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DEPARTMENT OF ENERGY SCIENCE

[Energy Distinguished Lecture Series]

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Towards a Sustainable Society: Greenhouse Gas Mitigation and Clean Hydrogen Production

N Center #86120, Sungkyunkwan University, Suwon

Dr. Whi Dong Kim

KITECH

Abstract

The urgent need to mitigate climate change has driven the development of innovative technologies that reduce greenhouse gas emissions and enable the production of clean fuels. Our research focuses on two primary areas: advanced liquid metal-based processes and photocatalytic systems, both aimed at achieving carbon neutrality.

For **greenhouse gas mitigation**, we focus on several independent approaches. First, liquid metal technologies are applied to remove fluorinated greenhouse gases (F-gases), a major contributor to global warming, from semiconductor manufacturing processes. This method provides a scalable and energy-efficient solution to significantly reduce F-gas emissions. Second, liquid metal is utilized for the conversion of CO_2 into either CO or solid carbon, offering a practical pathway for carbon capture and utilization in industrial applications. Methane dry reforming (DRM) is investigated using two innovative approaches to reduce greenhouse gases and produce syngas, a valuable industrial feedstock. Photocatalytic DRM employs photochemical reactions to facilitate the conversion of CO_2 and CH_4 into syngas under mild conditions, leveraging the advantages of solar energy. In parallel, liquid metal-based DRM is explored to enhance reaction efficiency and scalability for industrial implementation.

In the area of **clean hydrogen production**, we pursue two complementary methodologies. The first involves methane pyrolysis using liquid metal as a catalyst to produce turquoise hydrogen, with solid carbon as a byproduct. This approach leverages the existing natural gas infrastructure, enabling rapid and large-scale supply of clean hydrogen, which is critical for meeting immediate energy demands. The second focuses on photocatalytic systems for green hydrogen production through water splitting. Our research emphasizes the development of scalable hydrogen production modules utilizing large-area photocatalytic films, paving the way for commercialization and sustainable energy deployment.

Brief Bio

Dr. Whi Dong Kim is a Principal Researcher at the Korea Institute of Industrial Technology (KITECH), where he has worked since 2021. He earned his Ph.D. in Chemical Engineering from KAIST (2016) and was a Postdoctoral Associate at Los Alamos National Laboratory (LANL). At KAIST and LANL, his research centered on the optical and charge-carrier dynamics of semiconductor nanocrystals, which he applied to photocatalytic green hydrogen production and CO2 conversion. Building on this foundation, his work at KITECH has extended consistently into thermochemical pathways for green and turquoise hydrogen production and CO2/F-gas mitigation using liquid-metal reactor platforms. He leads national R&D programs on methane pyrolysis, CO2 reduction, and molten-metal-based greenhouse gas decomposition. He has authored 54 SCI-indexed publications, holds 10 registered patents, and has an H-index of 25.

Department of Energy Science, SKKU

Center for fostering renewable energy integrated system researcher, SKKU