

# Report for MERIT Overseas Dispatch

Nozaki Group, Department of Chemistry and Biotechnology, Graduate School of Engineering

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<b>Hosting Institute</b>	Byers Group (Department of Chemistry, Boston College)
<b>Period of Stay</b>	August 1, 2022 – October 31, 2022
<b>Research Project</b>	Copolymerization of ethylene and CO <sub>2</sub> using electrochemical switching of a catalyst

## Research Project

In this MERIT overseas dispatch, I stayed at Prof. Jeffery A. Byers' Group at Boston College for three months. I researched polyolefin synthesis utilizing electrochemistry. Byers Group mainly studies catalysis and polymer synthesis using iron complexes. In one of their papers, it is reported that electrochemical switching of the oxidation state of an iron complex changes the monomer that can be polymerized by the iron catalyst. Nozaki Group, which I am working for, has attempted to achieve copolymerization of ethylene and CO<sub>2</sub>. I thought that the incorporation of CO<sub>2</sub> into a polymer would be possible by switching the oxidation state of ethylene polymerization catalysts like the report of Byers Group. Thus, I emailed Prof. Byers and proposed this research project. He generously allowed me to stay at his group to start this MERIT overseas dispatch.

In the first half of this stay, I established the condition for electrochemical switching that is compatible with ethylene polymerization step. Electrochemical reactions are generally conducted in polar solvents with electrolyte salts so that the current flows in the solution. On the other hand, ethylene polymerization is generally conducted in non-polar solvents like toluene to avoid catalyst deactivation. Therefore, an electrochemical condition compatible with ethylene polymerization catalyst is required. Finally, I found a condition where a catalyst maintains the activity like that in toluene after examining the combination of catalysts, electrolytes, and polar solvents.

In the latter part of this stay, I worked on the electrochemical switching of polymerization catalysts under high pressure of ethylene and CO<sub>2</sub>, using the condition that I found in this stay. In this work, Wang Group generously lent us a reactor for high-pressure electrochemistry and gave us some advice on electrochemistry. Unfortunately, CO<sub>2</sub> insertion into the polymer chain was not observed. In a discussion with Prof. Byers, he suggested that low concentration of the catalyst made the electron transfer to the catalyst difficult, and that the polymer with low solubility might act as an insulator. Recently, Byers Group reported a polymerization by a catalyst bound on an electrode surface. For the former problem, this method will be a solution, so I learned the technique as well.

I will utilize the techniques that I learned in this stay to the synthesis of polyolefins in our group, and we would like to achieve copolymerization with CO<sub>2</sub> eventually.

## Life in the Laboratory

Boston College is located in the suburbs of Boston which makes it a good location for conducting research in a relaxed environment. The Byers Group is a small group with four graduate students and one undergraduate student, but they had two gloveboxes, two GCs, GPC, and so on. NMRs were common-use instruments, but it was located in the same building, and I could book them easily. A technical officer was stationed in the lab on weekdays, so if I had any problems, I could talk with him immediately. Therefore, the environment was well prepared to carry out

experiments. In particular, the Byers Group was active in collaborative research with other laboratories in the department, and I could learn electrochemistry through the Wang Group as I mentioned before, as well as flow chemistry and MOF chemistry through the collaborative research of other members.

I was allowed to participate in laboratory meetings as well. Progress reports were held once a week. The students in charge report on the progress of their research for the last couple of weeks. Although I was a little surprised at the style of meeting, chalkboard talk without PowerPoint or resume, we had a lively discussion over beer and snacks, and I was able to get some good opinions. In particular, it impressed me that the students talked the introduction at every meeting and the professor commented on it to brush up the standpoint of their research. Journal club was held once a week as well. The professor asked us not only about the content of the paper itself but also how we would feel about the paper if we were the reviewer. Because my stay overlapped with the beginning of the school year, I could experience the orientation and lectures for new graduate students. The graduate students concentrate on the lectures for the first semester and decide which lab to belong to by looking around the labs in the meanwhile. The lectures start from confirming the fundamental understanding. The program of this school seems to be designed so that student can show their performance in the maximum in the lab.



The building of the Chemistry Department of Boston College  
(Merkert Chemistry Center)

### **Life in Boston**

Boston is located at about the same latitude as Sapporo and is famous for its cold winters. However, in summer, the temperature often exceeds 30 degrees. I felt the temperature change dramatically even though I stayed for only three months. I stayed at a private accommodation, but it was a shared house-style accommodation. It was a valuable experience for me to live with people from various countries who stayed in Boston as visiting researchers like me.

In holidays, I could enjoy sightseeing around Boston. Although the U.S. is a car-based society, Boston has a well-developed rail network, including the MBTA subway system (known as the oldest subway in the United States). That make it possible to visit various famous places without a car. In Boston, I could enjoy various cultural facilities such as the Boston Museum of Fine Arts and the Boston Symphony Orchestra. In addition, I could visit Concord, Salem, and Plymouth, in just over an hour and learned about the early history of the U.S.

### **Acknowledgements**

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