliminate micropollutants. The objectives of this study was to optimize the combined treatment processes for achieving higher and more consistent micropollutant removal. The MBR process was able to remove a wide spectrum of pharmaceuticals, and the removal efficiencies of carbamazepine and diclofenac that are resistant to MBR was significantly enhanced as combined with AOPs. It was found that the UV/H2O2 process is more efficient than the cat/H2O2 process, and carbamazepine and diclofenac were completely removed by UV/H2O2 within 60 min. However, zebrafish in UV/H2O2–treated water showed a greater decrease in sensitivity in the short–wavelength region and activity, which correspond to the inhibitory contribution. During chloramination of wastewaters, NDMA formation was inhibited for low dissolved oxygen concentration (〈 1 mg O2/L) and pH 〈6. In addition, nitrite was found to influence the formation of other disinfection byproducts as much as NDMA formation. A significant amount of the NPs in sunscreens could be released into the swimming water and accumulate through the treatment system. However, the concentration of reactive oxygen species in the swimming pool should be below the level at which an adverse effect to bathers in concerned.



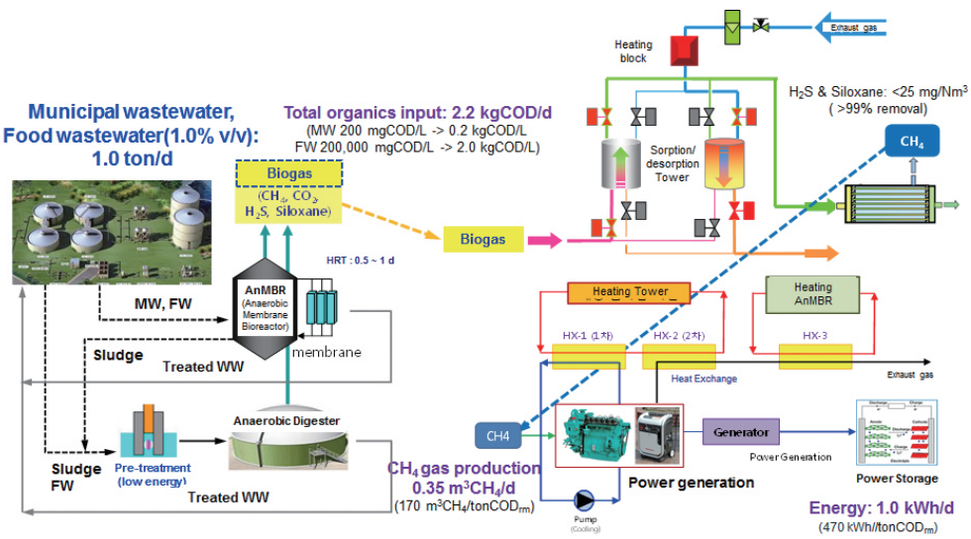
〈 Major achievements of this study 〉



〈 Fate and transport of microllutants in aerobic and anaerobic systems 〉

Development of core environment and energy technology for municipal wastewater treatment plant (Dr. Lee, Young Haeng)

Anaerobic membrane bio-reactor (AnMBR) was carried out with an overall exploitable production time of over 5 months. The AnMBR was loaded with mixture of municipal wastewater and food wastewater. The methane gas produced throughout the AnMBR process was over 160 m3CH4/tonCODremoved. The effect of plasma discharge treatment on anaerobic sludge disintegration and solubilization were studied. The solubilization degree of treated sludge increased significantly with increasing specific energy. Obtained sludge solubilization degree was higher than the results of ultrasonication at 7,000 kJ/kgTS for lower specific energy of 6,000 kJ/kgTS. A study on the removal capability of developed adsorbents towards selected H2S and siloxane which are generally present in the biogas was performed. The breakthrough curves show that both H2S and siloxane (D5) were below 20 mg/Nm3. Reusable polymer adsorbent were then successfully regenerated within 2 hrs at below 150oC. Considering monitored electricity generation efficiency of 29.8% for gas engine in this study, the electricity energy production is 470 kWh/tonCODremoved.



〈 Proposed convergence system for renewable energy production in MWTP 〉

3. Specified results

(1) Achievement Summary

Research Grants [KRW]	9,155,314,794
Publication (SCI, SCIE)	48
Intellectual Property	68
Technology transfer fee [KRW]	166,200,000

(KRW 1,150 = USD 1)

(2) Grants

- Ministry of Land, Infrastructure and Transport / Development of fouling control technology for membrane distillation application / ₩413,400,000 / PI: Lee, Seock Heon
- National Research Foundation of Korea / Development of core technologies for sustainable urban environment / ₩661,849,703 / PI: Lee, Seock Heon
- KIST / Development of decentralized water reuse system / ₩1,004,657,550 / PI: Lee, Seock Heon
- National Research Council of Science & Technology/ Development of Innovative Technology and Integrate Management System for Sustainable Sanitation in ASEAN / ₩400,000,000 / PI: Ahn, Kyu Hong
- Ulsan District Env. Pre. Association / Development of Effect of Air Pollution on Agricultural Activity in Ulsan / ₩50,000,000 / PI: Park, Wan Chul
- Ministry of Land, Infrastructure and Transport / Estimation of water quality change by geochemical reactions in the aquifer / ₩150,000,000 / PI: Lee, Seung Hak
- Ministry of Environment / Development of a method for identifying the source of heavy metal and chlorinated compound contamination in the subsurface of industrial complex / ₩186,000,000 / PI: Lee, Seung Hak
- KIST / Planning for Korea – China International Cooperation in Environment / ₩20,000,000 / PI: Lee, Seung Hak
- KIST / Development of core environment and energy technology for municipal wastewater treatment plant / ₩1,525,827,000 / PI: Lee, Young Haeng
- Ministry of Science, ICT and Future Planning / Development of electro-active anodes with a reduced precious metal content and wastewater electrolysis process for water treatment and molecular hydrogen production / ₩214,000,000 / PI: Cho, Kang Woo
- National Research Foundation of Korea / Development of a novel photo-electrochemical water treatment reactor through co-optimization of optical and fluidic fields and immobilization of catalysts / ₩15,000,000 / PI: Cho, Kang Woo
- KIST / Development of domestic purification systems based on photo-electrochemical catalysts / ₩250,000,000 / PI: Cho, Kang Woo
- Ministry of Science, ICT and Future Planning / Standardization of Best Available Technology(BAT) for effective water treatment during algal blooming / ₩1,280,000,000 / PI: Lee, Sang Hyup
- Korea Environmental IndustryTechnology Institute / Development of next generation smart water grid system for establishment of automated management system for non-point pollution source behavior and point source / ₩400,000,000 / PI: Lee, Sang Hyup
- Ministry of Science, ICT and Future Planning / Development of alternative adsorbent and process for removing algae toxic and T&O matters / ₩271,667,000 / PI: Song, Kyung Guen
- Korea Agency for Infrastructure Technology Advancement / Development of membrane distillation water purification technology using a multi-layer thin-film photothermal conversion material for decentralized water supply / ₩289,400,000 / PI: Song, Kyung Guen
- KIST / Development of micropollutants management technologies in urban water cycle / ₩953,498,000 / PI: Song, Kyung Guen
- Ministry of Science, ICT and Future Planning / Development of alternative oxidant and unit process for advanced water treatment during algal blooming / ₩280,000,000 / PI: Hong, Seok Won
- Korea Environmental IndustryTechnology Institute / Development of immobilized antimicrobial catalyst for chemical-free disinfection system and its application for waterscape facilities / ₩269,000,000 / PI: Hong, Seok Won
- Korea Environmental IndustryTechnology Institute / Development of electrochemically assisted technologies to treat high-strength organic and nitrogen wastewater / ₩327,467,000 / PI: Hong, Seok Won
- Korea district heating corporation / Optimization of environment-friendly technology for reducing dissolved oxygen to prevent corrosion of heating pipe / ₩462,548,541 / PI: Hong, Seok Won

(3) Publications

- Lee et al., Application of carbon foam for heavy metal removal from industrial plating wastewater and toxicity evaluation of the adsorbent, Chemosphere, 153, 1-9 (2016) (IF=3.698)
- Jung et al., Adsorption of phosphate from aqueous solution on to pyrolyzed drinking water treatment residuals: Statistical process optimization, equilibrium, and kinetic analysis, Environmental Progress & Sustainable Energy, 35(4), 1035-1046 (2016) (IF=1.631)
- Jeong et al., Advanced organic and biological analysis of dual media filtration used as a pretreatment in a full-scale seawater desalination plant, Desalination, 385, 83-92 (2016) (IF=4.412)
- Chung et al., Alleviation of membrane fouling in a submerged membrane bioreactor with electrochemical oxidation mediated by in-situ free chlorine generation, Water Research, 96, 52-61 (2016) (IF=5.991)

- Kang et al., Ammonium-functionalized mesoporous silica MCM-41 for phosphate removal from aqueous solutions, Desalination and Water Treatment, 57, 10839-10849 (2016) (IF=1.272)
- Son et al., Analysis of phosphate removal from aqueous solutions by hydrocalumite, Desalination and Water Treatment, 57(45), 21476-21486 (2016) (IF=1.272)
- Cha et al., Bayesian modeling approach for characterizing groundwater arsenic contamination in the Mekong river basin, Chemosphere, 143, 50-56 (2016) (IF=3.698)
- Jung et al., Characteristics of biochar derived from marine macroalgae and fabrication of granular biochar by entrapment in calcium-alginate beads for phosphate removal from aqueous solution, Bioresource technology, 211, 108-116 (2016) (IF=4.917)
- Ko et al., Chromate adsorption mechanism on nanodiamond-derived onion-like carbon, Journal of hazardous materials, 320, 368-375 (2016) (IF=4.836)
- Park et al., Comparison of Antibiotic Resistance Removal Efficiencies Using Ozone Disinfection under Different pH and Suspended Solids and Humic Substance Concentrations, Environmental science & technology, 50(14), 7590-7600 (2016) (IF=5.393)
- Kang et al., Comparison of optimization algorithms for modeling of Haldane-type growth kinetics during phenol and benzene degradation, Biochemical engineering journal, 106, 118-124 (2016) (IF=2.463)
- Jung et al., Comprehensive reuse of drinking water treatment residuals in coagulation and adsorption processes, Journal of environmental management, 181, 425-434 (2016) (IF=3.131)
- Shin et al., Correlations between bacterial populations and process parameters in four full-scale anaerobic digesters treating sewage sludge, Bioresource technology, 214, 711-721 (2016) (IF=4.917)
- Park et al., Determination of optimum isotherm and kinetic models for phosphate sorption onto iron oxide nanoparticles: nonlinear regression with various error functions, DESALINATION AND WATER TREATMENT-SCIENCE AND ENGINEERING, 57, 3107-3118 (2016) (IF=1.272)
- Tun et al., Dewatering of source-separated human urine for nitrogen recovery by membrane distillation, Journal of membrane science, 512, 13-20 (2016) (IF=5.557)
- K.W.Jung and K.H.Ahn, Dual purpose recovered coagulant from drinking water treatment residuals for adjustment of initial pH and coagulation aid in electrocoagulation process, Environmental technology, 37(13), 1605-1617 (2016) (IF=1.760)
- Jeong et al., Effect of microbial community structure on organic removal and biofouling in membrane adsorption bioreactor used in seawater pretreatment, Chemical engineering journal, 294, 30-39 (2016) (IF=5.310)
- Han et al., Effect of nitrogen doping on titanium carbonitride-derived adsorbents used for arsenic removal, Journal of hazardous materials, 302, 375-385 (2016) (IF=4.836)
- Jung et al., Entrapment of powdered drinking water treatment residues in calcium-alginate beads for fluoride removal from actual industrial wastewater, Journal of industrial and engineering chemistry, 39(25), 101-111 (2016) (IF=4.179)
- Kim et al., Evaluating integrated strategies for robust treatment of high saline piggery wastewater, Water research, 89, 222-231 (2016) (IF=5.991)
- Kang et al., Evaluation of the Use of Sea Sand, Crushed Concrete, and Bentonite to Stabilize Trace Metals and to Interrupt Their Release from Contaminated Marine Sediments, Water, air, and soil pollution, 2257, 308-1-308-12 (2016) (IF=1.551)
- Chung et al., Experimental determination of nonequilibrium transport parameters reflecting the competitive sorption between Cu and Pb in slag-sand column, Chemosphere, 154, 335-342 (2016) (IF=3.698)
- Jung et al., Fabrication of granular activated carbons derived from spent coffee grounds by entrapment in calcium alginate beads for adsorption of acid orange 7 and methylene blue, Bioresource technology, 219, 185-195 (2016) (IF=4.917)
- K.W.Jung and K.H.Ahn, Fabrication of porosity-enhanced MgO/biochar for removal of phosphate from aqueous solution: Application of a novel combined electrochemical modification method, Bioresource technology, 200, 1029-1032 (2016) (IF=4.917)
- Jung et al., Facile synthesis of magnetic biochar/Fe3O4 nanocomposites using electro-magnetization technique and its application on the removal of acid orange 7 from aqueous media, Bioresource technology, 220, 672-676 (2016) (IF=4.917)
- Ramasundara et al., Highly reusable TiO2 nanoparticle photocatalyst by direct immobilization on steel mesh via PVDF coating, electrospraying, and thermal fixation, Chemical engineering journal, 306, 344-351 (2016) (IF=5.310)
- Ko et al., Identification of the microbes mediating Fe reduction in a deep saline aquifer and their influence during managed aquifer recharge, The Science of the total environment, 545-546, 486-492 (2016) (IF=3.976)
- Jung et al., Influence of pyrolysis temperature on characteristics and phosphate adsorption capability of biochar derived from waste-marine macroalgae (Undaria pinnatifida roots), Bioresource technology, 200, 1024-1028 (2016) (IF=4.917)
- Jeong et al., Integration of forward osmosis process and a continuous airlift nitrifying bioreactor containing PVA/alginate-immobilized cells, Chemical engineering journal, 306, 1212-1222 (2016) (IF=5.310)
- Yun et al., Mitigation of Ammonia Inhibition by Internal Dilution in High-Rate Anaerobic Digestion of Food Waste Leachate and Evidences of Microbial Community Response, Biotechnology and Bioengineering, 113(9), 1892-1901 (2016) (IF=4.243)
- Cha et al., Modeling spatiotemporal bacterial variability with meteorological and watershed land-use characteristics, Water research, 100, 306-315 (2016) (IF=5.991)

- Jeong et al., Modification of bi-composite membrane support layer by macro puncture for membrane distillation application, Desalination, 385, 106-116 (2016) (IF=4.412)
- Win et al., Monitoring the microbial community shift throughout the shock changes of hydraulic retention time in an anaerobic moving bed membrane bioreactor, Bioresource technology, 202, 125-132 (2016) (IF=4.917)
- Jeong et al., Nanostructured PVDF membrane for MD application by an O2 and CF4 plasma treatment, Desalination, 399, 178-184 (2016) (IF=4.412)
- Cho et al., Nitrification resilience and community dynamics of ammonia-oxidizing bacteria with respect to ammonia loading shock in a nitrification reactor treating steel wastewater, Journal of bioscience and bioengineering, 122(2), 196-202 (2016) (IF=1.964)
- Lee et al., Nutrient Recovery of Starch Processing Waste to Cordyceps militaris: Solid State Cultivation and Submerged Liquid Cultivation, Applied biochemistry and biotechnology, 180(2), 274-288 (2016) (IF=1.606)
- Aryapratama et al., Performance evaluation of hollow fiber air gap membrane distillation module with multiple cooling channels, Desalination, 385, 58-68 (2016) (IF=4.412)
- Jeon et al., Potential risks of TiO2 and ZnO nanoparticles released from sunscreens into outdoor swimming pools, Journal of hazardous materials, 317, 312-318 (2016) (IF=4.836)
- Jung et al., Preparation of modified-biochar from Laminaria japonica: Simultaneous optimization of aluminum electrode-based electro-modification and pyrolysis processes and its application for phosphate removal, Bioresource technology, 214, 548-557 (2016) (IF=4.917)
- Ha et al., Preparation processes and characterizations of alumina-coated alumina support layers and alumina-coated natural material-based support layers for microfiltration, Ceramics international, 42(12), 13796-13804 (2016) (IF=2.758)
- Lee et al., Removal and recovery of Cr(VI) from industrial plating wastewater using fibrous anion exchanger, Water, air, and soil pollution, 227, 287-1-287-11 (2016) (IF=1.551)
- Lee et al., Seasonal monitoring of bacteria and archaea in a full-scale thermophilic anaerobic digester treating food waste-recycling wastewater: Correlations between microbial community characteristics and process variables, Chemical engineering journal, 300, 291-299 (2016) (IF=5.310)
- Kang et al., Sequential approach to joint flow-seismic inversion for improved characterization of fractured media, Water resources research, 52(2), 903-919 (2016) (IF=3.792)
- Cho et al., Simultaneous dechlorination and disinfection using vacuum UV irradiation for SWRO process, Desalination, 398(15), 22-29 (2016) (IF=4.412)
- Bang et al., Simultaneous reduction of copper and toxicity in semiconductor wastewater using protonated alginate beads, Chemical engineering journal, 288, 525-531 (2016) (IF=5.310)
- Yoo et al., Tin porphyrin immobilization significantly enhances visible-light-photosensitized degradation of Microcystins: Mechanistic implications, Applied catalysis B, Environmental, 199, 33-44 (2016) (IF=8.328)
- Kim et al., Treating high-strength saline piggery wastewater using the heterotrophic cultivation of Acutodesmus obliquus, Biochemical engineering journal, 110, 51-58 (2016) (IF=2.463)
- Cho et al., Use of hybrid composite particles prepared using alkoxysilane-functionalized amphiphilic polymer precursors for simultaneous removal of various pollutants from water, Chemosphere, 156, 302-311 (2016) (IF=3.698)

(4) Intellectual Property

1) Patent (Registered)

- Core-shell composite comprising zero valent iron and lipids and method for fabricating the same, ZL 201410049790.X (Dr. Seunghak Lee)
- Method and apparatus for analyzing oil type using Unresolved Complex Mixture of gas chromatography, KR 10-1618307 (Dr. Seunghak Lee)
- Hydrotalcite coated sulfate and fabricating method for the same, ZL201210148456.3 (Dr. Sang-Hyup Lee)
- Absorbent for removal of toxic heavy metals using jujube concentrate and fabricating method for the same, KR 10-1598996 (Dr. Jae Woo Choi)
- Apparatus and method for recovery of retentate using gas separation membrane, KR 10-1600930 (Dr. Sang-Hyup Lee)
- Ion-exchange resin and fabricating method for the same, ZL201310041253.9 (Dr. Sang-Hyup Lee)
- Apparatus and method purifying contaminated soils, KR 10-1617326 (Dr. Jae Woo Choi)
- Water purification aparatus having double-pipe, KR 10-1624118 (Dr. Sang-Hyup Lee)
- Apparatus and method for recovery of retentate, KR 10-1636770 (Dr. Sang-Hyup Lee)
- Apparatus and method for recovery of retentate, KR 10-1636767 (Dr. Sang-Hyup Lee)
- Apparatus and method for recovery of retentate using gas separation membrane, KR 10-1640040 (Dr. Sang-Hyup Lee)
- Method for treating recycle water of wastewater treatment, KR 10-1646590 (Dr. Jae Woo Choi)
- Filtering unit for water treatment, KR 10-1672229 (Dr. Jae Woo Choi)
- Porous composite of eliminating posphorus and manufacturing method thereof, KR 10-1672232 (Dr. Sang-Hyup Lee)(Dr. Jae

- Chitosan composite of eliminating phosphorus and manufacturing method thereof, KR 10-1672231 (Dr. Jae Woo Choi)
- Chitosan-melamine composite of eliminating phosphorus and manufacturing method thereof, KR 10-1672234 (Dr. Jae Woo Choi)
- Apparatus and method for sludge solubilization with electrolysis and hydrodynamic cavitation, KR 10-1595473 (Dr. Kyu-Hong Ahn)
- Floating type adsorbent for removal of phosphate in aqueous solution and method for fabricating the same and method for regeneration of the same, US 929574 (Dr. Seok Won Hong)
- Immobilized titanium dioxide nanowires on substrate and method for fabricating the same and water treatment method using the immobilized titanium dioxide nanowires on substrate, CN ZL201210240806.9 (Dr. Seok Won Hong)
- Adsorbent for removal of cation and anion heavy metal and fabricating method of the same, US 9358522 (Dr. Seok Won Hong)
- Flexible nanostructure photocatalyst of TiO2 nanoparticles-immobilized PVDF nanofabric and method for fabricating the same, KR 10-1641123 (Dr. Seok Won Hong)
- Apparatus and method for sulfide crystallization of Cu and Ni using fluidized bed reactor, KR 10-1681701 (Dr. Seok Won Hong)
- Apparatus and method for cultivating micro-algae applied ozone oxidation, KR 10-1622936 (Dr. Kyung Guen Song)
- Apparatus and method for anaerobic wastewater treatment with fluidized media membrane distillation bioreactor, KR 10-1667931 (Dr. Kyung Guen Song)
- Apparatus and method for anaerobic wastewater treatment with membrane distillation, KR 10-1667932 (Dr. Kyung Guen Song)
- Movable water treatment apparatus and algae induced taste and odor matter removal method using activated carbon fiber packed column, KR 10-1670728 (Dr. Kyung Guen Song)
- Method for measuring a pollution level of inorganic ion, KR 10-1652685 (Dr. Seongpil Jeong)
- Water treatment apparatus using membrane distillation method, KR 10-1605535 (Dr. Seongpil Jeong)
- Water treatment apparatus using membrane distillation method, KR 10-1605536 (Dr. Seongpil Jeong)

2) Patents (Pending)

- Method and apparatus for analyzing the binding status of heavy metals in contaminated soils by combining Laser Ablation and Sequential Extraction Analysis, KR 2016-0008073 (Dr. Seunghak Lee)
- Quantitative analysis method for dissolved inorganic ion using laser ablation, KR 2016-0101446 (Dr. Seunghak Lee)
- Water treatment process using pyrophyllite ceramic membrane, KR 2016-0124641, US 15/377319 (Dr. Chanhyuk Park)
- Elastic body for cleaning flat-sheet type ceramic membrane, KR 2016-0082854 (Dr. Chanhyuk Park)
- Bead immobilized adsorbent and microorganism and method for fabricating the same, US 15/064939 (Dr. Jae Woo Choi)
- Apparatus and method for high permeable gas separation, KR 2016-0001329 (Dr. Sang-Hyup Lee)
- Apparatus and method for high permeable gas separation, KR 2016-0001330 (Dr. Sang-Hyup Lee)
- Apparatus and method for bidirectional high permeable gas separation, KR 2016-0001331 (Dr. Sang-Hyup Lee)
- Activated carbon for removal of microcystin, 2-MIB, and geosmin and water treatment method, KR 2016-0032889 (Dr. Sang-Hyup Lee)
- Activated carbon for removal of microcystin, 2-MIB, and geosmin and water treatment method, KR 2016-0032894 (Dr. Sang-Hyup Lee)
- Movable ship for eliminating algae, KR 2016-0034411 (Dr. Sang-Hyup Lee)
- Water treatment system using activated carbon, KR 2016-0077237 (Dr. Sang-Hyup Lee)
- Water treatment system using activated carbon for removal of microcystin and odor compound, CN 201610942427.2 (Dr. Sang-Hyup Lee)
- Water treatment system using activated carbon for removal of microcystin and odor compound, KR 2016-0077218 (Dr. Sang-Hyup Lee)
- Calcium silicate hydrate immobilize nitrogen and method for fabricating the same, KR 2016-0112588 (Dr. Jae Woo Choi)
- Floating body for treatment of algae, KR 2016-0116422 (Dr. Sang-Hyup Lee)
- Floating body equipped wireless control system for treatment of algae, KR 2016-0116337 (Dr. Sang-Hyup Lee)
- Floating body for treatment of algae, KR 2016-0132295 (Dr. Sang-Hyup Lee)
- Centrifual separator and method for sludge separating using the same, JP 2016-080982 (Dr. Kyu-Hong Ahn)
- Method and apparatus for recovery of heavy metal using cross-linking of sodium alginate and heavy metal ion, KR 2016-0038268 (Dr. Kyu-Hong Ahn)
- Magnetic biochar impregnated magnetite and apparatus for fabricating the same, KR 2016-0115580 (Dr. Kyu-Hong Ahn)
- Bead immobilized ammonium oxidation bacteria and method for fabrication the same, US 15/361539 (Dr. Hyokwan Bae)

- Bead immobilized ammonium oxidation bacteria and method for fabrication the same, KR 2016-0073109 (Dr. Hyokwan Bae)
- Membrane cleaning method for the membrane distillation, KR 2016-0073984 (Dr. Seockheon Lee)
- Apparatus for treatment of a high temperature wastewater by using a membrane distillation process, JP 2016-017954 (Dr. Seockheon Lee)
- Membrane distillation system which is capable of real-time monitoring on membrane scaling, KR 2016-0073532, US 15/297,797 (Dr. Seongpil Jeong)
- Membrane distillation system which is capable of real-time monitoring on membrane scaling, KR 2016-0073532, KR 2016-0073532 (Dr. Seongpil Jeong)
- Forward osmosis membranes based on multilayered thin films using a molecular layer-by-layer crosslinking assembly of organic monomers and method for fabricating the same, US 15/119305 (Dr. Seockheon Lee)
- Double-layer oxidizing electrode with metal ion concentration gradient and method for fabricating the same, KR 2016-0014507 (Dr. Kangwoo Cho)
- Methods of zinc nanoparticles having magnetic property by underwater plasma discharge, KR 2016-0145822 (Dr. Young Haeng Lee)
- Removal methods of zinc and copper from wastewater by underwater plasma discharge, KR 2016-0145818 (Dr. Young Haeng Lee)
- Porous fluidized bed media and Method of manufacturing the same, KR 2016-0146337 (Dr. Young Haeng Lee)
- PMMA membrane microorganism capsule and manufacturing method thereof, KR 2016-0146341 (Dr. Young Haeng Lee)
- Pretreatment methods of sludge solubilization for anaerobic digestion, KR 2016-0149806 (Dr. Young Haeng Lee)
- Apparatus and method for water treatment using oxidation and reduction of manganese dioxide catalyst, US 15/052085 (Dr. Seok Won Hong)
- Apparatus and method for water treatment reducing cyanotoxins using permanganate and activated carbon, KR 2016-0009130 (Dr. Seok Won Hong)
- Hydrogen peroxide-titanium dioxide photocatalyst doped by cobalt, method for producing the same and method for treating organic compound using the same, KR 2016-0054777 (Dr. Seok Won Hong)
- Method for immobilizing photocatalyst on polyimide film and photocatalyst substrate fabricated by the same, KR 2016-0104605 (Dr. Seok Won Hong)
- Photocatalyst substrate for water treatment and method for fabricating the same, KR 2016-0163184 (Dr. Seok Won Hong)

(5) Technonlogy Transfers

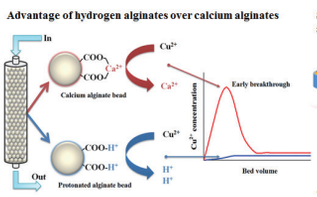
Name of the Transferred Technology	Loyalty[KRW]	P.I.
Development of copper recovery technology for ecotoxicity reduction of semiconductor wastewater	31,200,000	Hong, Seok Won

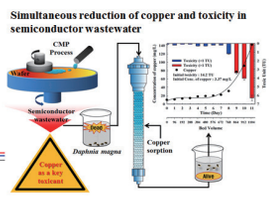
⟩⟩ Overview of Transferred Technology

- Simultaneous recovery of copper and reduction of toxicity in semiconductor wastewater using protonated alginate beads
- Protonated alginate beads were favored over Ca-alginate for Cu2+sorption
- High reusability was confirmed for over 10 cycles with no loss of sorption capacity

⟩⟩ Expectation Effect

- Contribution to toxicity reduction of copper containing wastewater as well as recovery of copper during treatment
- Environment-friendly and cost-effective technology for treatment of heavy metals containing wastewater

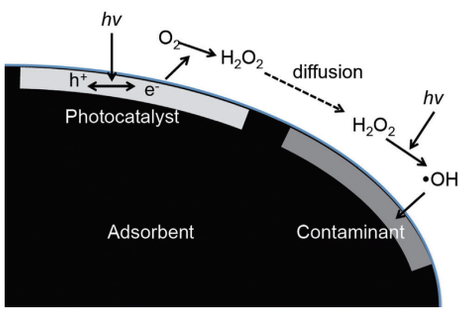




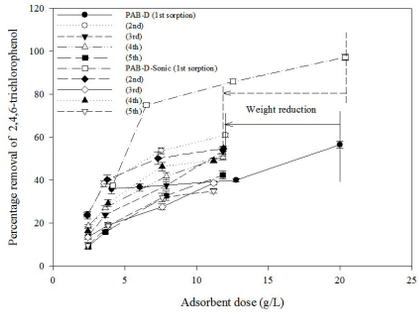
Name of the Transferred Technology	Loyalty[KRW]	P.I.
Alginate bead impregnated bubble and photocatalyst method for the same	75,000,000	Lee, Sang Hyup

》Overview of Transferred Technology
- Development of high efficiency adsorbent for the removal of toxic orgnic contaminant which induces lymphomas and leukemia etc.
- Presentation of effective regeneration technique related to recycling of adsorbent

》Expectation Effect
- The photo-regenerable adsorbent will be applicable for treatment of most photodegradable organic pollutants
- This adsorbent and regeneration technique will be useful as an efficient regeneration method in the water treatment process for sewage or wastewater



〈Regeneration mechanism of the photo-regenerable adsorbent via UV irradiation〉

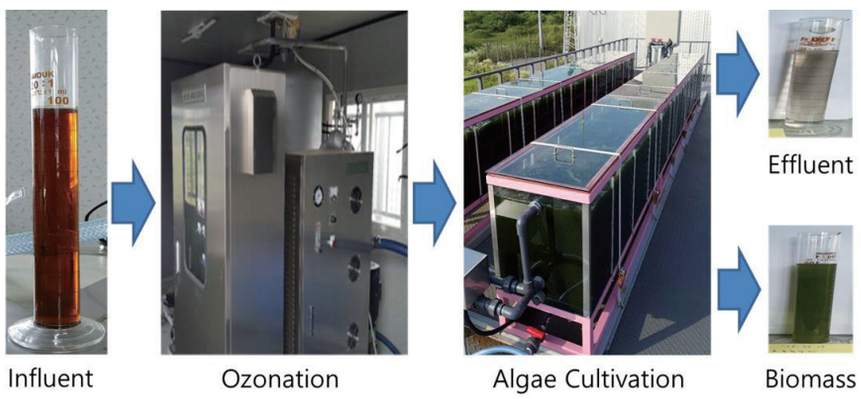


〈Effect pf adsorbent dose on the percentage removal of phenols〉

Name of the Transferred Technology	Loyalty[KRW]	P.I.
Apparatus and method for cultivating micro-algae applied ozone oxidation	20,000,000	Song, Kyung Guen

》Overview of Transferred Technology
- Direct micro-algae cultivation in high organic strength and colored wastewater by ozonation
- Enhancement of micro-algae growth rate using decolorized wastewater by ozonation

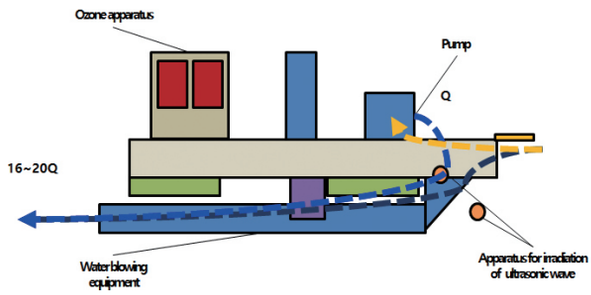
》Expectation Effect
- Nutrient removal from high strength wastewater and simultaneous production of algae biomass for bioenergy
- Cost Reduction in high strength wastewater treatment



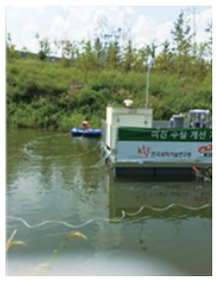
Name of the Transferred Technology	Loyalty[KRW]	P.I.
Water purification aparatus having double-pipe	40,000,000	Lee, Sang Hyup

》Overview of Transferred Technology
- Development of protective technology for algal bloom at retention or detention area in river
- Formation of artificially turbulent water flow for stagnant water

》Expectation Effect
- Contract for the transfer of technology : e-BISKOREA, INC.
- e-BISKOREA's sales figures : 970,000,000 KRW
- contracting authority : Suwon-city In Gyeonggi Province



〈Configure all system features and functions〉



〈Field application and site image〉

02

Center for Environment, Health and Welfare Research

02 Center for Environment, Health and Welfare Research

Mission

Integrated Management Technology for a Green City

The vision for the Center for Environment, Health and Welfare Research is to become a leading research institute addressing national challenges associated with tcreating a Green-City through sustainable technologies. Our research is focused on developing fundamental technologies for 1) urban/indoor air pollution monitoring and modeling, 2) urban hazardous pollutant diagnosis and control, 3) integrated risk assessment and prediction systems, and 4) integrated network technology for managing urban environmental conditions. These are practical as well as applicable globally in the fields of pollution prevention, monitoring, risk assessment, and restoration of urban environments. As a leading research group responding to international environment, health, and welfare, as well as innovating in support of national environmental policies, our emphasis is on practical, cooperative research among industries, academia, and research institutes. To accomplish our mission, we continually strive to contribute the towards growth of KIST through mutual team cooperation based on respect and confidence, as well as collaborations with professionals, governments and businesses.

Dr. Bae, Gwi-Nam

Head of the Center for Environment, Health and Welfare Research

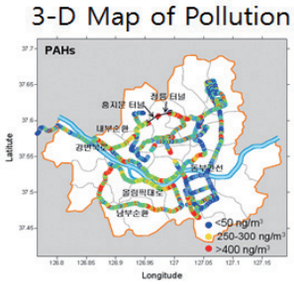
Research Areas

I. Characterization of atmospheric fine particles & climate–chemistry modeling

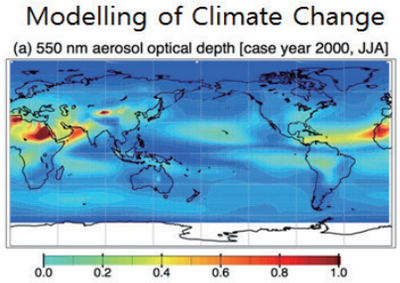
〉〉 Modeling and evaluation of complex urban air pollution
〉〉 3–D urban air quality monitoring in high resolution
〉〉 Development of risk assessment technology using micro–scale air pollution data
〉〉 Smog chamber investigations of the SOA formation mechanisms due to long–range transport of pollutants.
〉〉 Global climate–chemistry modeling with CESM (Community Earth System Model)

Mobile Lab

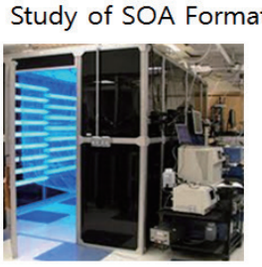
3-D Map of Pollution



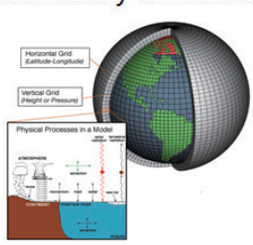
Modelling of Climate Change

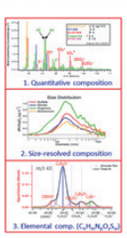


Study of SOA Formation Mechanism



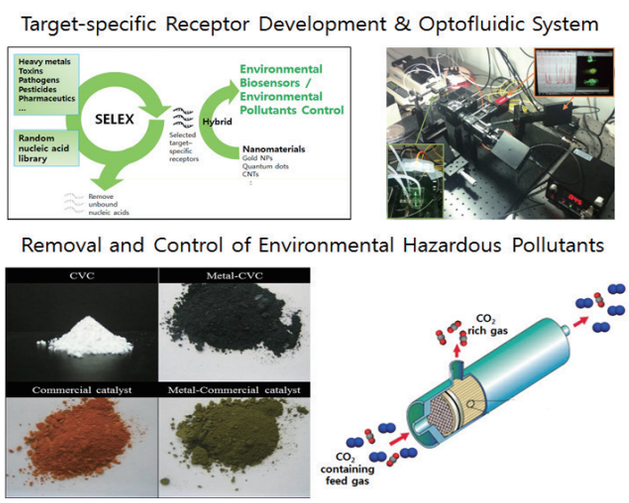
Community Climate System Model





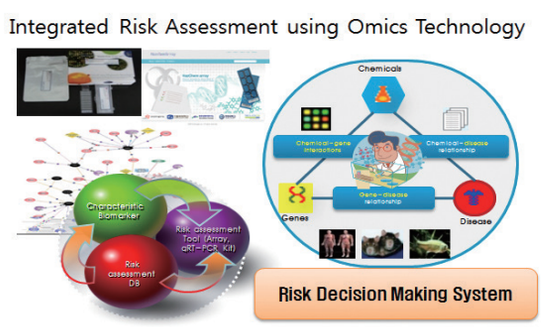
II. Environmental biosensors for diagnosis, removal of hazardous pollutants, climate change mitigation

》Bioreceptor development for urban environmental hazardous pollutants
》Biomolecules–nanomaterials hybrid for environmental biosensors
》Environmental biosensor systems (point–of–care/real–time)
》Optofluidics with fluorescence spectroscopy
》Nanoparticle–based catalytic oxidation, adsorption and recovery of environmental hazardous pollutants
》Synthesis of nanoparticle catalyst and antimicrobial nanostructured material
》Treatment system development for unpleasant odor and indoor air pollutants including bioaerosols
》Removal of VOCs (acetaldehyde) and indoor air pollutants over metal (V_2O_5, Mn_2O_3) loading on TiO_2 catalysts
》Air purification facility for Indoor air pollutants and smoking rooms
》Porous functional materials for greenhouse gas treatment



III. Integrated risk assessment

》Environmentally harmful chemical substance in vitro screening framework
》Securing environmentally harmful substances (PAHs, VOCs, POPs, EDCs etc.)
》Research on risk mechanism: risk mechanism identification, risk map creation
》Risk DB development, array development



1. Staff

Head, Principal Research Scientist
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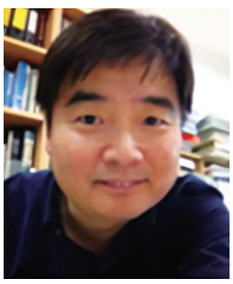

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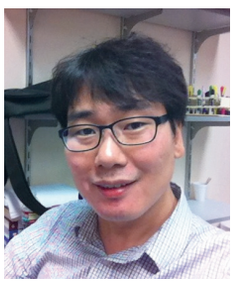

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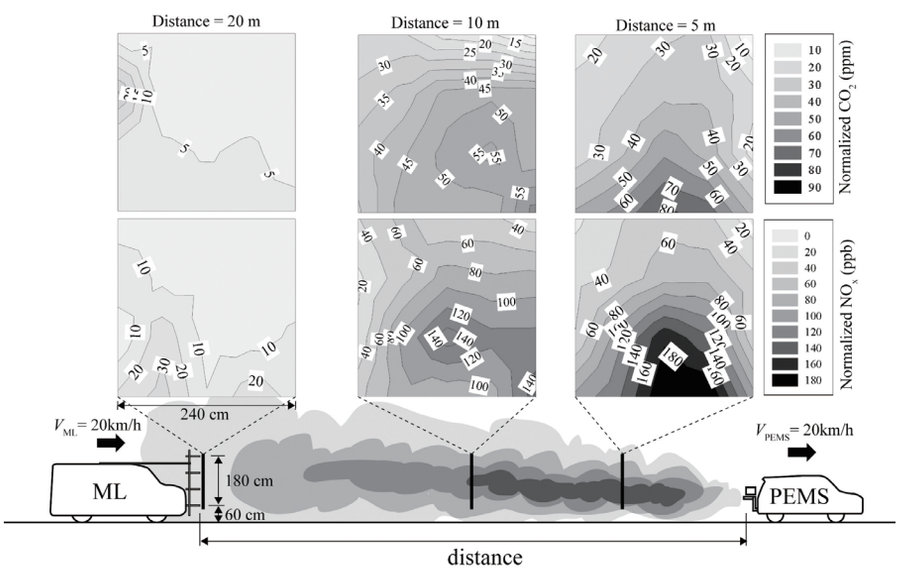
2. R&D Highlights

Overestimation of on-road air quality surveying data measured with a mobile laboratory caused by exhaust plumes of a vehicle ahead in dense traffic areas (Dr. Lee, Seung-Bok & Bae, Gwi-Nam)

The unintended influence of exhaust plumes emitted from a vehicle ahead to on-road air quality surveying data measured with a mobile laboratory (ML) at 20–40 km h^{-1} in dense traffic areas was investigated by experiment and life-sized computational fluidic dynamics (CFD) simulation. The ML equipped with variable sampling inlets of five columns by four rows was used to measure the spatial distribution of CO_2 and NO_x concentrations when following 5–20 m behind a sport utility vehicle (SUV) as an emitter vehicle equipped with a portable emission monitoring system (PEMS). The PEMS measured exhaust gases at the tailpipe for input data of the CFD simulations. After the CFD method was verified with experimental results of the SUV, dispersion of exhaust plumes emitted from a bus and a sedan was numerically analyzed.

More dilution of the exhaust plume was observed at higher vehicle speeds, probably because of eddy diffusion that was proportional to turbulent kinetic energy and vehicle speed. The CO_2 and NOx concentrations behind the emitter vehicle showed less overestimation as both the distance between the two vehicles and their background concentrations increased. If the height of the ML inlet is lower than 2 m and the ML travels within 20 m behind a SUV and a sedan ahead at 20 km h^{-1}, the overestimation should be considered by as much as 200 ppb in NO_x and 80 ppm in CO_2. Following a bus should be avoided if possible, because effect of exhaust plumes from a bus ahead could not be negligible even when the distance between the bus and the ML with the inlet height of 2 m, was more than 40m. Recommendations are provided to avoid the unintended influence of exhaust plumes from vehicles ahead of the ML during on-road measurement in urban dense traffic conditions.



〈Experimental set up of a PEMS-ML system and spatial distributions of CO_2 and NOx concentration downstream of the PEMS vehicle exhaust〉

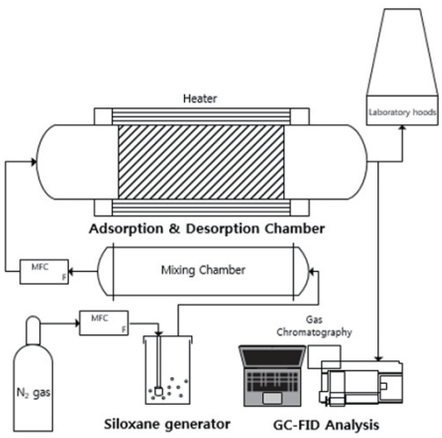
Low temperature regeneration of a polymeric adsorbent on siloxane (D5) removal for cost-effective purification of biogases from siloxane (Dr. Jurng, Jongsoo)

Biogas, a fuel used to generate electricity, contains siloxanes that can damage combustion engines, leading to expensive repairs and service interruptions. Thermal swing adsorption-regeneration using siloxane adsorbent is an effective method to remove siloxane from biogas.

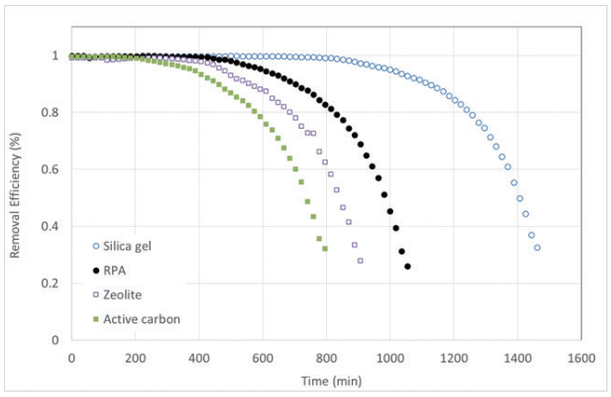
In the present study, a novel polyacrylic acid (PAA)-based polymer adsorbent was studied as biogas siloxane adsorbent in subsequent adsorption/regeneration cycles. The regeneration of exhausted polymer adsorbent was done using washing with the heated air at 60 to 80 degree C. The heated air regeneration result in the similar capacity for siloxane (D5) adsorption. At the fixed inlet D5 concentration (4,000 mg m^{-3}) and the flow rate (200 mL min^{-1}), at 25 ℃, the D5 siloxane concentration in the gas was measured by GC/FID.

The breakthrough point of the adsorbent bed is considered to be when the outlet D5 siloxane concentration reaches 10% of the inlet concentration and the removal efficiency of D5 siloxane is 90%. In this experiment, the 10% breakthrough time of RPA is 700 min, and the 90% breakthrough time is 1,100 min.

At room temperature (25℃), the siloxane adsorption capacity of this polymer adsorbent was approximately 80% that of silica gel. In addition, the thermal desorption of siloxane (D5) from the polymer material was more than 95% at a low regeneration temperature of 80℃, where no siloxane regeneration was observed using the conventional silica gel.



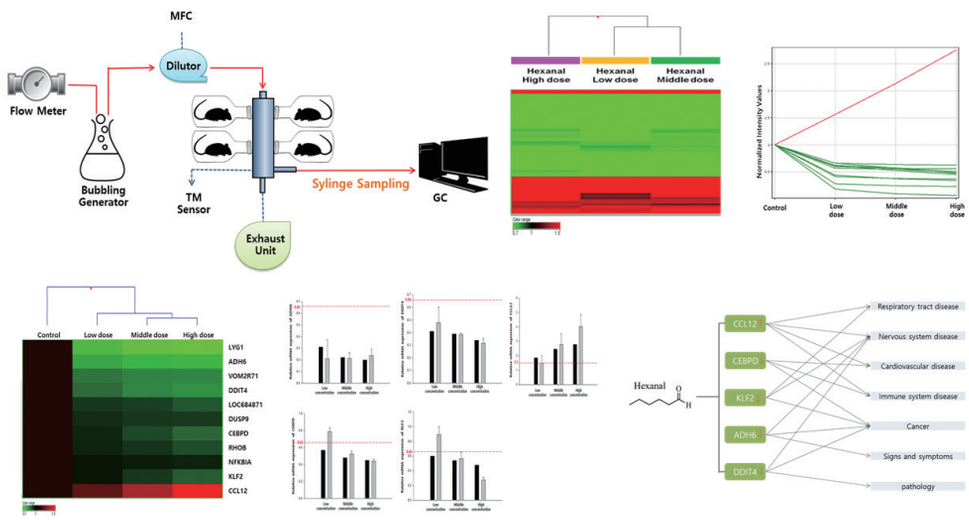
〈Fixed-bed breakthrough test set-up for the evaluation of adsorption capacity for polymeric adsorbent (RPA) and silica gel〉



〈Removal efficiency of D5 siloxane from the fixed-bed adsorbents vs. time for various adsorbents〉

Toxicogenomic analysis of the pulmonary toxic effects of hexanal in F344 rat (Dr. Ryu, Jae-Chun)

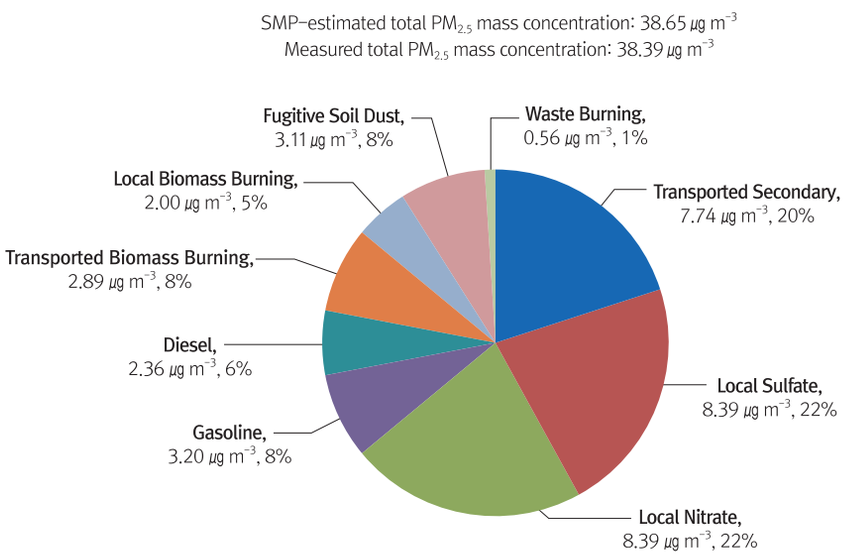
Hexanal is a major component of indoor air pollutants and is a kind of aldehydes; it has adverse effects on human health. We performed an in vivo inhalation study and transcriptomic analysis to determine the mode of toxic actions in response to hexanal. Fischer 344 rats of both sexes were exposed by inhalation to hexanal aerosol for 4h/day, 5 days/week for 4 weeks at 0, 600, 1000 and 1500 ppm. Throughout our microarray-based genome-wide expression analysis, we identified 56 differentially expressed genes in three doses of hexanal; among these genes, 11 genes showed dose-dependent expression patterns (10 down-regulated and 1 up-regulated, 1.5-fold, $p<0.05$). Through a comparative toxicogenomics database (CTD) analysis of 11 genes, we determined that five genes (CCL12, DDIT4, KLF2, CEBPD and ADH6) are linked to diverse disease categories such as cancer, respiratory tract disease, and immune system disease. These diseases were previously known for being induced by volatile organic compounds (VOCs). Our data demonstrated that the hexanal-induced dose-dependent altered genes could be valuable quantitative biomarkers to predict hexanal exposure and to perform relative risk assessments, including pulmonary toxicity.



〈The integrative toxicogenomic analysis approaches focused on pulmonary toxicity of hexanal〉

Transported vs. local contributions from secondary and biomass burning sources to PM2.5 (Dr. Kim, Jin Young)

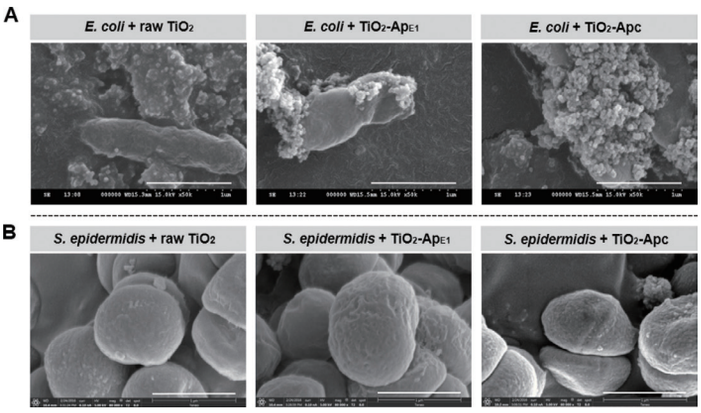
The concentration of fine particulates in Seoul, Korea has been lowered over the past 10 years, as a result of the city's efforts in implementing environmental control measures. Yet, the particulate concentration level in Seoul remains high as compared to other urban areas globally. In order to further improve fine particulate air quality in the Korea region and design a more effective control strategy, enhanced understanding of the sources and contribution of fine particulates along with their chemical compositions is necessary. In turn, relative contributions from local and transported sources on Seoul need to be established, as this city is particularly influenced by sources from upwind geographic areas. In this study, $PM_{2.5}$ monitoring was conducted in Seoul from October 2012 to September 2013. $PM_{2.5}$ mass concentrations, ions, metals, organic carbon (OC), elemental carbon (EC), water soluble OC (WSOC), humic-like substances of carbon (HULIS-C), and 85 organic compounds were chemically analyzed. The multivariate receptor model SMP was applied to the $PM_{2.5}$ data, which then identified nine sources and estimated their source compositions as well as source contributions. Prior studies have identified and quantified the transported and local sources. However, no prior studies have distinguished contributions of an individual source between transported contribution and locally produced contribution. We differentiated transported secondary and biomass burning sources from the locally produced secondary and biomass burning sources, which was supported with potential source contribution function (PSCF) analysis. Of the total secondary source contribution, 32% was attributed to transported secondary sources, and 68% was attributed to locally formed secondary sources. Meanwhile, the contribution from the transported biomass burning source was revealed as 59% of the total biomass burning contribution, which was 1.5 times higher than that of the local biomass burning source. Four-season average source contributions from the transported and the local sources were 28% and 72%, respectively.



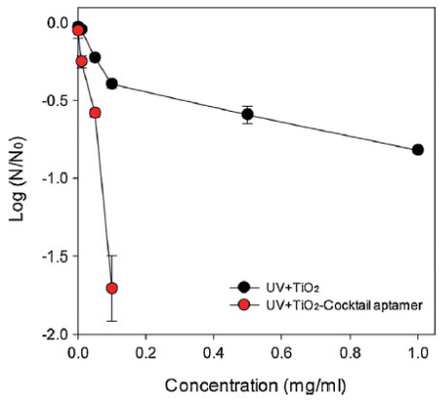
〈Four-season average source contributions〉

Bacterial target specific receptor–conjugated photocatalyst for enhanced antibacterial efficiency toward target bacteria (Dr. Kim, Byoung Chan)

TiO_2 particles conjugated with an *Escherichia coli (E. coli)* surface–specific ssDNA aptamer (receptor) cocktail (composed of three different aptamers isolated from *E. coli*) for targeted and enhanced disinfection of E. coli was developed. The target–specific and enhanced inactivation of this composite (TiO_2–Apc), which were compared to those of TiO_2 conjugated with a single aptamer (one of the three different aptamers, TiO_2–Aps) and non–modified TiO_2 were examined. We found that TiO_2–Apc enhanced the inactivation of targeted E. coli under UV irradiation compared to both the non–modified TiO_2 and TiO_2–Aps. A higher number of TiO_2–Apc than TiO_2–Aps particles was observed on the surface of *E. coli*. The amount of TiO_2–Apc required to inactivate ~99.9% of *E. coli* (10^6 CFU/ml) was 10 times lower than that of non–modified TiO_2. The close proximity of functionalized particles with E. coli resulting from the interaction between the target surface and the aptamer induced the efficient and fast transfer of reactive oxygen species to the cells. In a mixed culture of different bacteria (*E. coli and Staphylococcus epidermidis*), TiO_2–Apc enhanced the inactivation of only *E. coli*. Taken together, these results support the use of aptamer cocktail–conjugated TiO_2 for improvement of the target–specific inactivation of bacteria.



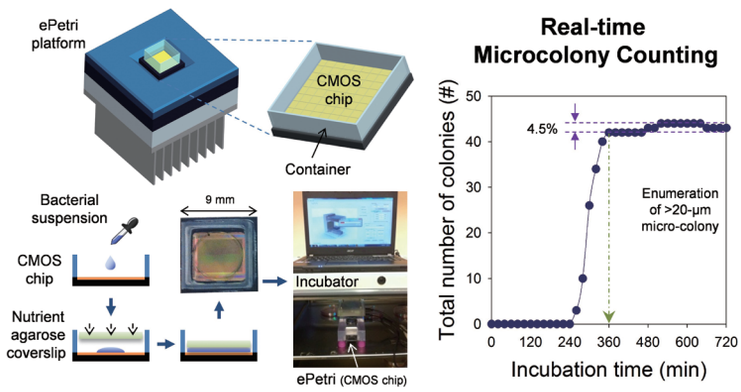
〈SEM images of particle binding on (A) *E. coli* and (B) *S. epidermidis*. The images show that more TiO_2–Apc (aptamer cocktail) particles were localized and distributed on the cell surface compared to the TiO_2–ApE1 (single aptamer) or non–modified TiO_2 particles. The white scale bars in images denote 1 μm〉



〈Concentration dependency of the antibacterial effect of non–modified TiO_2 and TiO_2–Apc on E. coli after 30 min of UV irradiation〉

Real-time bacterial microcolony counting using on-chip microscopy (Dr. Jung, Jae Hee)

Observing microbial colonies is the standard method for determining the microbe titer and investigating the behaviors of microbes. Here, we report an automated, real-time bacterial microcolony-counting system implemented on a wide field-of-view (FOV), on-chip microscopy platform, termed ePetri. Using sub-pixel sweeping microscopy with a super-resolution algorithm, this system offers the ability to dynamically track individual bacterial microcolonies over a wide FOV of 5.7 mm X 4.3 mm without requiring a moving stage or lens. As a demonstration, we obtained high-resolution time-series images of S. *epidermidis* at 20-min intervals. We implemented an image-processing algorithm to analyze the spatiotemporal distribution of microcolonies, the development of which could be observed from a single bacterial cell. Test bacterial colonies with a minimum diameter of 20 μm could be enumerated within 6 h. We showed that our approach not only provides results that are comparable to conventional colony-counting assays but also can be used to monitor the dynamics of colony formation and growth. This microcolony-counting system using on-chip microscopy represents a new platform that substantially reduces the detection time for bacterial colony counting. It uses chip-scale image acquisition and is a simple and compact solution for the automation of colony-counting assays and microbe behavior analysis with applications in antibacterial drug discovery.

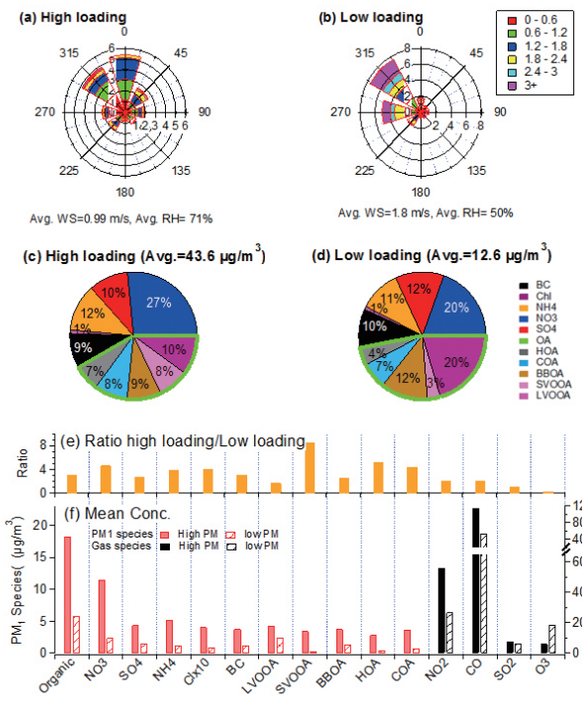


〈Real-time measurement of bacterial microcolonies :
1) bacterial suspension loading onto the CMOS chip. 2) CMOS chip covering with the nutrient agarose sheet〉

Sources and atmospheric processing of wintertime aerosols in Seoul, Korea: Insights from real-time measurements using a high-resolution aerosol mass spectrometer (Dr. Kim, Hwa Jin)

Highly time-resolved chemical characterization of non-refractory submicrometer particulate matter (NR-PM1) was conducted in Seoul, the capital and largest metropolis of Korea, using an Aerodyne high-resolution time-of-flight aerosol mass spectrometer (HR-ToF-AMS). The measurements were performed during winter when persistent air quality problems associated with elevated particulate matter (PM) concentrations were observed. This is the first time that such detailed real-time measurement results have been reported from Seoul, Korea, providing insights into the various sources and processes of PM in the atmosphere. The average concentration of submicron aerosol was 27.5 $\mu g\ m^{-3}$, and the total mass was dominated by organics (44%), followed by nitrate (24%) and sulfate (10%). The concentrations (2.6-90.7 $\mu g\ m^{-3}$) and composition of PM_1 varied dynamically during the measurement period, due to the influences of different meteorological conditions, emission sources, and air mass origins. Five distinct sources of OA were identified via positive matrix factorization (PMF) analysis of the HR-ToF-AMS data: vehicle emissions (HOA), cooking activities (COA), wood combustion (BBOA), and secondary organic aerosol (SOA) represented by a semi-volatile oxygenated OA factor (SV-OOA) and a low volatility oxygenated OA factor (LV-OOA).

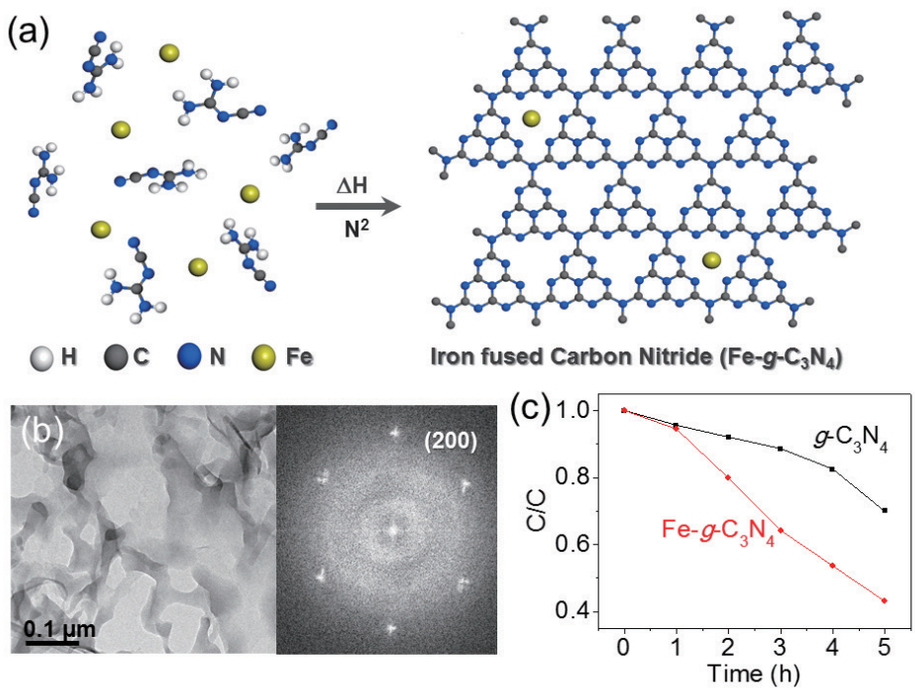
Our results indicate that air quality in Seoul during winter is influenced strongly by secondary aerosol formation with sulfate, nitrate, ammonium, SV-OOA, and LV-OOA together accounting for 64% of the PM_1 mass during this study. However, aerosol sources and composition were found to be significantly different between clean and polluted periods. During stagnant periods with low wind speed (WS) and high relative humidity (RH), PM concentration was generally high (average ± 1s = 43.6 ± 12.4 $\mu g\ m^{-3}$) with enhanced fractions of nitrate (27%) and SV-OOA (8%), which suggested a strong influence from local production of secondary aerosol. Low PM loading periods (12.6 ± 7.1 $\mu g\ m^{-3}$) tended to occurred under higher WS and lower RH conditions and appeared to be more strongly influenced by regional air masses, as indicated by higher mass fractions of sulfate (12%) and LV-OOA (21%) in PM_1.Overall, our results indicate that PM pollutants in urban Korea originate from complex emission sources and atmospheric processes and that their concentrations and composition are controlled by various factors including meteorological conditions, local anthropogenic emissions, and upwind sources.



〈Comparisons of averaged properties measured during high particulate matter (PM_1), loading and low PM loading periods〉

Divalent Fe concentration in two-dimensional microporous graphitic carbon nitride and its potential photocatalytic remediation of organic pollutants (Dr. Oh, Youngtak)

Graphitic carbon nitride (g-C_3N_4) is a rising two-dimensional material possessing intrinsic semiconducting property with unique geometric configuration featuring superimposed heterocyclic sp2 carbon and nitrogen network, nonplanar layer chain structure, and alternating buckling. The inherent porous structure of heptazine-based g-C_3N_4 features electron-rich sp2 nitrogen, which can be exploited as a stable transition metal coordination site. Multiple metal-functionalized g-C_3N_4 systems have been reported for versatile applications, but local coordination as well as its electronic structure variation upon incoming metal species is not well understood. Here we present detailed bond coordination of divalent iron (Fe^{2+}) through micropore sites of graphitic carbon nitride and provide both experimental and computational evidence supporting the aforementioned proposition. In addition, the utilization of electronic structure variation is demonstrated through comparative photocatalytic activities of pristine and Fe-g-C_3N_4. Its photocatalytic functionality allow sustainable degradation of organic pollutants with high regenerability and energy-efficiency.



〈(a) Synthesis scheme of iron fused carbon nitride. (b) electron microscope image and diffraction. (c) photocatalytic functionality of Fe-g-C_3N_4 〉

3. Specified results

(1) Achievement Summary

Research Grants [KRW]	4,113,896,000
Publication (SCI, SCIE)	22
Intellectual Property	6
Technology transfer fee [KRW]	215,000,000

(KRW 1,150 = USD 1)

(2) Grants

- National Research / Commercialization of Room Aircare System / ₩125,000,000 / PI: Jurng, Jongsoo
- Council of Science and Technology / using nano coating catalyst and IoT technology (2016-2017) / ₩125,000,000 / PI: Jurng, Jongsoo
- Ministry of Science, ICT, and Future Planning / R&D strategy against particulate matters pollution / ₩50,000,000 / PI: Bae, Gwi-Nam
- Korea Institute of Science and Technology/ Commercialization of VOCs decomposition module and air purification device using nano-catalyst coating material / ₩140,000,000 / PI: Jurng, Jongsoo
- Korea Institute of Science and Technology / Next generation low dimensional functional nano materials for environmental application / ₩3,000,000 / PI: Oh, Youngtak
- Ministry of Envrionment / Development of monitoring Technologies for priority hazardous air pollutants in urban areas / ₩350,000,000 / PI: Lee, Seung-Bok
- Ministry of Land, Infrastructure, and Transport / Development of air pollutant removal technology for operation train / ₩435,000,000 / PI: Bae, Gwi-Nam
- Korea Institute of Science and Technology / Commercialization of VOC removal module and Air Purifier using nano-catalyst coated filters (2016-2017) / ₩120,000,000 / PI: Jurng, Jongsoo
- Korea Institute of Science and Technology / Green house gas capturing porous functional material synthesis and application development / ₩20,000,000 / PI: Oh, Youngtak
- Korea Institutel of Science and Technology / Toxic micro fine particle characterization and future generation detection technology development / ₩1,435,696,000 / PI: Kim, Jin Young
- Ministry of Science, ICT, and Future Planning / Dectection and analysis of organic and inorganic air pollutants within yellow dusts / ₩71,000,000 / PI: Kim, Jin Young
- Ministry of Oceans and Fisheries / Ship emission PM/BC detection and climate change effect analysis / ₩200,000,000 / PI: Kim, Jin Young
- Ministry of Envrionment / Real-time air quality monitoring study for improvement of air pollution level in hot spot areas / ₩85,000,000 / PI: Bae, Gwi-Nam
- Ministry of Envrionment / Verification research of practical application of advanced predictive system for VOCs exposure using epigenomic biomarkers / ₩253,200,000 / PI: Ryu, Jae-Chun
- Ministry of Envrionment / Research and development of detection system using genomic tools for environmental pulmonary diseases / ₩450,000,000 / PI: Ryu, Jae-Chun
- Ministry of Envrionment / Development of characterization technology of indoor/outdoor air and biological hazards / ₩250,000,000 / PI: Bae, Gwi-Nam

(3) Publications & Works

- Y.B. Lim, H. Kim, J.Y. Kim, B.J. Turpin, Photochemical organonitrate formation in wet aerosols, Atmospheric Chemistry and Physics, 16, 12631-12647 (2016) (IF = 5.69)
- J.H. Lee, B.C. Kim, B.K. Oh, J.W. Choi, Rapid and sensitive determination of HIV-1 virus based on surface-enhanced raman spectroscopy, Journal of Biomedical Nanotechnology, 11(12), 2223-2230, (2016) (IF = 3.929)
- D.L. Nguyen, J.Y. Kim, S.-G. Shim, Y.S. Ghim, X.-S. Zhang, Shipboard and ground measurements of atmospheric particulate mercury and total mercury in precipitation over the Yellow Sea region, Envionmental Pollution, 219, 262-274 (2016) (IF = 4.839)
- B.M Kim, J. Seo, J.Y. Kim, J.Y. Lee, Y. Kim, Transported vs. local contributions from secondary and biomass burning sources to $PM_{2.5}$, Atmospheric Environment, 144, 24-36 (2016) (IF = 3.459)
- M.Y. Song, J. Jurng, Y.-K. Park, B.C. Kim, An aptamer cocktail-functionalized photocatalyst with enhanced antibacterial efficiency towards target bacteria, Journal of Hazardous Materials, 318, 247-254 (2016) (IF = 4.836)
- U.J. Kim, B.C. Kim, DNA aptamers for selective identification and separation of flame retardant chemicals, Analytica Chimica Acta 936, 208-215 (2016) (IF = 4.712)
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(4) Intellectual Property

1) Patents (Registered)

- Single-stranded nucleic acid aptamers specifically binding to klebsiella pneumoniae and method for detecting K. pneumonia using the same, USA 9,284,550 (Dr. Jong Soo Jurng)

- Single-stranded nucleic acid aptamers specifically binding to klebsiella pneumoniae and method for detecting K. pneumonia using the same, KR 13-141753 (Dr. Jong Soo Jurng)

2) Patents (Pending)

- Catalyst filter comprising nano metallic catalyst sprayed on the surface of support, USA 15-227001 (Dr. Jong Soo Jurng)

- Catalyst filter comprising nano metallic catalyst sprayed on the surface of support, JPN 2016-153956 (Dr. Jong Soo Jurng)

- Apparatus for decomposing low concentration of volatile organic compounds by high flow, USA 15-224922 (Dr. Jong Soo Jurng)

- Apparatus for decomposing low concentration of volatile organic compounds by high flow, KR 10-2015-0182575 (Dr. Jong Soo Jurng)

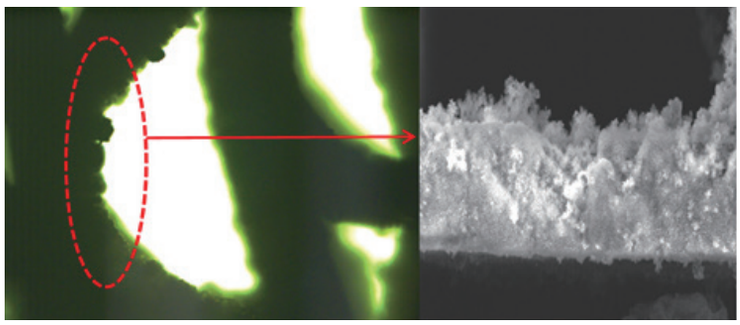
- Single-stranded DNA aptamers that can bind to hemagglutinin of avian influenza virus subtype H5 specifically and use of cocktail combination of isolated aptamers to detect avian influenza virus subtype H5, KR 10-2016-0104591 (Dr. Byoung Chan Kim)

(5) Technonlogy Transfers

Name of the Transferred Technology	Loyalty[KRW]	P.I.
Technology of catalyst filter comprising nano metalic catalyst sprayed on the surface of support	54,000,000	Jurng, Jongsoo
Design technology of air purification systems for hotels' indoor air using nano-catalyst coated filters	107,000,000	Jurng, Jongsoo
Low Temperature VOC Removal Technology using Hybrid Ozone-Catalyst	54,000,000	Jurng, Jongsoo

》Overview of Transferred Technology
- Catalyst filter technology comprising nano metalic catalyst sprayed on the surface of support
- a surface-supported catalyst in which a small amount of nanocatalyst particles exhibiting catalytic performance are carried on the surface of a filter medium by using a catalyst slurry prepared by using a particulate catalyst, wherein the slurry state, binder type, temperature, It is possible to produce an air cleaning catalyst which is different from the conventional technology and exhibits an optimum activity at a low temperature and which is excellent in economy.

》Expectation Effect
- The technology is expected to effectively exhibit high market competitiveness during air cleaning product development for practical use of the nano-catalyst effective to decompose the gas phase pollutants removal of ultra low concentrations of room air. The nano metal catalyst is uniformly sprayed on the surface of the corrugated cardboard, and thus the catalyst filter according to one aspect of the present invention can be confirmed to include the nano metal catalyst in a highly dispersible manner.



〈Microscope observations of Catalyst filter technology comprising nano metalic catalyst〉

(6) Presentations

Conference/Symposium	Titles	Date	Speaker
3th International Energy and Environment Conference	Development of Monitoring Technologies for Priority Hazardous Air Pollutants in Urban Areas	October, 2016	Dr. Lee, Seung-Bok Invited Speaker
3th International Energy and Environment Conference	Synthesis, Analysis, and Envrionmental Application of Aerogels based on Soft Nano Building Blocks	October, 2016	Dr. Oh, Youngtak Invited Speaker

(7) Research Activities

- Dr. Jae-Chun Ryu has served as a Honorary President for Korean Society of Environmental Risk Assessment and as a Chairman for Korean Society of Toxicogenomics and Toxicoproteomics. He is also an advisory editorial board member at Journal of Molecular and Celluar Toxicology and an editor-in-chief at Journal of Toxicology and Environmental Health Sciences.

- Dr. Jung, Jae Hee has served as a test/evaluation member for Private Expert Committee on Republic of Korea Joint Chiefs of Staff. He has also served as a committee member for the Korean Society of Mechanical Engineers, and for Korean Association for Particle and Aerosol Research.

(8) Raising Public Awareness

• Education for the general public

2016 KIST science camp for high school students on the subject of risk assessment of environmental hazardous chemicals using toxicogenomic tools, organized by Dr. Jae-Chun Ryu, Jul. 18-22, 2016.

• Broadcasts

"Proper response to the ozone" on TV Chosun (May 20)

"Ultra fine particle emission 50% reduction by 2023" on KBS News (Nov 14)

• Newspaper

"Science is the key to solve micro fine particle pollution" in Electric Newspaper (Aug 18)

초미세먼지, 열쇠는 과학 지식이다

과학산책

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KIST 녹색도시기술연구소 환경복지연구단장
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최근 극심한 스모그, 자동차 디젤입자, 석탄화력발전소에서 발생하는 황산염, 주방 조리 시 생성되는 입자 등 매우 다양한 형태의 초미세먼지가 일상생활을 위협하고 있다. 정부에서도 지난 6월 3일 미세먼지 관리 특별 대책을 내놓는 등 초미세먼지는 매우 중요한 사회문제 현안으로 떠올랐다. 지금까지 환경부가 많은 비용을 들여서 대기 질을 관리한 결과 서울의 공기가 과거에 비해 많이 깨끗해진 것을 누구나 인정할 것이다.

다만 초미세먼지를 발생시키는 외부 요인에 대한 우려는 국민들의 불안감을 유발하고 있다. 그 예로 2013년 중국에서 발생한 극심한 스모그 현상이나 독일 자동차회사 디젤 스캔들을 들 수 있다. 특히 독일 회사의 디젤 스캔들이 터짐으로써 도시 지역의 주된 대기오염물질 배출원인 자동차가 고농도 미세먼지 오염 주범으로 주목받게 된 계기가 됐다. 정부에서 지난달 미세먼지 관리 특별대책 세부이행 계획을 발표했지만 국민은 아직 못미더워하고 있다. 우리가 초미세 먼지에 대해 잘 알지 못하는 상황에서 나온 대책이기 때문이다.

왜 눈에 보이지도 않는 초미세먼지로 온 국민이 허둥대는 모습을 보이는지 생각해 볼 필요가 있다. 통상 미세먼지는 담배연기나 자동차 매연처럼 연소에 의해 직접 발생하는 것으로 알려져 있다. 하지만 전문가들은 공장이나 자동차에서 발생하는 이산화황, 질소산화물, 휘발성유기화합물 등이 기체 상태로 대기 중에 배출된 후 물리·화학 반응을 거쳐 고체 상태로 바뀌어 발생하는 초미세먼지에 주목할 필요가 있다는 입장이다.

이 초미세먼지를 굴뚝이나 자동차 배기관에서 직접 배출된 초미세먼지와 구별해 이차생성 초미세먼지라고 한다. 문제는 이러한 이차생성 초미세먼지가 대기 중 초미세먼지 절반 이상을 차지하고 있다는 사실이다. 즉 이 부분을 간과하고서는 제대로 된 초미세먼지 관리가 어렵다는 뜻이다. 물론 대기환경 전문가도 이차 초미세먼지가 생성되는 모든 경로를 알고 있는 것은 아니다. 그러나 우리가 대기환경 선진국으로 나아가려면 반드시 풀어야 할 과제임에는 틀림없다.

아는 것이 힘이다. 우리가 아는 만큼 초미세먼지 오염 문제를 더 잘 관리할 수 있다. 그리고 우리가 초미세먼지에 대해 명명백백하게 파헤칠 수 있는 도구는 과학임에 분명하다. 조금 늦은 감이 있지만 정부에서는 과학 지식의 중요성을 이해하고 특별대책에 미세먼지의 원인 규명과 기술 개발을 포함시킨 가운데 다양한 분야의 전문가들을 모아 연구기획 작업을 실시하고 있다.

이 연구 결과는 국민에게 초미세먼지에 대한 더 많은 정보를 제공할 뿐만 아니라 대기오염 문제로 어려움을 겪고 있는 개발도상국에도 희망의 모델이 될 수 있다. 현재 초미세먼지 관리 대책이 미덥지 못한 것은 정부나 기업만의 잘못이 아니라 우리가 모르는 것이 아직 많기 때문이다.

과학자들이 초미세먼지의 정체를 밝혀 나가려면 정부와 기업의 든든한 후원과 국민의 지지 및 격려가 필요하다. 국민과 국가, 기업이 합께할 때 더욱 높은 효율을 거두고 시행착오가 적을 것이다. 미세먼지라는 안갯속 미로를 과학기술이라는 지도를 이용해 헤쳐 나간다면 그 깊의 끝에는 안개가 걷힌 밝은 하늘이 우리를 기다리고 있을 것이다.

03

Center for Urban Energy Research

03 Center for Urban Energy Research

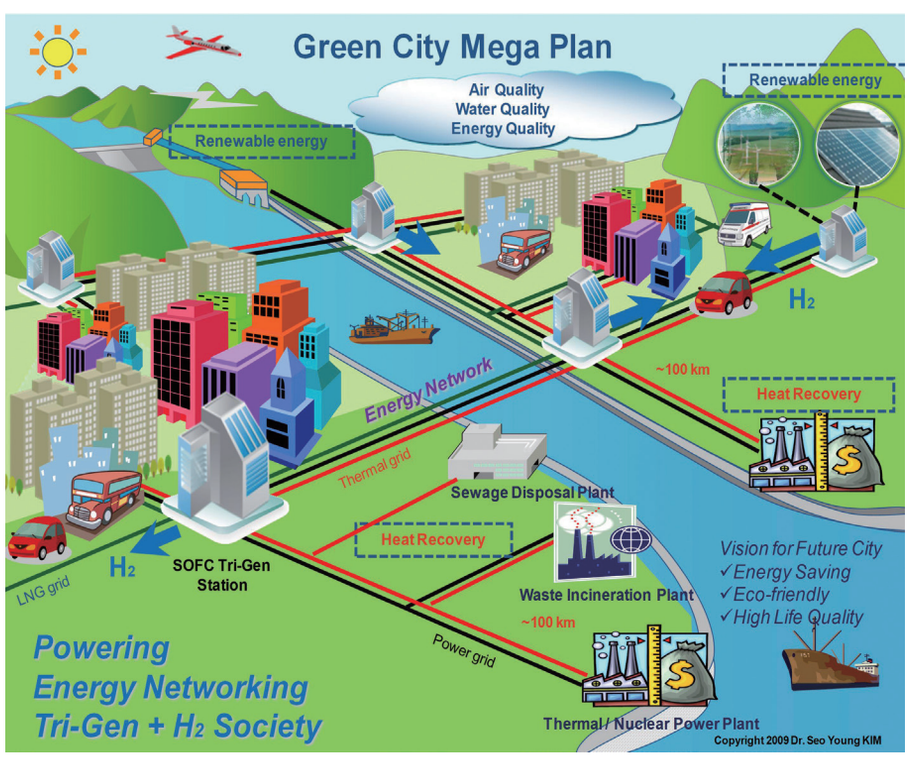
Mission

Development of a Green City for Self-Sustainable Energy

The Center for Urban Energy Research seeks the realization of an environmentally-friendly and energy-independent Green City through the development of future fusion/combination energy systems and energy management technology. Through cooperatinon armong related experts, our research center is dedicated to improving the efficiency and reliability of energy systems and developing technology for energy savings. Our research will accomplish the formation of the virtuous cycle through the independence of Green City energy, the networking of future urban energy usage through fusion technology, and the creation of the Social Overhead Capital(SOC) management paradigm. Therethrough, the realization of our research will contribuce to economic growth.

Dr. Lee, Dae-Young

Head of the Center for Urban Energy Research



Development of Green City Tri-Gen

- District power, heating, cooling supply
- Energy storage, management, networking
- Ultimate energy saving
- Ultimate CO_2 reduction
- Hydrogen liquefaction and liquid hydrogen storage

Research Areas

Ⅰ. Green-City Development

》High-efficiency distributed generation systems technology
》Tri-generation system
》Energy Harvesting – Global climate-chemistry modeling with CESM (Community Earth System Model)

Ⅱ. Building Energy Savings Technology

》Nature inspired cooling/heating/ventilation development
》Smart metering for demand control
》Energy remodeling protocols for old buildings

Ⅲ. SOC (Social Overhead Capital) Energy Saving Technology

》Eco-friendly metro transportation development
》Power grid for Green vehicles(FCEV/EV)
》PV powerded LED lighting development

Ⅳ. Urban Energy Management Technology

》Energy management optimization techonlogy for Green-City
》LCCA (Life Cycle & Cost Analysis)
》Urban energy networking

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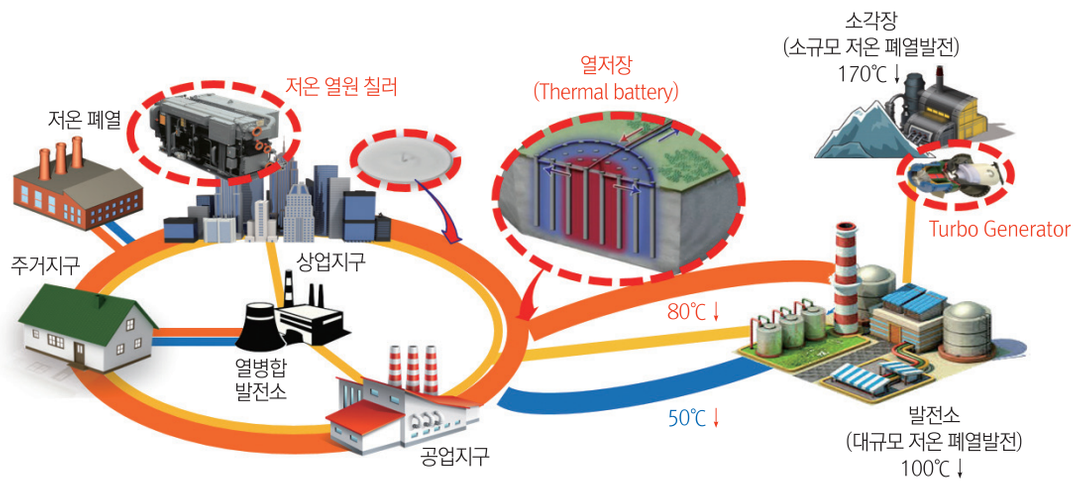
2. R&D Highlights

District heating and cooling with low-grade thermal energy (Dr. Lee, Dae-Young)

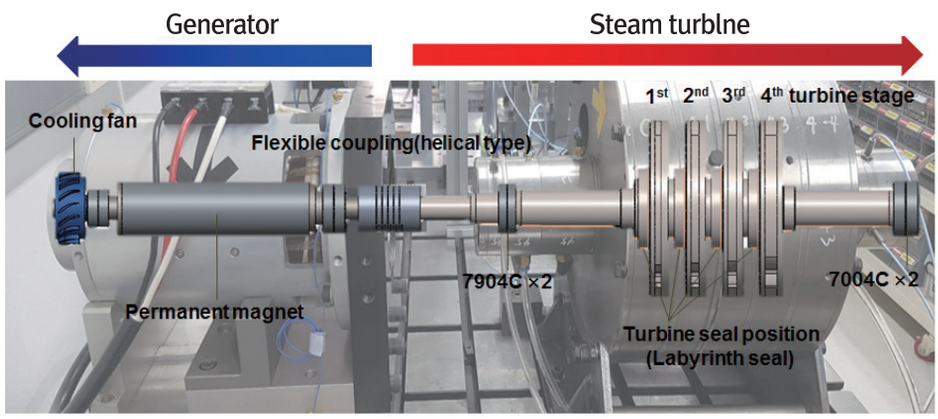
District Heating and Cooling(DHC) has been considered as an effective measure for global challenge on responding climate change. DHC is usually based on the Combined Heat and Power(CHP) plant and has been assessed to reduce the total energy consumption and thus the global warming gas emissions by more than 40%. Recently efforts have been focused to improve further the effects of DHC by lowering the supply temperature, which enables the utilization of the renewable or waste thermal energy. Our center initiated the research project to provide the technology necessary for converting the existing DHC network to the low-grade thermal system. The detailed objectives of the project are: the development of compact thermal energy storage system suitable to be installed at the demand side, the development of high density thermal energy storage material, the cooling technology for building utilizing low grade thermal energy, and the power generation with the waste heat from the incineration plant. This is the first year of the three-year project and fundamental research has been carried out including the heat and mass transfer analysis, simulation tool development, and preliminary experiments.



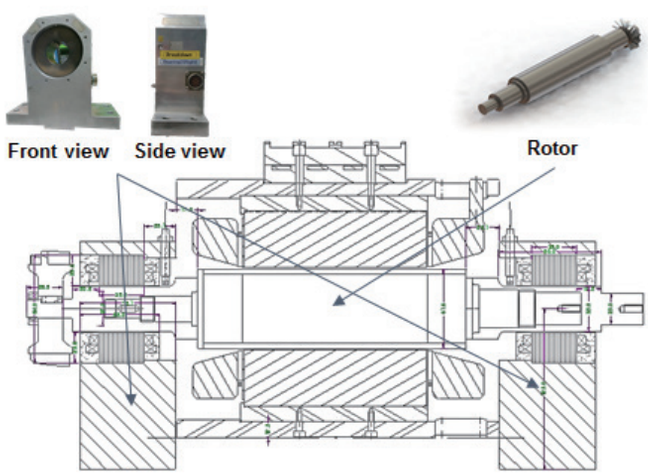
〈Overview of Low-Temperature Thermal Grid〉

20 kW Class high-speed generator and power conversion system for low-temperature waste heat (Dr. Lee, Yong Bok)

- Small scale permanent magnet generator technology for waste heat recovery
- Development of power generator applied reaction steam turbine
- Design and manufacture of HFMB(Hybrid Foil-Magnetic Bearing) considering design variables such as Static load of bearing, Area of pole and Air gap
- Estimation of HFMB's characteristic depending on control variables
- Rated speed : 15,000 rpm(DN number : 525,000)



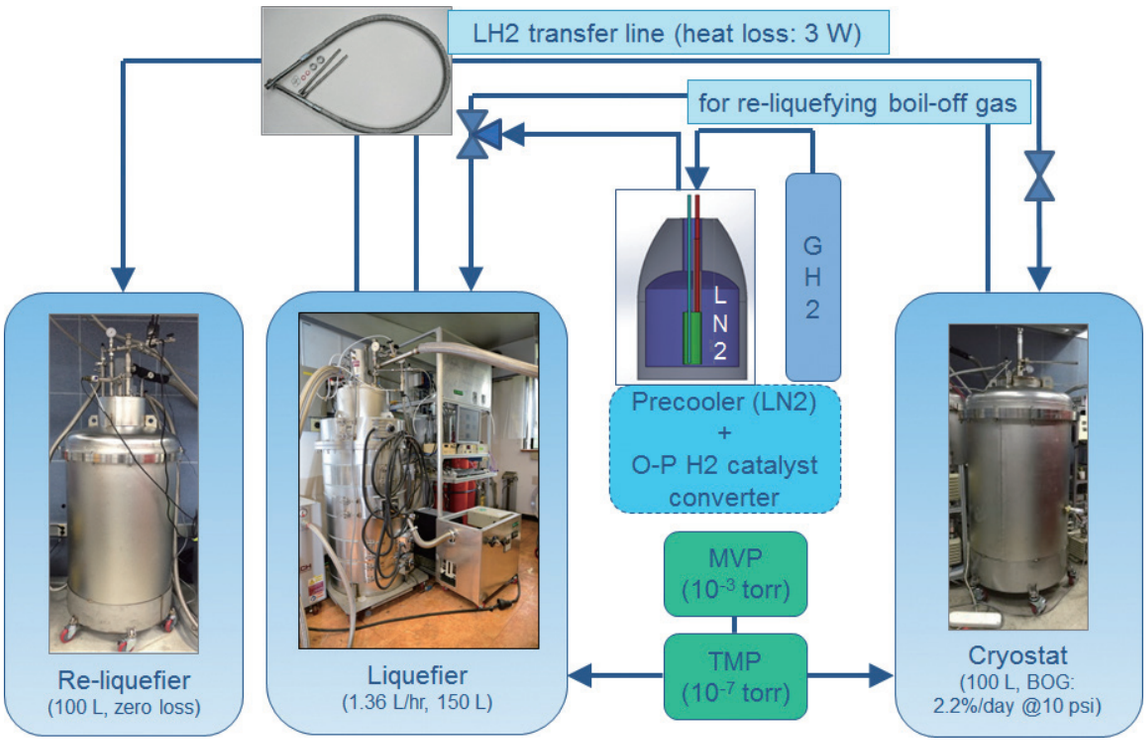
〈Reaction type steam turbine system for waste heat recovery〉



〈HFMB, motor, rotor specific design〉

Hydrogen liquefaction and liquid hydrogen (LH2) storage
(Dr. Karng, Sarng Woo)

- Design, manufacturing, and test of the liquid hydrogen storage vessel with combined technologies of hydrogen permeation protection, super insulation, re-liquefaction
- Hydrogen liquefaction rate: 1.36 L/hr
- Liquid hydrogen storage tank: 100 L scale, BOG 2.2%/day @ 10 psi
- Transfer line for LH2: heat loss 1.5 W/m
- 100 L scale re-liquefying liquid hydrogen storage tank for zero loss



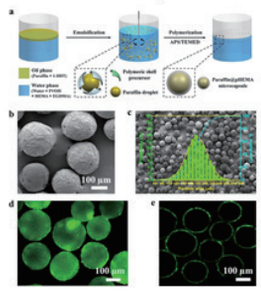
〈Liquefied Nitrogen Tank System〉

Micro- and macro-encapsulation of phase change materials (PCMs) for thermal storage (Dr. Choi, Ung Su)

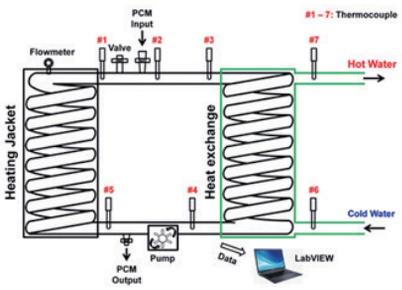
In order to enhance the efficiency of heat transfer fluids, encapsulated phase change materials (PCMs) have been researched as the media for storing and release of a latent heat. We manufactured micro- and macro-PCM capsules using emulsion method and fluidic device based continuous system.

- Latent heat of PCM capsule: 235 J/g
- Thermal conductivity: 0.58 W/m·K
- Heat-exchanger design and manufacturing for estimation of the durability and heat capacity of PCM capsules
- Development of 3~7 mm sized PCM capsule manufacturing system (Continuous system)

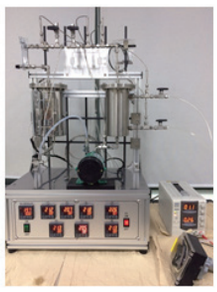
<MicroPCM capsules>



MicroPCM capsules
(Emulsion method)

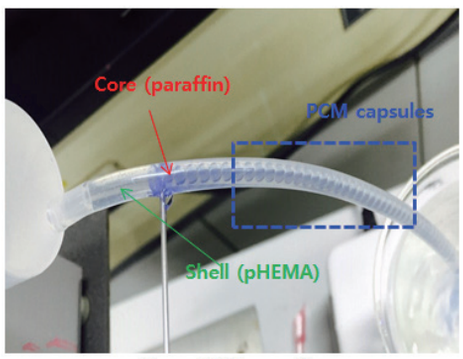


Heat-exchanger design

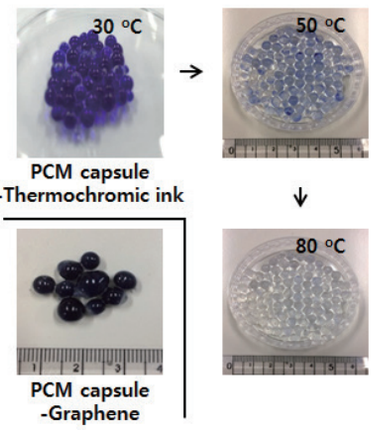


Heat-exchanger

<MacroPCM capsules>



MacroPCM capsules
(Fluidic device based continuous system)

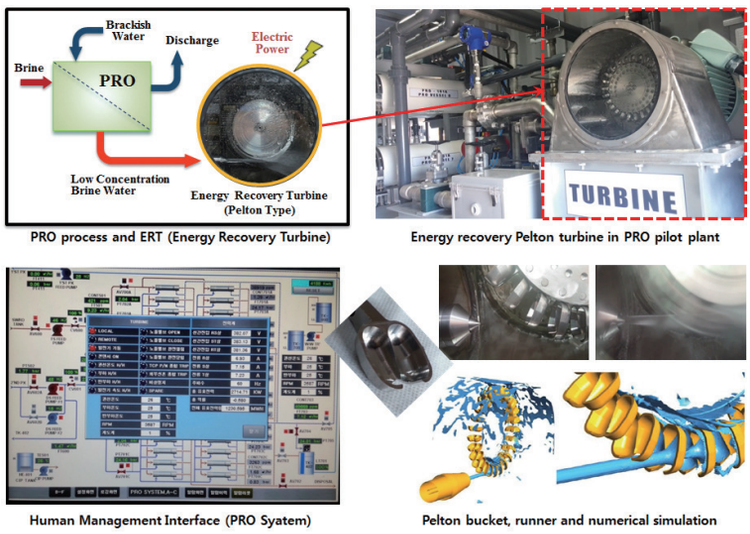


PCM capsule
-Thermochromic ink

PCM capsule
-Graphene

Energy recovery device of PRO process for desalination (Dr. Shin, Youhwan)

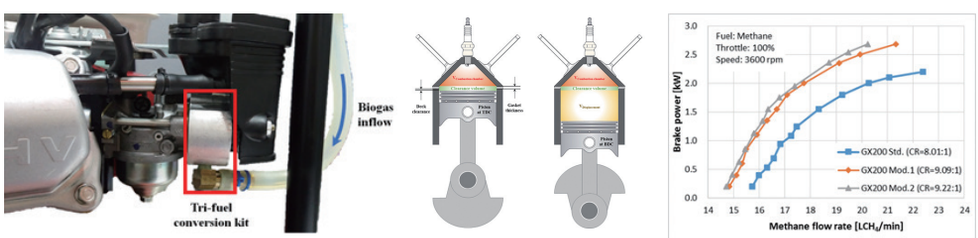
- Development of energy recovery device for PRO (Pressure Retarded Osmosis) system
- Hydro-turbine design, manufacturing and performance estimation for PRO system
- Pilot plant operational conditions for pressure energy recovery (Head: 300 m, Flow rate: 400 ton/day)
- Pelton hydro-turbine design, manufacturing and test facility
- Power generation and performance estimation of Pelton turbine for PRO pilot plant



〈PRO Process for Desalination〉

Biogas-driven power generation (Dr. Choi, Sun)

In order to cope with power shortage in rural areas of developing countries and to reduce greenhouse gas emissions, we are researching the performance of small biogas-fueled internal combustion (IC) engines of which power is intermediate range(less than 5 kW). In particular, the influence of compression ratio on the engine is primarily examined. By decreasing the combustion chamber volume, compression ratio is increased to enhance brake power output, brake thermal efficiency and brake specific fuel consumption (BSFC) of the engine. In addition, as means to examine the effect of the biogas composition on engine performances, various carbon dioxide dilution ratios are under test.



〈Overview of Biogas-driven Power Generation〉

3. Specified results

(1) Achievement Summary

Research Grants [KRW]	4,812,246,230
Publication (SCI, SCIE)	7
Intellectual Property	38
Technology transfer fee [KRW]	–

(KRW 1,150 = USD 1)

(2) Grants

- NRF / Total Management of Contract and Sub Projects / ₩255,000,000 / PI: Karng, Sarng Woo
- NRF / Development of Cryogenic Liquefaction System and Combined Insulation Storage Tank / ₩274,000,000 / PI: Karng, Sarng Woo
- KAIA / Development of Pressure Recovery Device of PRO Process for Desalination / ₩300,000,000 / PI: Shin, Youhwan
- KEIT / Aerodynamic Design of 500RT Class High Efficiency Turbo-Compressor Using Low GWP Refrigerant / ₩200,000,000 / PI: Shin, Youhwan
- Industrial Company / Performance Improvement of Separate-type Regenerative Evaporative Cooler / ₩120,000,000 / PI: Lee, Dae-Young
- KETEP / Development of Solar Thermal Cascade Desiccant Cooling System / ₩150,000,000 / PI: Lee, Dae-Young
- KETEP / Development of Adsorption Hybrid Desiccant Cooling Technology fro 25% Reduction of Energy Consumption Compared to Vapor Compression Cycles / ₩400,000,000 / PI: Lee, Dae-Young
- KIST / Development of Commercialization Technologies for KIST Polymer Desiccant / ₩300,000,000 / PI: Lee, Dae-Young
- KIST / Development of elementary technologies for low temperature-thermal grid / ₩1,963,291,230 / PI: Lee, Yong-Bok
- KETEP / Development of Brush Seals For improvement of Steam Turbine Efficiency for Power Generation / ₩200,000,000 / PI: Lee, Yong-Bok
- KETEP / Driving efficiency maximizing technology development of pump/blower module for energy savings of buildings / ₩120,000,000 / PI: Lee, Yong-Bok
- NRF / Study on the ball bearing cage operated under the extreme environmental condition / ₩275,000,000 / PI: Lee, Yong-Bok
- LIGNex1 / Development of Cooling Systems for Fiber LASER Module / ₩120,000,000 / PI: Choi, Sun
- Small and Medium Business Administration / Development on chelate fibers based on acryl derivative for phosphorous removal / ₩134,955,000 / PI: Choi, Ung Su

(3) Publications

- Y. G. Ko, T. Do, Y. Chun, C. H. Kim, U. S. Choi., and J.-Y Kim, CeO2-covered nanofiber for highly efficient removal of phosphorus from aqueous solution, J. Hazard Mater. 307, 91-98 (2016) (IF=4.836)
- S. Jeong, and Y. B. Lee, Effects of eccentricity and vibration response on high-speed rigid rotor supported by hybrid foil-magnetic bearing, J. MECH. ENG SCI: Proc IMechE 230(6), 994-1006 (2016) (IF=0.730)
- M. Kim, S.-A. Hong, N. Shin, Y. H. Lee, and Y. Shin, Synthesis of strontium titanate nanoparticles using supercritical water, Ceramic International 42 17853-17857 (2016) (IF=2.758)
- M. Kim, B. Y. Lee, H. C. Ham, J. Han, S. W. Nam, H.-S. Lee, J. H. Park, S. Choi, and Y. Shin, Facile one-pot synthesis of tungsten oxide(WO3-x) nanoparticles using sub and supercritical cluids, J. of Supercritical Fluids 42 8-13 (2016) (IF=2.579)
- M. Kim, S.-A. Hong, N. Shin, K. H. Chae, H.-S. Lee, H.-S. Lee, S. Choi, and Y. Shin, Synthesis of manganese oxide microparticles using supercritical water, J. of Supercritical Fluids 112 114-118 (2016) (IF=2.579)
- H. K. Kim, C.-W. Lee, M. Kim, J. H. Oh, S.-A. Song, S.-C. Jang, C. W. Yoon, S. P. Yoon, S. W. Nam, D.-K. Choi, Y.-G. Shul, and H. C. Ham, Preparation of CoMO/Al2O3, CoMO/CeO2, CoMO/TiO2 catalysts using ultrasonic spray pyrolysis for the hydro-desulfurization of 4, 6-dimethyldibenzothiophene for fuel cell applications Int. J. of Hydrogen Energy 41 18846-18857 (2016) (IF=3.205)

(4) Intellectual Property

1) Patents (Registered)

- A low heat loss cryogenic storage equipment using a multi-cylindered support and baffles, KR 10-1643083 (Dr. Sarng Woo Karng)
- A double-tubed heat pipe surrounded by solid nitrogen for a hydrogen liquefier, KR 10-1585825 (Dr. Sarng Woo Karng)
- Purifier with precooling and Ortho-Para hydrogen catalyst converting for hydrogen liquefaction, KR 10-1618338 (Dr. Sarng Woo Karng)
- A low heat loss cryogenic liquid container, KR 10-1643092 (Dr. Sarng Woo Karng)
- Cryogenic Effective Thermal Conductivity Tester of Insulation Material, KR 10-1655906 (Mr. Hyung-Mook Kang)
- Organic Rankine Cycle System, KR 10-0087609 (Mr. Hyung-Mook Kang)

- Heating Method Using Air Heating Device and Air Heating Device Having Reusability, KR 10-1598419 (Dr. Kwang Ho Kim)
- Heat Stored Matetiral Having Heat Energy of Hydration and Its Preparation Method KR 10-1594438 (Dr. Kwang Ho Kim)
- Gas Foil Journal Bearing , KR 10-1638413 (Dr. Chang Ho Kim)
- Variable Pole Permanent Magnet Generator KR 10-1670811 (Dr. Youhwan Shin)
- Heating system using hot water KR 10-1642437 (Dr. Dae-Young Lee)
- Desiccant apparatus, air conditioning apparatus and system having the same US 9383116 (Dr. Dae-Young Lee)
- Desiccant Cooling System KR 10-1655370 (Dr. Dae-Young Lee)
- Solar Desiccant Cooling System KR 10-1594422 (Dr. Dae-Young Lee)
- Oil-Free Turbocharger Assembly US 9322294 (Dr. Yong-Bok Lee)
- Elastic Foundation Using Sandwich Herringbone Plate Gas Foil Bearing KR 10-1622570 (Dr. Yong-Bok Lee)
- Hierarchically Porous Amine-Silica Monolith and Preparation Method thereof KR 10-1597567 (Dr. Ung Su Choi)
- Double Layered Thermal Energy Storage Capsules and Method of Manufacturing the Same KR 10-1666401 (Dr. Ung Su Choi)
- Method for Preparing Metal Ion Coordinated Chelate Adsorbents and the Adsorbents KR 10-1623405 (Dr. Ung Su Choi)

2) Patents (Pending)

- A low heat loss cryogenic liquid container, US 15/096461 (Dr. Sarng Woo Karng)
- Reliquefying Liquid Hydrogen Storage Tank with a Detachable Cryocooler, KR 2016-0035105 (Dr. Sarng Woo Karng)
- Hydrogen Purifier, KR 2016-0035109 (Dr. Sarng Woo Karng)
- Detachable module type cylindrical container for latent heat storage, KR 2016-0073145 (Dr. Sarng Woo Karng)
- Reactor for Thermochemical Heat Storage, KR 2016-0094312 (Dr. Kwang Ho Kim)
- Reactor for Thermochemical Heat Storage, KR 2016-0094313 (Dr. Kwang Ho Kim)
- Gas Foil Journal Bearing , PCT PCT/KR2016/002932 (Dr. Chang Ho Kim)
- Method for Preparing Sodium Manganese Phosphate, Sodium Manganese Phosphate and Sodium Secondary Battery Including the Same KR 2016-0150153 (Dr. Youhwan Shin)
- Cascade desiccant cooling system KR 2016-0091445 (Dr. Dae-Young Lee)
- Multifunction Ventilation Unit US 15/195,049 (Dr. Dae-Young Lee)
- Multifunction Ventilation Unit CN 201610560016.7 (Dr. Dae-Young Lee)
- Solar desiccant cooling system KR 10-1594422 (Dr. Dae-Young Lee)
- Heat recovery device for adsorption heat pumps KR 2016-0114460 (Dr. Dae-Young Lee)
- Active rolling bearing oil seal device having an inclined structure KR 2016-0140937 (Dr. Yong-Bok Lee)
- Bearing Test Apparatus for Testing Behavior of the Bearing KR 2016-0150156 (Dr. Yong-Bok Lee)
- Bearing Test Apparatus Having an Improved Fluid Supplying Device KR 2016-0150157 (Dr. Yong-Bok Lee)
- A Fabrication Method of Print Head for Multiplex Chemotyping Microarray KR 10-2016-0079404 (Dr. Sun Choi)
- Acrylic Fibrous Absorbent Functionalized with Amines and Method of Manufacturing the same KR 2016-0030768 (Dr. Ung Su Choi)

04

Center for Energy Convergence Research

04 Center for Energy Convergence Research

Mission

Development of Green City for Self-Sustainable Energy

The Center for Energy Convergence Research originated from the Electrochemistry Lab, established in 1978. It changed its name to the Center for Energy Convergence Research in the year 2012, with the vision of realizing energy sustainability for Green Cities via energy storage and conversion technologies based on electrochemistry and materials engineering. The Center for Energy Convergence Research conducts basic and applied research for energy storage and conversion technologies related to electric vehicles, large scale energy storage, and portable devices. These research areas can be characterized as crossover technology among electrochemistry technology, nano technology, and processing technology. Major area of our research includes electrode materials for energy conversion/storage systems, electrolytes, rechargeable thin film batteries, clean electroplating, thin film electroplating proceses, environment -related process based on electrochemical techniques, CO_2 conversion technology, carbon materials, portable fuel cell, and other related research topics. It also conducts research on new concepts for energy storage and conversion systems.

Dr. Chung, Kyung Yoo

Head of the Center for Energy Convergence Research

Research Areas

I. Energy research for high performance green buildings

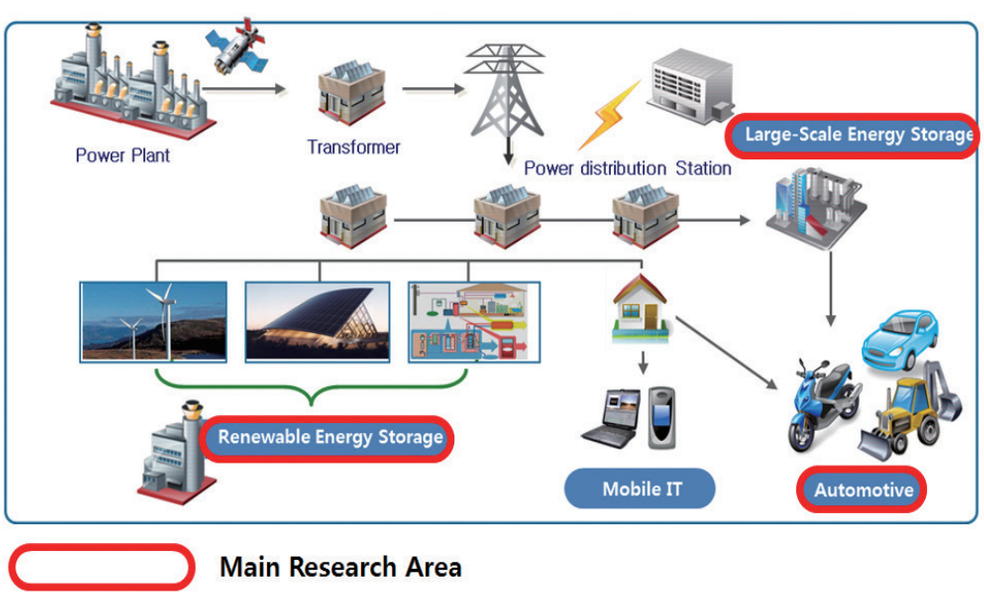
This research area involves the development of medium- and large-scale energy storage systems(ESS) and power control system(PCS) for an efficient use of electrical energy within green buildings. The related research areas not only include conventional rechargeable secondary batteries, but also include brand-new batteries or hybrid batteries for energy storage.

》Rechargeable Lithium batteries
》Sodium ion batteries
》Magnesium batteries
》Lithium sulfur batteries
》Redox flow batteries
》Photovoltaic batteries

II. Energy research for zero-emission vehicles and portable devices

This research area deals with energy storage systems for the transportation purposes such as electric vehicle(EV) and unmanned aerial vehicles(UAV) and for portable electronic devices. For next generation vehicles and device, advanced energy storing technology is needed such as lithium batteries with high capacity, safety and long life.

》High capacity lithium batteries
》Supercapacitors
》Battery recycling technologies
》All solid-state batteries
》Fuel cell vehicles
》Portable fuel cell



Ⅲ. Energy research for human interface technology

Human interfaced electronic devices for the medical and leisure purposes have been growing fast in recent years. This research area covers energy storage systems intended to use such electronic systems. These technologies affect to our lives directly and change the quality of life easily.

》3D Micro batteries
》Thin film batteries
》Electrochromic devices

Ⅳ. Unified energy conversion-storage system a novel concept

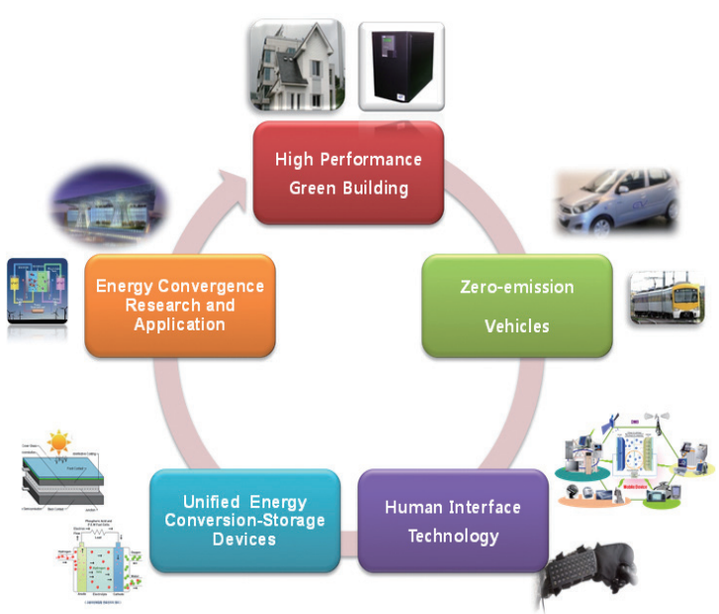
For this research area, energy storage systems based on a novel, innovational concept is desired which is beyond the conventional battery design and concept. By using cutting-edge materials and related catalysts, it is possible to achieve the breakthrough of previous limitation.

》Metal-air batteries
》Conversion-storage materials for photovoltaic energy
》Conversion-storage materials for chemical energy
》Electrocatalysts and carbon materials

Ⅴ. Energy convergence research and application

In this research area, the best and ideal solution of energy-related products or facilities for certain events or given situations are pursued. Integrated technologies for various application can make a synergistic improvement.

》Hybrid batteries
》Total energy solutions
》Electrochemical CO_2 conversion
》Modelling of electrochemical processes



1. Staff

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- Next-generation batteries; Battery materials; Electrochemistry; energy storage materials
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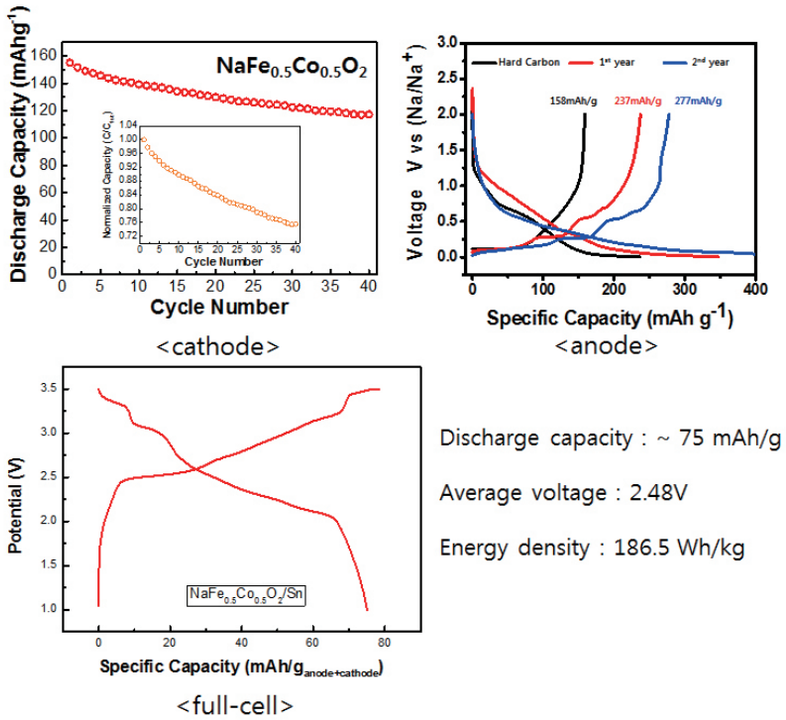
2. R&D Highlights

Development of cathode and anode materials for sodium ion batteries and prototype-cells made of developed electrode materials (Dr. Chung, Kyung Yoon)



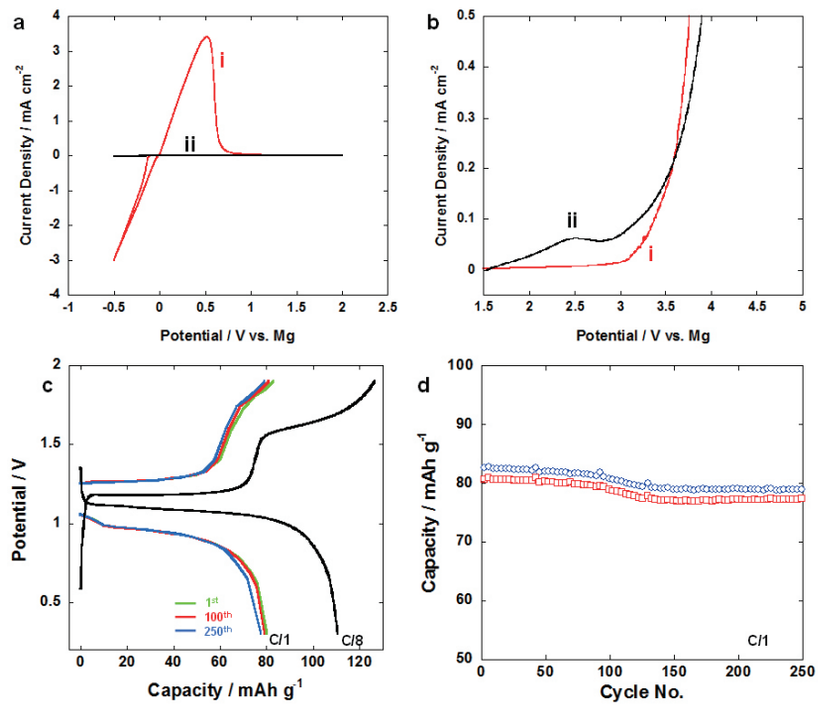
〈The capacity retention of the cathode, charge/discharge curve of anode materials, and the initial charge & discharge curve of the full cell〉

Cathode and anode materials for the sodium ion batteries are developed and the full-cell is fabricated using the developed electrode materials. The cathode developed is $NaFe_{0.5}Co_{0.5}O_2$. It showed well-crystalline R-3m structure. The cathode showed 155 mAh/g during the initial discharge and capacity retention of 76% after 40 cycles. The anode developed is Sn-hard carbon composite. It was synthesized by one-pot solution based synthesis route. The initial discharge capacity was 277 mAh/g and the capacity retention was 76.2% after 40 cycles. We also developed the electrolyte and separators for the sodium ion batteries and its ionic conductivity was 4×10^{-3} S/cm.

The prototype full cell was made of the electrode materials developed. For the anode, Sn metal was used instead of Sn-hard carbon composite. The protoype full cell showed the discharge capacity of 75 mAh/g with average voltage of 2.48V. The energe density of the full cell was calculated to be 186 Wh/kg.

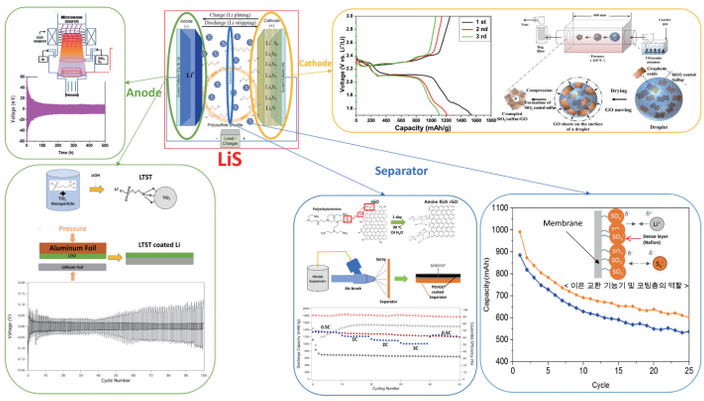
Development of fundamental technology for the next generation battery employing multivalent metal electrodes – Conditioning–free magnesium chloride complex electrolyte for rechargeable magnesium batteries (Dr. Oh, Si Hyoung)

We developed a novel electrolyte solution for rechargeable magnesium batteries through catalytic dissolution of magnesium metal in tetrahydrofuran solvent using anhydrous $CrCl_3$ in the presence of $AlCl_3$ salt. This yields an electrolyte consisting of all inorganic species which are mostly $[Mg_2Cl_3 \cdot 6THF]^+$ cations and $[AlCl_4]^-$ anions. This electrolyte shows almost 100% coulombic efficiency for magnesium electro–deposition and stripping at the negative electrode from the very first cycle on contrary to the conventional MACC electrolyte which requires a lengthy, cumbersome electrochemical pre–cycling called “conditioning process”. This electrolyte also exhibits a highly stable electrochemical window up to 3.1 V, which is equivalent to MACC electrolyte. Thus this approach represents a simple one–pot synthesis route to a MACC–like electrolyte. However, in distinct contrast to MACC, this electrolyte denoted as MaCC does not require a complex electrolytic conditioning due to the high initial Mg to Al content ratio in the electrolyte, which favours reversible Mg deposition.



〈 (a) Cyclic voltammograms (3rd cycle) and (b) linear sweep voltammograms for MaCC (i). The scan rate for the CV was 1 mV s^{-1} and for the LSV, 25 mV s^{-1}. (c) Discharge–charge profiles at the 1st, the 100th, and the 250th cycle and (d) capacity retention of Mg rechargeable batteries with the Chevrel phase cathode at 1C (=128mA g^{-1}) in MaCC 〉

Electrode stabilization and separator optimization for LiS batteries (Dr. Cho, Won Il)



〈Various research approaches for high performance of lithium sulfur battery〉

Stabilization of LiS electrodes and optimization of the separator are proposed in this work. First, stabilization of the anode is crucial in LiS system as the anode is host–less and reactive. Despite number of advantages using Li as anode, Li metal often suffer from its notorious side reactions and dendrites. To resolve these issues, artificial solid electrolyte interfaces (SEI) are created with various materials using two different methods: i) electron cyclotron resonance (ECR) plasma treatment of Li and ii) direct coating of ultrathin nanomaterial artificial SEI film on Li. Using the former method, ~50 nm of protection layer is created on top of the Li. By observing stripping and plating experiment on modified Li symmetric cells, longer cycle life and electrochemical stabilizations are obtained, and coulombic efficiency (CE) of 97.4% is achieved. The latter method utilizes facile coating method and simple nanoparticle functionalization process to create an effective artificial SEI layer directly on lithium surface. As shown above, Li is stably stripped and plated over repetitive cycles for more than 100 times, and no dendrite formation and proliferation are observed. The achieved CE using the latter method in LiS cells is 99.3%. Therefore, effective anode protection is done by applying artificial SEI layers on Li via proposed methods. Moreover, since the major problem is caused from the cathode in LiS system, fabricating sophisticated and stable cathode materials is important. Spray pyrolysis methods is developed to fabricate silica/graphene oxide wrapped nano–sulfur composite for advanced sulfur cathode materials. Utilizing this method not only suppress lithium polysulfide dissolution in the electrolyte but also provide high reversibility of the electrochemical reaction of sulfur. Extremely stable galvanostatic cyclings are obtained using this composite in the cathode, and low overcharge and high C rate performances are achieved. Furthermore, optimization of lithium sulfur separator has been done by modifying the surface of the separators with electrochemically functional groups and active materials. Since shuttling is allowed by transporting lithium polysulfides between the electrode, reutilization rate of dissolved lithium polysulfides can be dramatically increase by creating upper current collector on the separator. Functionalized graphene coatings are created on the separator to attract lithium polysulfides and reutilize over repeated cycles to increase the capacity retention rate. Applying this effect upper current collector, high C rate performance and negligible capacity fading are observed. Also, optimization of the pore structures and the surface of separator surface is established. The optimization of the pore structures is done by varying the polymer solutions, and the surface modification of the separator is done by attaching sulfonate groups to electrostatically repel the dissolved lithium polysulfide. By using this functionalized separator, ionic conductivity of 0.22 mS/cm^2 and lithium transfer number of 0.99 are achieved. Overall, key parts in the LiS battery are developed and studied to make a step forward to develop LiS pouch cells near future.

3. Specified results

(1) Achievement Summary

Research Grants [KRW]	6,506,991,000
Publication (SCI, SCIE)	60
Intellectual Property	40
Technology transfer fee [KRW]	100,000,000

(KRW 1,150 = USD 1)

(2) Grants

- Ministry of Science, ICT and Future Planning / Development of cathode fabrication technology for soft solid state batteries / ₩450,000,000 / PI: Chung, Kyung Yoon
- Ministry of Trade, Industry & Energy / Technology for the electrode materials for low cost flexible microbattery using plating method / ₩162,000,000 / PI: Chung, Kyung Yoon
- KIST / Development of basic sodium secondary battery technologies for beyond lithium ion batteries / ₩885,999,000 / PI: Chung, Kyung Yoon
- Ministry of Trade, Industry & Energy / Multi-layered ceramic coated separator with heat-resistance and improved electrode adhesion (30gf/10mm) for mid-, large-sized secondary batteries / ₩200,000,000 / PI: Chung, Kyung Yoon
- Ministry of Science, ICT and Future Planning / Development of smart electrode synthesis technologies for next generation secondary batteries / ₩55,420,000 / PI: Lee, Joong Kee
- Ministry of Science, ICT and Future Planning / Development of technologies for tailoring self-relaxed structures and controlling interfacial characteristics for the electrode in lithium ion batteries/ ₩320,000,000 / PI: Lee, Joong Kee
- Ministry of Science, ICT and Future Planning / Development of basic and core technologies for novel cathode and electrolyte for lithium secondary batteries and novel secondary battery system / ₩580,000,000 / PI: Cho, Byung Won
- Ministry of National Defense / Development of new concept metal-air battery / ₩101,870,000 / PI: Cho, Byung Won
- Ministry of Trade, Industry & Energy / Metal surface treatment technology and welding analysis for the next generation LiB capacitor ass'y / ₩200,000,000 / PI: Cho, Won Il
- Ministry of Science, ICT and Future Planning / Developing core technologies and pouch cell fabrication techniques for 260 Wh/kg Li metal batteries / ₩500,000,000 / PI: Cho, Won Il
- KIST / Development of Li-S battery core-technology and pouch cell / ₩1,055,232,000 / PI: Cho, Won Il
- Ministry of Trade, Industry & Energy / Development of technology for evaluating degradation and life prediction of vessel ESS / ₩130,000,000 / PI: Cho, Won Il
- Ministry of Trade, Industry & Energy / Development of ion selective membranes for redox flow batteries for use in energy storage systems / ₩250,000,000 / PI: Ha, Heung Yong
- Ministry of Science, ICT and Future Planning / Mineralization by Electrochemical CO_2 conversion using brine water / ₩350,000,000 / PI: Ha, Heung Yong
- KIST / Development of fundamental technology for the next-generation battery employing multivalent metal electrode / ₩1,066,470,000 / PI: Oh, Si Hyoung
- KIST / A study on the reaction and degradation mechanism of electrode materials for secondary batteries by using in-situ electron microscopy analysis / ₩100,000,000 / PI: Chang, Wonyoung
- KIST / Development of advanced materials for next-generation batteries / ₩100,000,000 / PI: Jung, Hun-Gi

(3) Publications

- Y. R. Lim, C. S. Jung, H. S. Im, K. Park, J. Park, W. I. Cho, and E. H. Cha, Zn_2GeO_4 and Zn_2SnO_4 nanowires for high-capacity lithium- and sodium-ion batteries, *J. Mater. Chem. A.,* 4(27), 10691-10699 (2016) (IF = 8.262)
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(4) Intellectual Property

1) Patents (Registered)

- Cathode active material comprising lithium manganese borate compound, lithium-ion secondary battery comprising the same and the prepration method thereof, KR 10-1637925 (Dr. Chung, Kyung Yoon)

- Cathode active material for sodium ion battery, and preparation process thereof, KR 10-1677535 (Dr. Chung, Kyung Yoon)

- Gel polymer based electrolyte and secondary battery comprising the same, KR 10-1677537 (Dr. Chung Kyung Yoon)

- Preparation method for micro-patterned transparent conductive oxide film and electrochromic window including thereof, KR 10-1589635 (Dr. Lee, Joong Kee)

- Direct synthesis of ZnO-MnO-carbon nano-composite materials for lithium secondary battery, KR 10-1632358 (Dr. Cho, Won Il)

- Method and apparatus for simultaneous controlling of fuel concentration by sensor-less and voltage amplitude-control based feed-back control, liquid fuel cell apparatus using the same, KR 10-1670727 (Dr. Ha, Heung Yong)

- Methods to fabricate 3-dimensional carbon nanotubes and the methods to fabricate non-noble electrocatalysts using the same, KR 10-1584170 (Dr. Ha, Heung Yong)

- Devices and methods of the concentration of reactant in a circulating liquid fuel without using a mechanical sensor, KR 10-1635728 (Dr. Ha, Heung Yong)

- Method for preparing spinel lithium manganese oxide with Li-ion conducting spinel oxide coating layer and the material for rechargeable lithium batteries, KR 10-1663621 (Dr. Oh, Si Hyoung)

- Spinel lithium manganese oxide with Li-ion conducting fluorine-doped metal oxide coating layer for rechargeable Li-ion battery and its preparation method, KR 10-1670664 (Dr. Oh, Si Hyoung)

- Solid electrolyte coated cathode materials for lithium ion battery, KR 10-1600476 (Dr. Choi, Won Chang)

- Silicon thin film electrode based on conducting carbon layer, KR 10-1654047 (Dr. Choi, Won Chang)

- Transition metal oxide coated cathode materials for lithium ion battery, KR 10-1588362 (Dr. Choi, Won Chang)

2) Patents (Pending)

- Anode material, secondary battery comprising the same, and the preparation method thereof, KR 2016-0094785 (Dr. Chung, Kyung Yoon)

- A sample supporting device for transmission mode X-ray diffractometry system and transmission mode X-ray diffractometry using thereof, KR 2016-0041693 (Dr. Chung, Kyung Yoon)

- Furnace for transmission mode X-ray diffractometer and transmission mode X-ray diffractometer using thereof, US 15/099678, KR 2016-0007916 (Dr. Chung, Kyung Yoon)

- Surface coated cathode material, method of preparing the same and secondary battery using the same, KR 2016-0004490 (Dr. Chung, Kyung Yoon)

- New concept metal-air fuel cell and the preparation thereof, KR 2016-0162990 (Dr. Cho, Byung Won)

- Preparation method of silicon oxycarbide compound for silicon oil precursor containing phenyl group and it employment for anode of lithium ion batteries and lithium ion capacitor, KR 2016-0064901 (Dr. Lee, Joong Kee)

- Self-relaxant ladder structure inspired high performance cathode material for lithium-sulfur battery, KR 2016-0069516 (Dr. Lee, Joong Kee)

- Preparation of large-area graphene sheet without the etching and transfer process by using fullerene (C_{60}) precursor, KR 2016-0034183 (Dr. Lee, Joong Kee)

- Preparation method for transparent heating glass and transperant heating film thereof, KR 2016-0094034 (Dr. Lee, Joong Kee)

- Facile fabrication and transfer of carbon and ceramic ultrathin films for lithium metal anode and battery with it and preparation method, KR 2016-0141707 (Dr. Cho, Won-Il)

- The method to synthesize the electrolytes containing organic additives and the redox flow batteries using the same, KR 2016-0084821 (Dr. Ha, Heung Yong)

- Electrolytes containing crown ether and its derivatives additives for redox flow batteries, KR 2016-0081151 (Dr. Ha, Heung Yong)

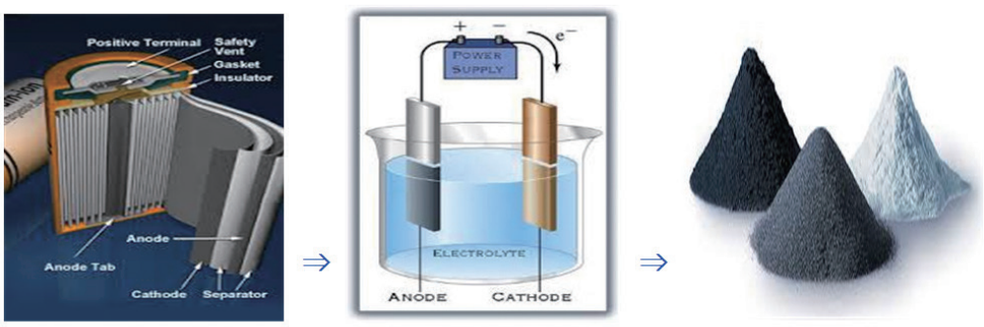
- Carbon materials having porous nanostructures on their surfaces and the fabrication methods thereof, US 15/335775 (Dr. Ha, Heung Yong)
- Electrowinning method of tellurium from acidic solutions, KR 2016-0003899 (Dr. Lee, Hwa Young)
- Inorganic particle coated carbon felts and method thereof, KR 2016-0050910 (Dr, Kim, Chang Sam)
- Cathode material for rechargeable magnesium batteries and rechargeable magnesium batteries comprising the same, KR 2016-0153213 (Dr. Oh, Si Hyoung)
- Passive emergency power source system for the nuclear power plant using self-activating magnesium-seawater battery, KR 2016-0049511 (Dr. Oh, Si Hyoung)
- Method for preparing a cathode containing polydimethylsiloxane, which acts as an efficient HF scavenger during the electrochemical cycling at the elevated temperature, KR 2016-0016154 (Dr. Oh, Si Hyoung)
- Synthesis of SiOC-Sb composite materials by employing silicon oil and antimony powders for anodes in sodium ion battery, KR 2016-0073923 (Dr. Choi, Won Chang)
- Coating of phosphate-based solid electrolyte on cathode material in lihium ion batteries, KR 2016-0018167 (Dr. Choi, Won Chang)
- Silicon type active material for lithium secondary battery and manufacturing method therof, US 15/149520 (Dr. Chang, Won Young)
- Preparation of porous carbon-silicon complex nanospheres for anode active materials in secondary battery, and the method thereof, KR 2016-0104919 (Dr. Jung, Hun-Gi)
- Producing method of TiO_2 composite powder using the same, negative active material and secondary battery including battery including produced TiO_2 composite powder, KR 2016-0053161 (Dr. Jung, Hun-Gi)
- Catalysts for degradation of hydrogen peroxide fume and the preparation method, KR 2016-0148320 (Dr, Nah, In Wook)
- Surface modified catalyst for exchanging ortho- hydrogen to para- hydrogen and its preparation method, US 15/258143 (Dr. Nah, In Wook)
- Analysis system of ortho- and para- hydrogen and its method, KR 2016-0105018 (Dr. Nah, In Wook)

(5) Technonlogy Transfer

Name of the Transferred Technology	Loyalty[KRW]	P.I.
Electro-reduction extraction of cobalt from cathodic active material of lithium battery	100,000,000	Lee, Hwa Young

》Overview of Transferred Technology
- Decomposition of Active Materials in Lithium Battery with Electro-reduction Method
- Separation and Recovery of Cobalt from Active Materials and Preparation of High-Purity Compounds

》Expectation Effect
- Contribution to Urban Mining Industry and Facilitation of Lithium Battery Recycling
- Cost Reduction in Manufacture of Lithium Battery



〈Raw Material〉 〈Electro-reduction〉 〈Products〉

(6) Presentation

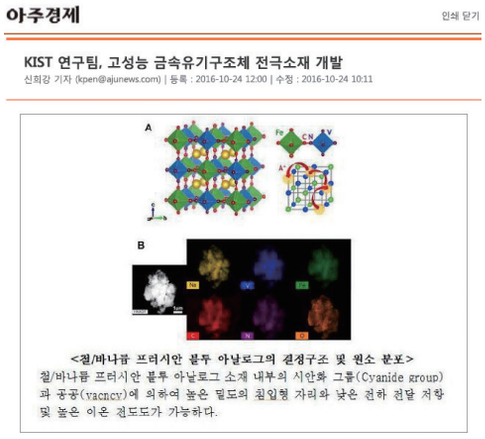
Conference/Symposium	Titles	Date	Speaker
Smart Materials-2016	$FeF_3 \cdot 0.5H_2O$-coupled Reduced Graphene Oxide as a Composite Cathode Material with High Sodium Storage Capacity and Long-term Cycling	March 5, 2016	Dr. Chung, Kyung Yoon Invited Speaker
ENM Spring Meeting 2016	Borate based cathode materials for lithium-ion batteries	March 8, 2016	Dr. Chung, Kyung Yoon Invited Speaker
2016 Spring Meeting of the Korean Battery Society	Iron based high-capacity cathode materials for sodium rechargeable batteries	May 12, 2016	Dr. Chung, Kyung Yoon Invited Speaker
252nd American Chemical Society National Meeting & Exposition	Iron fluoride nanoparticles as a high-capacity cathode for sodium-ion batteries	August 23, 2016	Dr. Chung, Kyung Yoon Invited Speaker
PRiME 2016	Investigation of the Reaction & Degradation Mechanism of Iron Based Cathodes for Sodium-ion Batteries Using X-ray Absorption and Time-Resolved X-ray Diffraction Techniques	October 6, 2016	Dr. Chung, Kyung Yoon Invited Speaker
Materials Research Society, Fall Meeting 2016, Boston, USA	Excellent electrocatalytic activity of Sn on carbon felt and graphite felt for all-vanadium redox flow batteries	November 27, 2016	Dr. Ha, Heung Yong Invited Speaker
2016 Korean Battery Symposium, KAIST, Daejon	Recent advances in rechargeable batteries employing multivalent metal electrodes	August 19, 2016	Dr. Oh, Si Hyoung Invited Speaker
The Korean Electochemical Society, Gwang-Ju	Application of lithium titanate ($Li_4Ti_5O_{12}$) as negative electrode for high power batteries	April 7, 2016	Dr. Jung, Hun-Gi Invited Speaker

(7) Research Activities

- Dr. Kyung Yoon Chung served as a committee member for the planning of "Mission Innovation Roadmap: Energy Storage System" conducted by multiple ministries of government
- Dr. Joong Kee Lee has served as president for Korean Battery Society for 2016.01 ~ 2016.12
- Dr. Hwa Young Lee has served as an auditor for Korea Institute of Resources Recycling for 2015.01 ~ 2016.12
- Dr. Si Hyoung Oh has served as an editorial board member for the journal, Scientific Reports.
- Dr. Wonyoung Chang has served as a battery committee member for the Corrosion Science Society of Korea for 2016.01 ~ 2016.12.

(8) Raising Public Awareness

- Aju Business Daily, October 24, 2016
- Digital Times, October 25, 2016



아주경제

인쇄 닫기

KIST 연구팀, 고성능 금속유기구조체 전극소재 개발

신희강 기자 (kpen@ajunews.com) | 등록 : 2016-10-24 12:00 | 수정 : 2016-10-24 10:11

<철/바나듐 프러시안 블루 아날로그의 결정구조 및 원소 분포>
철/바나듐 프러시안 블루 아날로그 소재 내부의 시안화 그룹(Cyanide group)과 공공(vacancy)에 의하여 높은 밀도의 침입형 자리와 낮은 전하 전달 저항 및 높은 이온 전도도가 가능하다.

디지털타임스

2016년 10월 25일 화요일

IT·과학 10면

KIST, 에너지 저장 1.5배↑ 이차전지 전극소재 개발

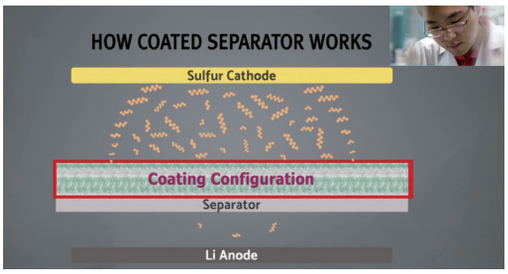
국내 연구진이 잔류난 해결 수단으로 주목받고 있는 '에너지저장시스템(ESS)'에 활용할 수 있는 저비용·고효율 이차전지 전극 소재를 개발했다.

한국과학기술연구원(KIST) 에너지융합연구단 정경윤 박사(사진) 팀은 금속유기구조체 소재 중 하나인 '프러시안 블루 아날로그' 구조를 기반으로 철과 바나듐 전이금속을 도입한 새로운 전극 소재를 개발했다고 24일 밝혔다.

금속유기구조체는 유기 결합 분자에 금속이온이 결합된 3차원 결정구조체로, 내부에 수많은 나노 기공이 있다. 연구팀이 개발한 철·바나듐 프러시안 블루 아날로그 소재는 비용은 낮고 수율은 높은 공법으로 개발됐으며, 기존 값은 소재와 비교해 에너지 저장용량이 150% 이상 높다. 또 높은 충·방전 효율과 출력 특성을 실험을 통해 확인했다. 남도영기자 namdo0@

〈Development of electrode materials which can increase the energy density up to 150% by applying Fe–CN–V based metal–organic frameworks(MOFs) as new electrode material (Dr. Chung, Kyung Yoon)〉

- Arirang TV, December 2, 2016



〈Development of new coating technology: The separator coating for the high performance of Li–S batteries (Dr. Cho, Won Il)〉

05

2016 News & Events

05 News & Events

1. People

2016 New Faculties

Name Oh, Youngtak

Position Senior Research Scientist

Department Center for Environment, Health, and Welfare
Korea Institute of Science and Technology, Hwarangno 14-gil 5, Seongbuk-gu, Seoul, 136-791, Korea

Tel +82-2-958-6806

E-mail ytoh@kist.re.kr

〉〉 Education

2003 – 2007 : Loyola University, USA
B.S., Chemistry

2007 – 2012 : Northwestern University, USA
Ph.D., Chemistry

Advisor : Professor, Mercouri G. Kanatzidis

〉〉 Employment & Experience

2016 – Present : Senior Research Scientist, Center for Environment, Health, and Welfare
Korea Institute of Science and Technology, Korea

2012 – 2016 : Postdoctoral, Department of Material Science and Engineering
Korea Advanced Institute of Science and Technology, Korea

〉〉 Selected Publications

1. Y. Oh, J.O. Hwang, E.-S. Lee, M. Yoon, Y.-H. Kim, D.H. Kim, S.O. Kim; Divalent Fe Atom Coordination in Two-Dimensional Microporous Graphitic Carbon Nitride, ACS Appl. Mater. Interfaces, 2016, 8, 25438

2. Y. Oh, V.-D. Le, N.M. Uday, J.O. Hwang, W.J. Park, J. Lim, K. Lee, Y. Bae, Y.-H. Kim, S.O. Kim; Selective and regenerative carbon dioxide capture by highly polarizing porous carbon nitride, ACS Nano 2015, 9, 9148

3. Y. Oh, C.D. Morris, M.G. Kanatzidis; Polysulfide chalcogels with ion-exchange properties and highly efficient mercury vapor sorption, J. Am. Chem. Soc. 2012, 134, 14604

Transference

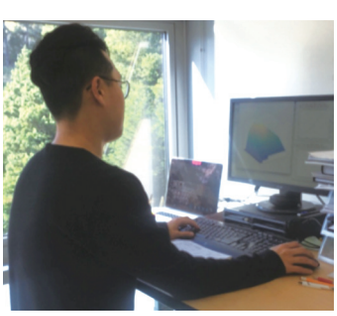
Dr. Oh, In-Hwan was appointed as new President of the Green Technology Center

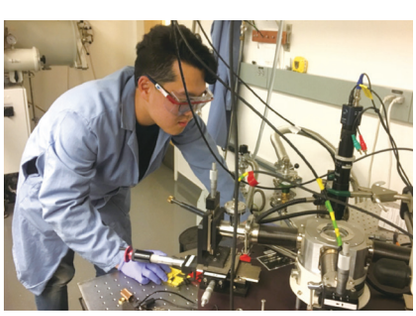
- June 16, 2016
- Dr. Oh, In-Hwan, former Director-general of the Green City Technology Center, was appointed as the Center's second President.

Training & Sabbatical Leave

Mr. Kang, Hyungmook started his doctoral course at University of California at Berkeley, and has been on a training leave from KIST.

He is majoring a heat transfer at the department of mechanical engineering with huge interests on energy science and technology. Professor Chris Dames advises his research on a topic of thermal rectification. A thermal rectifier is the heat-transfer analogue of the familiar electrical diode: a two-terminal device that transmits heat more easily in one direction than in the reverse direction. He is mainly involved in collaborative projects with Lawrence Berkeley National Lab (LBNL) and gets a position of graduate student research assistant under a co-advisor Jeff Urban in LBNL. He has a special interest on theoretical analysis and methodology for heat transfer, such as Molecular Dynamics and First Principles. Nowadays, He is preparing a preliminary exam (known as a kind of written qualifying exams) in early 2017.





Dr. Kim, Sang Ok received his doctoral degree in Materials Science and Engineering from the University of Texas at Austin in August, 2016.

Lithium-ion batteries are the dominant energy storage technology in portable electronics because of their high energy density, long cycle life, and low self-discharge rate. Efforts to extend their implementation into rapidly emerging electric vehicles and large-scale stationary energy storage systems require further advancements of performance and safety, as well as cost reduction. Therefore, the research on low-cost, high-performance electrode materials for next generation lithium- or sodium-ion batteries is being actively performed to meet these requirements. During the study period, several types of composite alloy-based anodes are developed by a low-cost and scalable method for the enhancement of lithium- or sodium-storage performance. Alloy anodes offer high theoretical specific capacity and high operating voltage, thereby showing great potential for realization of high-performance lithium- or sodium-ion battery systems. However, the large volume change of electrode materials upon electrochemical reactions results in low charge-discharge efficiency and severe capacity fading, making their implementation quite challenging. Aiming at overcoming this issue, the alloy-based composites are synthesized by employing the active/inactive matrix concept. The composites developed in this work possess high structural stability through a durable mechanical buffer, enhanced electrochemical reversibility through nanoscale active materials, as well as high conductivity and facile electron/ionic transport through a conducting phase. By controlling the type and amount of an inactive matrix, the effects of each inactive matrix on the electrochemical performance of the alloy-based composite anodes are investigated and the mechanism for the performance improvement is also examined.• Lab tour in L4 building and field tour in soil and wastewater treatment sites

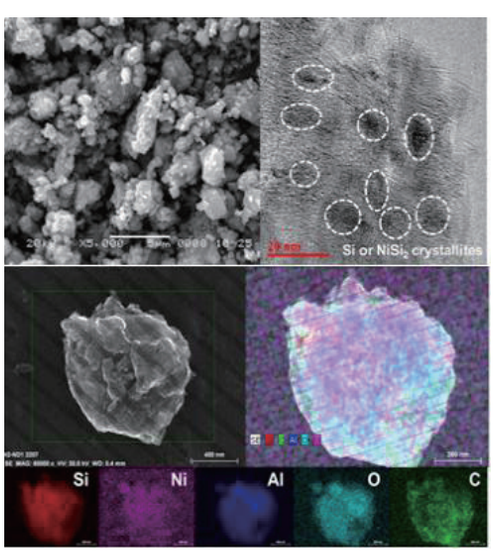


Fig.1 Electron microscope images of Si-based composite anode materials

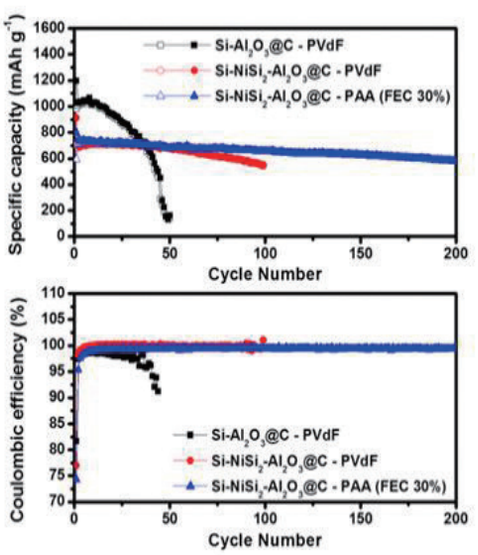


Fig.2 Cyclability and corresponding Coulombic efficiency of Si-based composites with and without the inactive matrix

2. Conference

Green Forum 2016

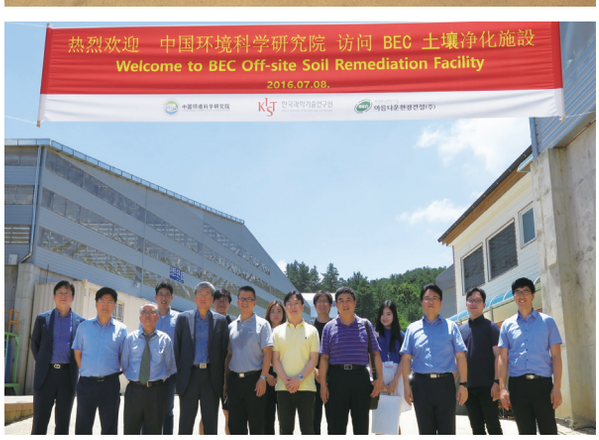
- April 27, 2016, at KIST
- Organized by the Green Forum committee
- Featured lecture
  - Lecture title: 3,000-Hour Rule for Research
  - Lecturer: Dr. Oh, In-Hwan (Director-general of the Green City Technology Center)
- Discuss how we can Conduct research through our fall efforts and devotion

The 3rd International Energy and Environment Conference (IEEC)

- October 26, 2016, Convention Hall, International Cooperation Building, KIST
- Organized by the Green City Technology Institute
- To exchange scientific views on the current state of climate change and environmental protection

KIST-CRAES Joint Workshop

- July 5-8, 2016, International Cooperation Building, KIST
- Organized by the Center for Water Resource Cycle
- Six delegates, including the vice president from the Chinese Research Academy of Environmental Sciences (CRAES)
- Three plenary presentations, four technical presentation, and a discussion session for the collaboration between KIST-CRAES
- In-depth discussions on the KIST-CRAES partnership for world-leading research in water and soil environments
- Lab tour in the L4 building and field tour at soil and wastewater treatment sites



3. Cooperation Program

MOU between KIST and the Cornell University

- June 16, 2016,
- Organized by Center for Energy Convergence Research
- To facilitate international academic exchange, to develop academic and scientific relationships, and in support of collaborate research activities Cornell Univ. and KIST

Contract Signing Ceremony for Transfering Virus Disinfection Technology to WoojungBSC Inc.

- October 31, 2016, Reception Room, Administration Building, KIST
- A ceremony to sign a technology transfer contract for (MERS) virus disinfection technology between GCTI and WoojungBSC Inc.

MOU between KIST and the Tancheon Water Recycling Center

- November 2, 2016, Reception Room, Administration Building, KIST
- Organized by the Center for Water Resource Cycle
- A ceremony to sign an MOU on research collaboration water recycle, water-energy nexus, smart operation systems, and micropollutant removal

Contacts & Map

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Science and Technology