I²CNER Seminar Series

International Institute for Carbon-Neutral Energy Research (WPI-I²CNER)
Kyushu University

Title

CO_2 Sorption/Reduction Systems for Direct Air Capture/Utilization

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Abstract

Carbon dioxide removal (CDR) is a new concept for removing CO_2 from the atmosphere. Direct air capture (DAC) is an important CDR technology which removes ultralow concentrations of CO_2 (~ 400 ppm) from the air. On the other hand, CO_2 capture and reduction with H_2 (CCR), which has been recently studied in catalysis community, targets at capturing high concentration CO_2 from combustion exhaust gas and then converting it to CO or CH_4. Several dual functional materials (DFMs) for CCR have been reported, but to the best of our knowledge, the CCR of CO_2 from the air has not yet been reported. In this study, the CCR system and a membrane DAC were combined to demonstrate the first example of direct air capture and utilization (DAC-U) for continuous production of CH_4 or CO from the air.

The screening tests for model CCR system showed that Ni nanoparticle (NP) on Ca-loaded Al_2O_3 (Ni-Ca/ Al_2O_3) was the best DFM for methanation. Pt NPs on Na-loaded Al_2O_3 (Pt-Na/Al_2O_3) was the best DFM for CO formation. In the DAC-U system, a membrane DAC module was connected to a vacuum pump, and the outlet of the pump was connected to the CCR system via a water trap. The DAC unit feeds approximately 2000 ppm CO_2 to the CCR unit. The CCR system consists of parallel double fixed-bed flow reactors (A and B) at 350℃ and timer-controlled 4-way valves. Each reactor contains 0.5 g Ni-Ca/ Al_2O_3. CO_2 (2000ppm)/air mixture was fed to the reactor A for 60 s, while H_2 was fed to the reactor B for 60 s. Then, the inverse gas was fed to each reactor by simultaneously switching the two 4-way valves. During a long-term (6000 min) DAC-U operation, the system continuously captured CO_2 in the air and converted it to CH_4 with the repetition of a few thousand cycles of CCR operation. Continuous and selective production of ca 2000 ppm CO from the air was demonstrated using a similar DAC-U system with a Pt-Na/ Al_2O_3 catalyst.

Similar sorption/reduction systems for CH_4 production from 10% CO_2/10% O_2 mixture and NH_3 production from 0.1% NO/10% O_2 mixture will be introduced.

About the Speaker

Prof. Kenichi Shimizu has been a full Professor in Institute for Catalysis at Hokkaido University since 2015. He has been a director of Institute for Catalysis since 2022. He received his Ph.D. degree at Nagoya University in 2000. He began his career as a Research Associate at Niigata University in 2000, then moved to Nagoya University in 2004 as an Assistant Professor, and then moved to Hokkaido University as an Associate Professor in 2010. His main interest is in heterogeneous catalysis for sustainable chemical transformations and emission control. He also works for in situ spectroscopies and catalysis informatics for molecular level design of heterogeneous catalysis.

Registration https://zoom.us/webinar/register/WN_5FhYzLW1ReqsJCOuHCC9aw

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