Researches on Next-Generation CO_2 Capture and Utilization Technologies ~Towards the Realization of Sustainable Carbon Neutral Cycle ~

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In recent years, people have become increasingly aware of the serious environmental issues that humanity faces — global warming.

An international treaty known as the Paris Agreement was adopted in 2015 with the goal of limiting global average temperature increases to below 2.0 degrees Celsius, and preferably to 1.5 degrees, for the mitigation of global warming. To fulfill this, we must cut global CO_2 emissions — said to be as high as 35 billion tons per year — to below net-zero eventually. As ambitious as this goal is, it still represents the bare minimum required to minimize extreme weather events, epidemics, ecological changes and other effects of global warming. On the domestic front, the government of Japan announced its 2050 Carbon Neutral Declaration in 2020. Industry, government and academia are working together to address this crucial challenge.

For the drastic reduction of CO_2 emissions, we must advance various low-carbon energy technologies such as solar photovoltaic power, solar thermal power, wind power and nuclear power while ensuring safety and local environmental conservation. At the same time, we also need to establish the way to convert the fossil fuels we have become so dependent on into clean energy sources emitting no CO_2. In other words, we need to build a so-called carbon-neutral cycle, as shown in Figure 1(a) — capturing CO_2 produced when fossil fuels are consumed and reusing it as new carbon resources and energy carriers. We expect this new carbon neutral cycle will allow the sustainable utilization of fossil fuels, the reduction of the load on low-carbon energy sources and the leveling out of energy fluctuations to deliver a new, stable, next-generation energy system.

In this challenge, we have focused on the advanced CO_2 capture and conversion technologies, such as low-energy-cost CO_2 capture, carbon-free hydrogen production, and high-efficiency CO_2 conversion processes. Among these endeavors, we expect that the molten ionic oxide-based CO_2 absorbents recently identified, as shown in Figure 1(b) will reduce drastically the energy consumption of CO_2 capture and utilization systems.

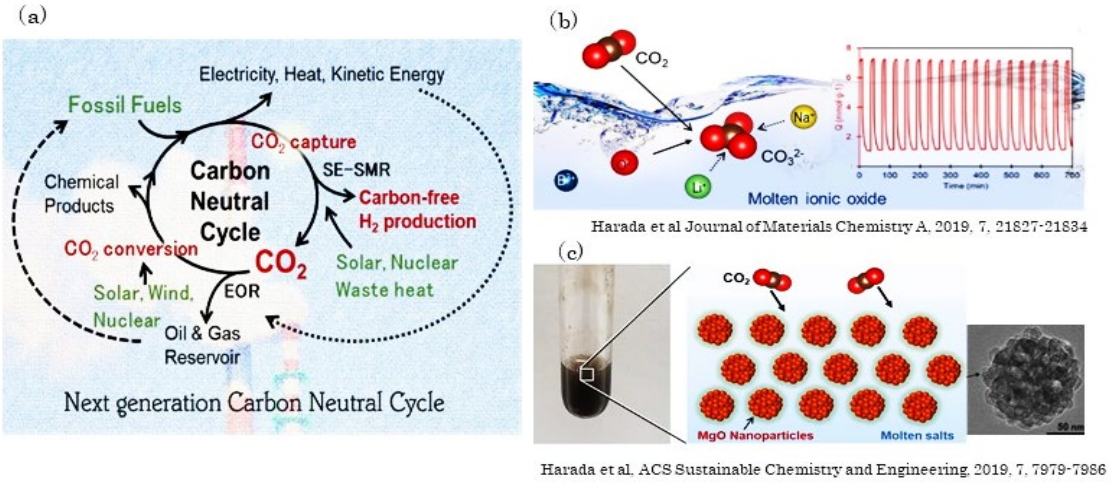

Fig.1 Schematic illustrations of, (a) next-generation carbon neutral cycle system, (b) high efficiency CO_2 capture by molten ionic oxide-based absorbents, and (c) non-aqueous colloidal absorbents.

Likewise, the nonaqueous colloidal absorbents developed by a new class of nano-hybrid technology, as shown in Figure 1(c) can serve as a new functional ionic medium allowing both selective gas separation of CO_2 and highly efficient CO_2 conversion. Further on, we will pursue various new innovative breakthroughs through the understanding of the truths and phenomena still hidden in nature, and learning plenty of engineering hints from them. We want to develop this new carbon neutral cycle together with Tokyo Tech students, who are highly motivated and full of future possibilities.

Last day, a student in my research group said to me: “The day might come when we ask our children and grandchildren, ‘Can you believe people used to emit CO_2 into the atmosphere?’ I hope that day does come, and soon!

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Dr. Takuya Harada, Associate Professor

Q1: When was your first experience with research, and what was it like?

A1. My first experience in research came during my first year as a doctoral student. The research theme was on the correlation between critical current and magnetic flux pinning properties in high-temperature superconductors. It was a new challenge for me, and I had a hard time getting the results I modeled. However, as I proceeded to identify the causes of the results, I found out that a completely different phenomenon was occurring inside the material over my expectation. Through this experience, I realized how profound and interesting research is.

Q2. What is the ultimate goal of your research? What you want to know most?

A2: I am engaged in the researches on so-called carbon neutral cycle technologies, which involve capturing, converting and reusing CO_2. Nature has already achieved this as photosynthesis in plants. I am always impressed by the nature, realizing such an sophisticated CO_2 recycling system. My ultimate goal is the innovation of such a superb and sustainable chemical system by engineering.

Q3: How do you stay motivated in your research?

A3: My family is what really keeps me motivated. I also meet many people in my research. That includes the research advisors who gave me the research opportunities, colleagues who worked alongside, and students who have just joined me. The gratitude and joy I feel for these encounters is also a great motivator to advance my researches.

Q4: What are your aspirations for the environment and SDGs?

A4. I believe that environmental conservation is the most fundamental and crucial problem we must solve to continue living on this planet. The reduction of CO_2 emission is an urgent technological challenge to be solved now. I will do explore further to attain the solid contributions in these global activities.

Message to Students

Solving the global warming problem requires various technological innovations yet to be realized. Pioneering unexplored area is a difficult task, but I hope you follow this path with a strong will and solid perseverance to accomplish the great results and fulfillment.