Press Release

Keio University

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Keio University

Success in Stably Storing Ozone by Hydration in a World First

—Improved usability of ozone gas, which is also effective against COVID-19—

Professor Ryo Ohmura of the Keio University Faculty of Science and Technology, Department of Mechanical Engineering collaborated with researchers at IHI Corporation and the University of Ottawa, and succeeded in stably storing ozone for the first time in the world as well as developing a technology to continuously produce ozone hydrate (※1). Ozone gas, which is the subject of this study and for which the technique was developed, is also said to be effective in inactivating COVID-19.

Traditional disinfectants use halides or strong acids and bases; however, because of their negative impact on the environment, the use of ozone has been considered, which has powerful disinfectant properties and high environmental affinity. Nevertheless, its use has been limited because it is difficult to preserve, and a technique to stably store it was therefore required.

In this study, a technology to manufacture ozone hydrate, the world's first technique to store high concentrations of ozone for long periods of time, was developed, and the researchers were successful in rapidly producing large quantities of ozone hydrate. In addition to inactivating COVID-19, ozone gas is effective in sterilizing and disinfecting food and tap water, and this technology is expected to have various industrial applications.

1. Main points of research

- It is a technique for storing ozone that has the potential to lead to the widespread use of the substance, which can also effectively inactivate COVID-19.
- Although ozone is an environmentally friendly disinfectant with no residual contamination, its use has been limited because it cannot be preserved.
- In this study, ozone was successfully stored for the first time in the world through ozone hydrate, and a technology to continuously and rapidly produce ozone hydrate was developed for its practical use.

2. Background of research

Up to now, halides containing chlorine or bromine were mainly employed in disinfectant gases used for the purpose of purifying air and sterilization. These halides induce disinfecting effects through their strong oxidizing properties, but they are also substances that are harmful to the environment with issues such as ozone layer depletion and residual contamination.

Ozone is a substance with a high disinfecting effect. Its oxidizing capabilities are second only to fluorine, and it is 7 times more effective than chlorine when it comes to air purification, etc. In addition, it is derived from oxygen in the air and any remaining ozone molecules react with each other and self-decompose to become oxygen molecules, meaning that there is no residual pollution.

It can be called a substance with high environmental affinity.

Since its discovery in 1840, ozone, which possesses these useful characteristics, has been studied and made use of; however, the reason why its use has not been more widespread is due to its characteristic to self-decompose, as mentioned before. Because of this characteristic, it cannot be stored and must be produced from oxygen in the air on site when it is to be utilized. This makes it a difficult substance to employ unless there is a certain scale for its continuous use, limiting its applications.

Taking the above background into consideration, in this research, investigations were carried out on methods to store ozone for long periods of time in a form that would enable it to be transported, thereby expanding its use. From the study, it was found that by converting ozone into ozone hydrate, water molecules insert themselves between the ozone molecules, preventing the ozone from self-decomposing and facilitating long term storage.

3. Content of research and results

- Development of demonstration equipment for the continuous production of ozone hydrate
  Demonstration equipment for the continuous production of ozone hydrate was designed and built. The equipment was operated, and proved to be successful in the continuous production of ozone hydrate containing ozone at a suitable level of concentration for its practical use.
- Investigation of the crystallographic characteristics of ozone hydrate
  The crystal growth process of ozone hydrate was observed and its crystallographic characteristics was identified. The crystallographic characteristics of ozone hydrate determined through these observations will provide a basis for improving performance at the plant.

4. Future developments

For the practical use of ozone hydrate, in the future, research and development of ways to improve the performance of the technologies to continuously produce ozone hydrate and store ozone will be carried out based on the knowledge gained from the two studies above.

＜Details of original paper ＞

Tomomi Hatsugai, Ryutaro Nakayama, Shigeo Tomura, Ryo Akiyoshi, Shirou Nishitsuka, Ryo Nakamura、 Satoshi Takeya, Ryo Ohmura, “Development and Continuous Operation of a Bench-scale System for the Production of O_3 + O_2 + CO_2 Hydrates” *Chemical Engineering Technology*, just accepted
https://onlinelibrary.wiley.com/doi/10.1002/ceat.202000044

Riku Matsuura, Kazuya Ozawa, Saman Alavi, Ryo Ohmura, “Crystal Growth of Clathrate Hydrate with Ozone: Implication on Ozone Preservation” *ACS Sustainable Chemistry and Engineering*, just accepted
https://pubs.acs.org/doi/10.1021/acssuschemeng.0c05345

＜Glossary＞

※1 Hydrate

Crystals that are formed when molecules are inserted into cages created by hydrogen-bonded water molecules. Crystals containing ozone inside the cage are called ozone hydrates. They are formed under low-temperature and high-pressure conditions, and when they decompose, the crystals break and the gas inside is released.

※Please direct any requests or inquires to the contact information provided below in advance.

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