Strategic Young Researcher Overseas Visits Program
for Accelerating Brain Circulation 2011

"Development of Young Researchers Based on International Joint Research on Green Energy Systems" Progress Report

1. Name: Koki Urita

2. Title: Assistant Professor

3. Host Institution: Université Paul Sabatier (France)

4. Host Researcher: Proffesor Patrice Simon

5. Duration: 1- April- 2014 – 24- March- 2015

6. Research Topic:

Synthesis of pore size-controlled porous carbons for innovative energy storage devices and the system development

7. Overview of the Results of the Collaborative Research:

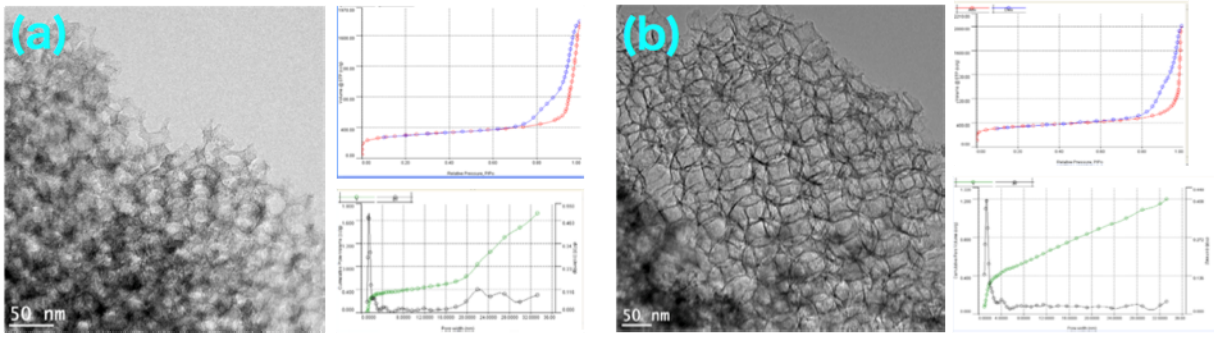

Fig. 1 TEM images, N_2 adsorption isotherms and the pore size distributions of mesoporous carbons with the average pore size of (a) 25 nm and (b) 80 nm.

Synthesis of porous carbons as electrodes for energy storage devices; The target materials are micro and mesoporous carbons with controlled pore size used as electrodes for energy storage devices. It was believed that microporous carbon did not have a potential as electric double-layer (EDL) capacitors because the pore size is not large enough against solvated electrolyte ions forming the EDL. Recent studies in Prof. Patrice Simon's group where I visited by this program and his research collaborator reported a dramatic increase in carbon capacitance even with pore size less than 1 nm. They and our group indicated that the increase was occurred by a desolvation of electrolyte ions in micropores from different ways. Since we considered that most appropriate pore size for improving EDL capacitances was ~ 0.6 nm from our results, I studied the synthesis of microporous carbons with the narrow pore size distribution around 0.6 nm. We have not received enough results to apply them to the electrodes of EDLC and I continue the study as one of the collaborative research. I also synthesized mesoporous carbons for another goal that is to improve an EDL capacitance by grafting functional groups on the carbon surface. The Fig.1 shows mesoporous carbons with the average pore sizes of 25 nm and 80 nm, which I synthesized by using a silica-opal template method. They will be grafted by a group of Nantes University and Prof. Patrice Simon's group will measure an EDLC performance. We keep up the study where I will synthesize mesoporous carbons with narrow pore size distribution.

Development of a capacitive deionization (CDI) system; We propounded new concept of a capacitive deionization system for desalting brackish and seawater. A traditional CDI system has limitation of ion storage capacity. After the electrodes in CDI system are saturated by ion adsorption, deionization cannot occur without an ion release step. We here used a flowable electrode composed porous carbon spheres and an electrolyte solution to disembogue a constant concentration solution. Fig. 2 shows the schematic of concept and the flow capacitive deionization cell.

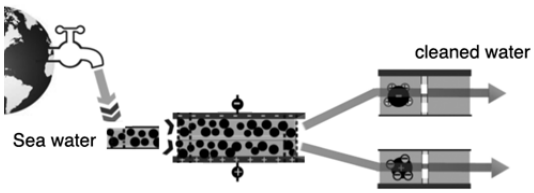

Fig. 2 Schematic of new concept of CDI system.

8. Deployment Plans for Future Collaborative Research:

I will continue collaboration on the two research topics with Prof. Patrice Simon. One that is an ongoing project in this research program is the development of innovative porous carbon electrodes. I synthesize pore size-controlled carbons with meso or micropores and they study the electrochemical performance of them. Especially, as far as mesporous carbon electrodes

concerned, another group joins in the project as the surface treatment. Another is new theme achieved effectively by using a special *in-situ* technique of electron microscopy. One of the PhD students in Prof. Patrice Simon's team will come to Nagasaki University to carry out collaborative research this year.

9. The List of Collaborative Research Progress:

Publication(s)

1) K. B. Hatzell, E. Iwama, A. Ferris, B. Daffos, K. Urita, T. Tzedakis, F. Chauvet, P. –L. Taberna, Y. Gogotsi and P. Simon "Capacitive deionization concept based on suspension electrodes without ion exchange membrances." *Electrochem. Commun.*, **43**, 18-21 (2014).