Sustainable Production Scheme of Water-Electricity-Ammonia in the Dead Sea Basin

Principal Investigator: Takaya Ogawa
Institution: Kyoto University, Yoshida-Honmachi, Sakyo-ku, Kyoto, Japan 606-8501
TEL&FAX +81-75-753-5488
E-mail: ogawa.takaya.8s@kyoto-u.ac.jp
Cooperated by: Water, Energy and Environment Center, The University of Jordan

[Abstract]

We proposed a Water-Electricity-Ammonia (WEA) scheme that produces freshwater, electricity, and ammonia simultaneously. We investigated its economic when the scheme is operated in the desert below 0 m above sea level around Dead sea Basin in Jordan by using a large amount of sunlight and seawater brought in infinitely by potential energy. This scheme is expected to improve economic efficiency by using waste heat in each process for other productions, reducing the total number of processes based on simultaneous production, and converting electricity into high value-added drinking water and ammonia in the desert.

Based on the simulation results with models using ASPEN Plus©,[1] the economic rationale is likely to be valid at the price of ammonia and water in Jordan, and a certain scale of photovoltaics (PV) capacity, although subsidies for existing electricity are required. In addition, the ammonia synthesis catalyst developed in Japan in recent years was shown to be promising for cost reduction in the case of operation using storage batteries, etc., without existing electricity subsidies. The WEA scheme was simulated not only to Jordan but also to other regions, showing that CO_2 emissions can be reduced by optimizing the allocation of PV power to water, electricity, and ammonia production, even if the region is extremely landlocked or in high altitudes, thus demonstrating that the scheme is versatile.[2] Furthermore, we experimentally demonstrated that hydrogen storage capacity halves the activation energy of ammonia synthesis reaction. This is as an important property of ammonia synthesis catalysts, which are undergoing remarkable development. This is a finding that expands the selection criteria for catalyst development.[3,4]

Key Words: Photovoltaics, Desalination, Ammonia synthesis, Dead Sea, Water-Energy-Food Nexus, Economic rationality, Reduction of environmental damage

[References]

1) Yoshida, M.†; Ogawa, T.†; Imamura, Y.; Ishihara, K. N., Int. International Journal of Hydrogen Energy, 46, 28840-28854. (2021) （IF: 5.816） †Equal contribution
Economies of Scale in Ammonia Synthesis Loops Embedded with Iron- and Ruthenium-Based Catalysts.

2) Ogawa T.; Imamura Y.; Yoshida M.; Ishihara N. K.; Fukuhara R.; Shammout W. M.; Shatanawi, R. M.; Yamasue E.; ChemRxiv, (2022) (https://doi.org/10.26434/chemrxiv-2022-2fh88)
“Life Cycle Assessment of CO_2 emission from Multigeneration of Water-Electricity-Ammonia Scheme using Sunlight in arid/semi-arid region and Seawater through Pipeline.”

3) Morimoto, R.†; Ogawa, T.†; ChemRxiv, (2022) (https://doi.org/10.26434/chemrxiv-2022-gqq4q) †Equal contribution
“The microkinetics of ammonia synthesis: the effect of surface coverage on apparent activation energy and reaction order”

4) Torii, K.†; Ogawa, T.†; Morimoto, R.; Seno, T.; Okumura, H.; Ishihara, K. N., ChemRxiv, (2021) (https://doi.org/10.26434/chemrxiv.13650359.v1) †Equal contribution
“Low Apparent Activation Energy of Ammonia Synthesis over Ru Catalyst Supported by Hydrogen Storage Material.”