6. INTEGRATED RESEARCH CENTER FOR CARBON NEGATIVE SCIENCE

2023 Activities

Introduction

The Integrated Research Center for Carbon Negative Science (ICaNS) was established in August 2022 to promote carbon negative science research toward the realization of a carbon neutral society in 2050. Currently, the balance between carbon dioxide emissions and absorption has been disrupted, resulting in an excess of carbon dioxide emissions and a serious impact on the earth in the form of climate change. Restoring the balance is difficult with "zero emission" technologies alone and requires the development and implementation of more active carbon dioxide fixation processes, so-called "carbon negative" technologies. The Center will work to develop such new carbon dioxide fixation technologies in collaboration with the Graduate School of Engineering and Graduate School of Energy Science at Kyoto University. It will also work to develop human resources for "carbon negative science," which has not been done before.

Last fiscal year (FY2022), three major research projects were launched: 1) Solar Energy Utilization for CO_2 Capture and Conversion, 2) Conversion of CO_2 into Useful Substances, 3) Biological Utilization of CO_2. This fiscal year (FY2023), continuing from the previous year, we promoted these priority research projects and established an educational system for "carbon negative science". In addition, an international seminar on carbon negative energy science was held, and the center's laboratories were upgraded and experimental equipment was installed.

1. Solar Energy Utilization for CO_2 Capture and Conversion

The objective of this group is to establish novel science and technology for efficient solar energy utilization required for capturing CO_2 and/or converting CO_2 into valuable materials. In FY2023, the following studies were primarily conducted in this group: Studies on high-purity carbon nanotube membranes toward solar energy harvesting and utilization, optical science and applications of quantum materials for carbon negative energy science, low-temperature growth of functionalized graphene nanoribbons with electrochemical on-surface synthesis, efficient hydrogen evolution with laser-textured electrodes, research on the effective use of long wavelength light using mid-infrared free electron laser. Based on these results, we will continue our efforts to realize new solar energy utilization technologies.

2. Conversion of CO_2 into Useful Substances

This project group aims to convert CO_2 into useful substances. We are particularly interested in electrochemical methods of conversion. By using high-temperature molten salts as electrolytes, for example, CO_2 could be converted into a wide variety of valuable carbon materials, such as diamonds, carbon nanotubes, and graphite. If aqueous solutions, organic solvents, or ionic liquids are used as electrolytes at relatively low temperatures, CO_2 can be converted into methane, ethylene, and other materials. In FY2023, various types of carbon were electrodeposited using chloride molten salts at 600-900°C. They were analyzed by Raman spectroscopy, and mainly amorphous carbons were obtained. A small amount of diamond was obtained under certain appropriate electrolytic conditions. It was also suggested that other carbon allotropes could be obtained.

3. Biological Utilization of CO_2

Research in this project focuses on bio-related methods, materials and enzymes with the goal to contribute to Carbon Negative Science. In FY2023, studies that were carried out include the following: the development of tools to better understand the biological cell and its energy conservation, and technology to enhance and/or prolong the activity of enzymes, particularly those related to CO_2-fixation. Development of membranes, reactors and processes to enhance biomass utilization and establish efficient biorefineries have been performed. New microbial enzymes or metabolic pathways that can utilize CO_2 or prevent its release have been identified. Although the individual groups may specialize in diverse areas, we will continue our collaborative research to achieve our common goals and contribute towards developing a bio-based society.

4. Education Activity

The content of "Carbon Negative Energy" was incorporated into the existing undergraduate course "Advanced Energy Science" and started in the second semester of FY2023. As for graduate-level lectures, "Carbon Negative Energy" was incorporated into "Socio-Environmental Energy Science I and II" in the Graduate School of Energy Sciences, as in the previous fiscal year. The concept of "Carbon Negative Energy" was also promoted to visitors to the institute.

5. Other Activities

We further upgraded Laboratory 1-5, Waiting Room 1-2, Program-Specific Associate Professor's Room and Program Specific Assistant Professor's

Room in the main building of the Uji Campus. As for experimental equipment, an ultrasonic homogenizer, electric furnaces for molten salt electrolysis, a vacuum oven and box-type dryers were installed, as shown in Figs 1-1, 1-2, and 1-3.

Fig. 1-1 An ultrasonic homogenizer.

Fig. 1-2 Electric furnaces for molten salt electrolysis.

Fig. 1-3 A vacuum oven and box-type dryers.

ICaNS Events

April 5: The 1st Steering Committee meeting was held.
May 1: Program-Specific Assistant Professor was appointed.
June 12: The 2nd Steering Committee meeting was held.
July 25: ICaNS website was launched.
September 1: Symposium on Exploring Carbon Negative Energy Science 2023 was held as a parallel seminar of the 14th International Symposium of Advanced Energy.
September 8: The 3rd Steering Committee meeting was held.
October 1: Program-Specific Assistant Professor was appointed.
October 27: The 4th Steering Committee meeting was held.
February 15, 2024: The 5th Steering Committee meeting was held