FCDIC Report 33rd Issue

To World Members

"FCDIC Report No.33" is issued on 31st May, 2023. Please refer to the following contents. The main topics of this issue are summary of bibliographic matters on the 30th FCDIC Fuel Cell Symposium Proceeding. It is appreciated if you give us any comment on this new report.

1. Publication of "The Journal of Fuel Cell Technology", Vol.22 No.4

Spring Issue, Vol.23(No.4) is published on 30th April and sent to overseas members by PDF with 99 pages.

2. Summary of Bibliographic Matters of the 30th FCDIC Fuel Cell Symposium Proceedings

The 30th Fuel Cell symposium was held hybrid in venue (Tower-hall Funabiri) and on-line on 25th and 26th May, 2023. The symposium contains 43 oral and 17 poster presentations. Four short presentations are included, categorized on "Products Introduction Session". The presentations of every title, speaker, affiliation and abstract available are shown below. Five special lectures are included from NEDO (NEDO India, NEDO Europe (on-line), NEDO USA (on-line)) and up-dated in China, beside Japanese strategy by METI. **In this symposium, situation of India is firstly introduced**.

Oral Presentations

1. Special Lectures (Arbitrary Order)

(1) "**Updates on Japanese hydrogen policy**"
Tomohiko Adachi (Ministry of Economic, Trade and Industry/ METI)

(2) "**Recent trends in hydrogen and fuel cells in India**"
Yoshiro Kaku (New Energy and Industrial Technology Development Organization/NEDO)

(3) "**Updates on China hydrogen and fuel cell industry 2023**"
Kyohei Yamashita (METI)

(4) "**Policies and industrial trends on hydrogen in Europe**"
Setsuko Wakabayashi (NEDO)

(5) "**Policy trends on hydrogen and fuel cells in U.S.**"
Taishu Hara (NEDO)

2. Award Talk (FCDIC Honoring Systems in the 2022 Fiscal Year)

(1) Award in Industry: "**Achievement of "ENE FARM" cumulative production of 20,000 units**"
Chihiro Tanikawa (Panasonic Corporation)

(2) Award in Industry: "**The role of Fuji Electric in the fuel cell development in Japan**"
Hiroshi Yoshioka (Fuji Electric Co., Ltd.)

(3) Award in Science: "**Synthesis and evaluation of highly active and durable electrocatalysts for fuel cell and electrolyzer**"

Katsuyoshi Kakinuma (Yamanashi University)

(4) Award in Incentive: "**Design and development of metalloenzyme-inspired electrocatalysts**"
Masaru Kato (Hokkaido University)

3. Co-session with Hydrogen Energy Systems Society of Japan (Invited Talk)

(1) "**Development od self-repairing electrocatalyst for alkaline water electrolysis powered by renewable energy**"
Yoshiyuki Kuroda (Yokohama National University)

(2) "**Development of AEMs for water electrolysis cells**"
Kenji Miyatake (Yamanashi University)

(3) "**Recent membrane development situation for PEM water electrolysis**"
Kousuke Sumikura (AGC)

4. Mobility

(1) Invited: "**Fuel cell development in Honda – Towards versatile application**"
Shuich Togasawa (Honda R&D Co.Ltd.)

(2) Invited: "**Electrification technologies and tasks foe commercial vehicles**"
Susumu Fukunaga (Isuzu advanced engineering Center, Ltd.)

(3) Invited: "**Development of hydrogen-powered train named "HYBARI**""
Osamu Omichi (East Japan Railway Company)

(4) "**Contribution to the hydrogen society from the space exploration**"
Yoshitsugu Sone (Japan Aerospace Exploration Agency (JAXA))

Abstract Space exploration have been utilizing various kind of electrochemical devices like oxygen generator by water electrolysis, fuel cell for energy generation, batteries for energy storage, and so on.
Currently, the water electolyzer which realizes the endothermic operation by using the pressurized water without circulation. The technique is combined with Sabatier reactor to generate 'e-methane' and going to be applied to the terrestrial application to realize the carbon neutral society.
In order to save the input energy to generate methane, the electrochemical reactor by applying PEFC and PEEC technique. Currently, selectivity of the methane was enhanced with very low input electricity to generate e-methane.
Especially for fuel cell, JAXA (former NASDA) was historically first agency which demonstrated the fuel cell operation without external humidifier. It was revealed that the simple counter flow of hydrogen and oxygen could realize the stable operability of fuel cell.
Furthermore, the combination of the know-how for fuel cell and water electolyzer, realizes the reversible-type regenerative fuel cell, today. Interdigitated structure developed for the water electrolysis with pressurized water creates the dry surface condition of electrode which realizes the switching of the operation without interval between fuel cell reaction and water electrolysis.
These techniques should be utilized as the terrestrial applications to realize the hydrogen society of the Earth.

5. Residential

(1) Invited: "**Development of Toshiba's stationary hydrogen fuel cell system**"
Kenta Oorui (Toshiba Energy & Systems Solutions)

(2) Invited: "**Panasonic's environmental efforts through the social implementation of stationary fuel cell**"
Motomichi Kato (Panasonic Corporation)

(3) "**Development of stationary PEFC power system at Fuji Electric**"
Masaki Takahashi (Fuji Electric Co., Ltd.)

Abstract Fuji Electric is developing a new stationary hydrogen fuel cell power generation system to use fuel cell module for fuel cell electric vehicle. For stationary use, new technology of the multi fuel cell module switching operation has been developed to realize long term continuous generation and long life endurance. This system is expected to be commercially available by spring 2024.

6. Regional

(1) Invited: "**Introduction of initiatives related to hydrogen in Fukushima Prefecture**"
Yasuhiro Hattori (Energy Agency, Fukushima)

7. PEFC

(1) Invited: "**Technical Targets and development issues of NEDO technology roadmap**"
Masakazu Yoneda (Mizuho Research & Technologies)

(2) "**Heat-treatment of aromatic fourteen-membered macrocyclic complex and in-situ synchrotron spectroscopy**"
Yuta Nabae (Tokyo Institute of Technology)

Abstract A fourteen-membered macrocyclic Fe complex was loaded on a carbon support and then heat-treated, and found to be quite active as a non-precious metal oxygen reduction catalyst. Such a catalyst was analyzed by in-situ X-ray absorption spectroscopy to clarify the degradation mechanism. The durability of the Fe catalyst after heat-treatment was much better than that without heat-treatment. Co based catalysts have been also studied by the same method and their durability was compared to Fe based catalysts.

(3) "**Fundamental studies on cathode catalysts for PEFC (XXII) – Enhancement of oxygen reduction activity of zirconium oxide-based catalysts**"
Akimitsu Ishihara (Yokohama National University)

Abstract To increase in energy conversion efficiency of polymer electrolyte fuel cells, we tried to increase in onset potential of oxygen reduction reaction (E_{ORR}) of zirconium oxide-based catalysts by Fe-addition. Fe-added zirconium oxide catalysts were synthesized by using pyrazine carboxylic acid. Fe-added zirconium oxide with a Fe/Zr atomic ratio of 0.1 showed highest E_{ORR}, 0.917 V vs. reversible hydrogen electrode among other zirconium oxide-based catalysts including the previous study. We found that a positive correlation between a ratio of ZrO_2 monoclinic structure and E_{ORR}. High quality active sites such as lattice distortion were formed by substitution of Zr^{4+} by Fe^{3+} in ZrO_2 monoclinic structure. As a result, the use of pyrazine carboxylic acid was found to be useful to form high quality active sites and a suitable electron conduction path.

(4) "**Development of highly active Pt catalysts under high temperature and low humidification conditions: Part III**"
Minoru Inaba (Doshisha University)

Abstract Reduction of the usage of platinum, which is used as a catalyst in polymer electrolyte fuel cells (PEFCs), is one of the most important issues for the widespread commercialization of fuel cell vehicles. To achieve the activity in the 2030 NEDO target, development of highly active and durable Pt core-shell and alloy catalysts was started in 2020 by five academic and industrial institutions focusing on the following innovative technologies: 1) innovative core-shell catalyst technology, 2) innovative surface modification with special organic compounds, 3) innovative supporting materials with high surface areas interconnected pores, 4) innovative proton conduction within the pores of supporting materials

using ionic liquids. In this talk, the preparation and performance of innovative catalysts using meso-porous carbon support and effects of proton-conductive ionic salt addition are discussed.

(5) "**Catalytic properties for ORR of Pt supported on ordered mesoporous carbon with network structure**"

Toshihiro Miyao (University of Yamanashi)

Abstract Ordered mesoporous carbon with a novel hierarchical network structure (ns-OMC) was synthesized using nonionic surfactant micelles as a template with phenol-formaldehyde resole resin. A newly developed technique allowed the selective deposition of Pt nanoparticles within the OMC nanopores. Pt/ns-OMC catalysts showed higher activity for the ORR and higher durability for the potential step cycling compared with commercial Pt/CB catalyst.

(6) "**Investigation of catalyst layer structure with high electrode reduction activity in PEFC cathode by large scale reactive molecular dynamics simulation**"

Nobuki Ozawa (Tohoku University)

Abstract To clarify the catalyst layer structure with high electrode reaction activity in PEFC, by using molecular dynamics method with ReaxFF force field and a 3-million-atoms large-scale catalyst layer model, we investigated the effect of the carbon support structure with multiple aggregated amorphous carbon particles on the Nafion and water coverage toward the Pt nanoparticles (NPs) and oxygen reduction reaction activity (ORR) of the catalyst layer in the cathode. When the Pt NPs are placed inside the pores between the carbon particles, some Nafion chains connect with water layers adsorbed on a part of the Pt NP surface, leading to low oxygen transmission resistance and high proton conductivity. To evaluate the ORR activity of our constructed catalyst layer model, we performed molecular dynamics simulations of the catalyst layer with O_2 molecules. When the Pt NPs are deep in the pore or on the carbon support surface, many H_2O and few O_2 molecules adsorb on the Pt NPs, indicating less ORR activity. On the other hand, when the Pt NP is put around the entrance of the pore, many O_2 molecules can adsorb on the Pt NPs, which are not fully covered with H_2O molecules. This indicated that the Pt NPs around the entrance of the pore are expected to show high ORR activity. Then, we suggest that there is an optimal position of Pt NPs inside the pore of the carbon support in the catalyst layer to show high electrode activity at the cathode.

8. SOFC

(1) "**Phase stability of $Ba(Zr,Yb)O_{3-\delta}$-based perovskite electrolytes under a fabrication process**"

Ryuma Malik Matsuda (Central Research institute of Electric Power Industry (CRIEPI))

Abstract Development of Ultra-High Efficiency Protonic Ceramic Fuel Cell (PCFC) Devices in NEDO project are started from 2020. Three working packages are working on research and development in a collaborative system to improve a performance of cell consisting of $BaZr_{1-x}Yb_xO_{3-\delta}$(BZYb)-based perovskite electrolytes. The phase stability of BZYb is one of the factors for improving cell performance. It was found that a fabrication process affected the phase stability of BZYb. Understandings of the phase stability of BZYb could help further improve the cell performance to achieve the development target and PCFC applications.

(2) "**Theoretical investigation on electrode-derived elemental diffusion in $Ba(Zr,M)O_{3-\delta}$ based solid electrolytes under power generation conditions of PCFC**"

Kaoru Nakamura (CRIEPI)

Abstract $Ba(Zr,M)O_{3-\delta}$ used as solid electrolytes in proton-conducting fuel cells are subject to degradation due to solid solution of Ni and Co from the electrodes. First-principles calculations were utilized to find insights to suppress cell degradation. Precipitation of BaM_2NiO_5 due to reaction between Ni and electrolyte was found to be organized by the ionic radius of the dopant element. Co was found to segregate at the grain boundary to form spinel and Ni is solid solute into the spinel. This study suggests that the degradation of PCFC associated with the precipitation of Co and Ni complex oxide can be suppressed by selecting the appropriate dopant *M* element.

(3) "**Development of toughening technology for solid oxide electrochemical cells**"

Hirohumi Sumi (National Institute of Advanced Industrial Science and Technology: AIST)

Abstract New Energy and Industrial Technology Development Organization (NEDO) performs the development of toughening technology for solid oxide electrochemical cells (SOCs). Metal-supported SOCs are developed using wet process and thermal spraying process, and their evaluation technologies are investigated to improve the mechanical reliability during rapid startup, and the electrode durability during manufacturing and operating under fuel cell and electrolysis modes.

(4) "Degradation analysis of SOFC cell-stack performance (8) – Long -term durability test with high fuel utilization and evaluation for enhanced operation"

Akiumi Ido (CRIEPI)

Abstract In the NEDO project "Development of Advanced Evaluation and Analysis Techniques for Solid Oxide Fuel Cell Stacks", our organization is conducting long-term durability tests using a manufacturer-produced SOFC cell stack under high fuel utilization and performing degradation analysis based on our performance evaluation method. Furthermore, we are conducting load fluctuation tests as accelerated degradation tests and developing a SOFC dynamic simulation model. In this study, we will report on the results of the above-mentioned tests and the development of analysis techniques.

(5) "**Progress and achievement of evaluation & analysis methods of SPFC stack durability**"

Teruhisa Horita (AIST)

Abstract Recent progress and achievements of the NEDO national project are presented on the evaluation and analysis methods for the durability of SOFC stacks (from FY2020). This project develops the evaluation and analysis methods for the cell-stack degradation and durability operated for 130,000 hours and efficiency of 65%LHV. The project also focuses on the development of analytical methods for load cycling and the rapid start of the stacks. Several analytical methods were examined which enables us to evaluate a long lifetime and upper limit of the stack performance. Some pieces of these results are presented.

9. Underlying technologies and others

(1) "**Development of ammonia borane for hydrogen source of portable fuel cell system**"

Tessui Nakagawa (University of the Ryukyus)

Abstract Ammonia borane (AB: NH_3BH_3) is an attractive material for hydrogen storage material due to high hydrogen capacity (19.6 mass%). Our goal is to commercialize AB as hydrogen source for FC including creating the supply chain of AB. Towards this goal, there are some issues such as mass production (cost), dehydrogenation (hydrolysis and/or thermolysis), recycle (hydrolysis and/or thermolysis), and transportation (handling guideline, shelf-life, safety, etc.). Our current progresses which have been done by the support of NEDO will be shown in this presentation.

(2) "**Development of innovative methanation technology using low temperature process**"

Koki Sato (Tokyo Gas Co., Ltd.)

Abstract Tokyo Gas is working on the social implementation of methanation, which can achieve carbon neutrality of gaseous energy while effectively utilizing existing city gas infrastructure, with the aim at realizing a carbon neutral society by 2050. For the social implementation of methanation, we report on efforts to develop innovative methanation technology using low temperature process in order to improve methane synthesis efficiency and reduce costs compared to conventional technology.

(3) "**Fabrication of inorganic-organic hybrid proton conductors formed by acid-base reaction and their application to medium-temperature anhydrous fuel cell**"

Keiichiro Maegawa (Toyohashi University of Technology)

No abstract

(4) Invited: "**Research and Developments of radical quenchers for PEFCs**"

Masahiro Rikukawa (Sophia University)

(5) Invited: "**JARI's approach for the evaluation of hydrogen impurities in automotive fuel cells**"

Yoshiyuki Matsuda (Japan Automobile Research Institute)

10. Young Invited

(1) "**Rational design of electrocatalysts for water electrolysis using material informatics technique**"
Yuuki Sugawara (Tokyo Institute of Technology)

Abstract Active and inexpensive electrocatalysts for anodic oxygen evolution reaction (OER) in alkaline water electrolysis are desired. We reveal that OER activities on the iron-based oxides are correlated with Fe–O bond lengths in their crystals. We then utilize databases to mine potential candidates based on the structure–activity relationship, and we rapidly find an excellent iron-based OER catalyst. Machine learning analysis proved that Fe–O bond length is the most dominant structural descriptor. Furthermore, we attempt to switch the OER mechanism by varying crystal structure and find that $CaFe_2O_4$ possesses outstanding OER activity because of its Fe atomic configurations.

(2) "**Development of fuel cell system simulator for the multi-purpose application**"
Shigeki Hasegawa (Kyoto University)

Abstract A fuel cell (FC) system simulator for the multi-purpose application such as passenger and commercial vehicles, stationary power generator, construction, railway, marine, and aviation purposes, was developed. The simulator includes the models of the FC stack, the subsystems of H_2, air, and cooling, and related controllers. It can reproduce the behavior of a state-of-the art fuel cell electric vehicle (FCEV), 2nd-generation MIRAI. It gives the information on the comprehensive interactions among the specification of the commercial products, system components, and controllers and it is expected that the significant cost and efforts for the iterative prototyping and testing activity can be reduced. In this study, the effects of material properties on system power, hydrogen consumption, and cooling performance will be discussed.

(3) "**Evaluation of molecular aggregation state in Nafion membrane on the basis of synchrotron X-ray measurements**"
Tomoyasu Hirai (Osaka Institute of Technology)

Abstract Molecular aggregation state in Nafion membrane was evaluated using wide-angle X-ray diffraction (WAXD) measurements. They showed specific broad diffraction peaks at q = 2.3 and 12 nm^{-1}, which are corresponding to a hydrophilic domain spacing and crystalline and amorphous domains, respectively. The diffraction intensity of hydrophilic domain was lineally decreased with increasing the deterioration time of Nafion membranes. This knowledge enables non-destructive evaluation in Nafion membranes.

(4) "**Development of Pt-based nanosheets**"
Daisuke Takimoto (University of Ryukyus)

Abstract Double-layer Pt nanosheets were synthesized via the topotactic reduction of 0.9 nm-thick PtO_x nanosheets. The oxygen reduction reaction (ORR) activity of the Pt nanosheets was 2 times higher than that of conventionally used 3 nm-sized Pt nanoparticles, attributable to their large electrochemically active surface area (124 $m^2 g^{-1}$). In addition, the durability of Pt nanosheets was superior to that of Pt nanoparticles; the electrochemically active surface area of Pt nanosheets after the accelerated durability test was 2 times larger than that of Pt nanoparticles.

11. Products Introduction

(1) "**Shaping the ecosystem of hydrogen storage and distribution pressure**"
Karuki Hamada (Faurecia Japan K.K.)

Abstract The momentum around Hydrogen as an energy carrier is becoming evident worldwide in many end applications beyond the industry usage. However, large scale deployment of hydrogen requires tackling the challenges of hydrogen storage and distribution. As an automotive expert, Forvia promotes the adoption of Hydrogen as a clean and sustainable energy source for the decarbonization of the mobility sector through the application of high-pressure Hydrogen storage systems. Beyond this, Forvia further bridges the gap to bring Hydrogen to its required point of use through large scale CONTAINERIZED SOLUTIONS for multiple Hydrogen storage purposes and transportation routes.

(2) "**Usable capacity of onboard cryogenic storage: Impact of tank operating pressure**"

Karuki Hamada (Faurecia Japan K.K.)

Abstract Onboard cryogenic hydrogen storage is a great solution for safe, long range, emission free heavy duty-applications. It enables large onboard capacities, together with affordable and fast refueling. This paper explores the influence of powertrain (e.g., fuel cell or internal combustion engine) operating pressure on the usable capacity for sLH2 and CcH2 storage systems, under the assumption of a 6 bar or a 30 bar operation. It is shown that due to increasing H2 temperatures at low tank state of charge, a great amount of energy can be stored in the vessel's wall which results in a lower maximum capacity uptake during subsequent direct refueling; hereby reducing the usable H2 amount for the vehicle. Relationships between state of charge prior to refueling and usable H2 capacities are given. It is shown that up to 50% more H2 uptake capacity can be achieved by reducing the minimum operating pressure in the cryogenic vessel from 30 to 6 bar.

(3) "**FCX® carbon black catalyst supports for fuel cells**"

Masatsugu Mizuguchi (Cabot Corporation Chemicals Inc.)

Abstract Introduction of Cabot's new carbon support products for use in fuel cell application

(4) "**Instruments for evaluating effects of temperature and humidity on fuel cell materials**"

Yuki Kawata (TA Instrument Waters L.L.C.)

Abstract Characterization of materials used in fuel cell have attracted high interest. The energy efficiency of a fuel cell is affected by the operating temperature and amount of water in the cell. Due to control of the performance of fuel cell, the control of the properties of the materials is necessary. In our presentation, we introduce our instruments; differential scanning calorimeter (DSC), dynamic vapor sorption analyzer (humidity-controlled thermogravimetric analyzer (TGA)), humidity-controlled dynamic mechanical analyzer (humidity-controlled DMA), and humidity-controlled thermomechanical analyzer (humidity-controlled TMA). As examples of material characterization using our instruments, we investigated the analysis of Nafion®, one of the perfluorosulfonic acid-based polymer electrolyte membranes.

Poster Presentations

(1) "**Study on Pt-Based Catalysts for PEFCs Operated under Low Humidity Condition**"

Hideo Daimon (Doshisha University)

Abstract An extremely high I-V performance is required for polymer electrolyte fuel cells (PEFCs) used in fuel cell electric vehicles (FCEVs) after 2030, and operating temperature of PEFCs is planning to be increased over 100°C in order to improve cooling efficiency. Therefore, it is needed to design Pt and Pt-based catalysts that work under the high temperature with a low humidity condition. In this study, the Pt catalyst was supported on a mesoporous carbon (MPC) and the Pt/MPC catalyst was decorated with salts of melamine derivatives to improve proton conductivity under the low humidity condition.

(2) "**Analysis of behaviors of melamine in a melamine-modified Pt catalyst**"

Shin-ichi Yamazaki (AIST)

Abstract We reported that surface modification with melamine increases the ORR activity of Pt/C. For the integration of this technology to implementation, behaviors of melamine in MEA need to be understood. In this study, we extracted melamine molecules from melamine-adsorbed Pt/C. While melamine

molecules adsorbed on carbon support are easily extracted, the molecules on Pt are hard to extract. This suggests that there is a strong interaction between melamine and Pt. Melamine is hardly extracted from MEA containing melamine. This implies that melamine which are desorbed from Pt/C are trapped in the electrolyte.

(3) "**Effect of anode gas composition on durability in PCFCs with BZYb-electrolyte**"
Shun Kobayasi (CRIEPI)

Abstract Protonic ceramic fuel cells (PCFCs) have been attracted much attention for next generation fuel cells due to high efficiency at lower temperatures below 600°C. However, PCFCs have some issues to be solved for practical use, such as improvement of power density, durability, and CO_2 resistance. $BaZr_{0.8}Yb_{0.2}O_{3-\delta}$ (BZYb) electrolyte which is a candidate material for PCFCs due to high proton conductivity has concerns about durability and CO_2 resistance. In this study, we investigated characterization and durability of PEFCs with BZYb electrolyte under various gas compositions for practical use.

(4) "**Improvement in durability- of fuel cell membranes by suppressing migration of cerium-based radical quenchers**"
Tatsuya Yamazaki (Sophia University)

Abstract Suppression of the migration of cerium-based radical quenchers is critical to improving the durability of polymer electrolyte membrane fuel cells (PEMFCs). In this study, we investigated the use of cerium ion complexes of zirconium phosphates (ZP) as radical quenchers for the electrolyte materials of PEMFCs. We evaluated the durability of membrane electrode assemblies by using open circuit voltage durability tests and electrochemical evaluations. The cerium-complexed quenchers exhibited excellent durability compared to cerium oxide. The complexes showed a superior quenching effect at low cerium concentrations (2 $\mu g/cm^2$), depending on the coordination state of the cerium ion and/or the ZP/cerium weight ratio.

(5) "**Core-shell type connected Pt-based catalysts with advanced oxygen-reduction performances for PEFCs**"
Aparna Chitra Sudheer (Tokyo Institute of Technology)

Abstract This work develops a novel synthesis method to prepare carbon-free, connected core-shell catalysts with non-Pt metal nanoparticles as core and Pt as atomic shell for oxygen reduction reaction (ORR). This method without high-temperature annealing provides high surface area and stable nanonetworks formed by Pt atomic shell. Using the method, the structure of Pt shell on core metals were turned and optimized to obtain high ORR performance. The connected Pd-core@Pt-shell catalyst synthesized in this study improved ORR mass activity (ca. 3 times) than the conventional Pt/C catalyst. Furthermore, high stability of this catalyst with good performance and structure retentions against load cycles was also demonstrated.

(6) "**Molecular analysis of the internal state of polymer electrolyte membranes in polymer electrolyte fuel cells below freezing temperature**"
Hiroki Nishizawa (Tohoku University)

Abstract Polymer electrolyte fuel cell (PEFC) has been attracted to achieve carbon neutralization. The problem of PEFC is the unclearness of structure at freezing temperature. We performed reactive force-field molecular dynamics simulation. We analyzed whether it was frozen or not by Radical Distribution Function. We found that melting point of bulk water in ReaxFF potential and analyzed the structure of water in the Nafion membrane. These analysis methods could not determine whether the water in the Nafion membrane was frozen or not. We will consider analyzing the specific heat of the water in the future.

(7) "**Introduction of alkyl group into fourteen-membered macrocyclic ligand**"
Mikio Okano (Tokyo Institute of Technology)

Abstract While fourteen-membered macrocyclic Fe complexes have received a great deal of attention as non-precious-metal catalytic materials, their catalytic activity for oxygen reduction is still much lower than that of Pt-based catalysts. To improve the catalytic activity, controlling the strength of the meal-oxygen bond by introducing substituting groups will be effective, but the methodology for the modification for such fourteen-membered macrocyclic ligands have not been established. This study focuses on the introduction of propyl group into the macrocyclic ligand.

(8) "**Applicability of oxide-based electrocatalysts with high rest potentials in acidic media to PEFC cathodes**"

Yudai Yanagi (Yokohama National University)

Abstract We attempted to propose a new concept of a catalyst design for catalysts in which oxygen reduction reaction (ORR) starts near equilibrium potential. The strategy was to find a redox system with a stable and high redox potential and connect it to ORR. Therefore, we focused on Ir-Ce binary oxides. The stable and high rest potential, 1.22 V vs. reversible hydrogen electrode, was obtained in Ir-Ce binary oxides with Ir:Ce=1:9 atom ratio. Unfortunately, no ORR polarization behavior was observed in the Ir-Ce binary oxides. Therefore, precious metals such as Au, Pd, Rh, Ru, and Pt were added to connect the high redox potential and the ORR.

(9) "**Design guidelines for base metal non-ferrous crystalline compound catalysts for alkaline water electrolysis using experiments and calculations**"

Taisei Uchiyama (Tokyo Institute of Technology)

Abstract Unlike conventional solid polymer electrolysis, alkaline water electrolysis has the advantage of using inexpensive metals such as nickel as catalysts, instead of requiring catalysts with noble metals such as IrO_2. In this study, we investigate the composition and structural or electronic parameters of base metal nonferrous crystalline compounds that may be important factors in the search for catalysts with high oxygen evolution reaction activity. Based on these parameters, we aim to use machine learning to propose design guidelines for efficient material development.

(10) "**Development of non-precious metal catalysts via electrodeposition for alkaline hydrogen evolution reaction in water electrolysis**"

Yotaro Fujii (Tokyo Institute of Technology)

Abstract Toward the realization of the hydrogen society, green hydrogen production using water electrolyzers has been attracting attention. However, the high cost of precious metal catalysts prevents their widespread use. In this study, we report on the development of non-precious metal catalysts for hydrogen evolution reaction (HER) in alkaline environments which can be prepared at a low cost. Thin films of non-precious metal nanoparticles (Co, Mo) were electrodeposited on porous Ni substrates. By optimizing the electrodeposition conditions, we successfully demonstrated the improvement of catalytic activity in HER.

(11) "**Effect of heat treatment for ZrO_2/IrO_2 by atomic layer deposition on oxygen evolution reaction**"

Satoshi Yamada (Yokohama National University)

Abstract Since IrO_2 has utilized as conventional anode of proton exchange membrane electrolysis, it is afraid to deteriorate the activity of IrO_2 by the operation of variable renewable energies(VRE). We have focused on ZrO_2 as support material of IrO_2 to provide the function for VRE durability. In this study, we have investigated the effect of heat treatment for the electrode of ZrO_2 film coated on IrO_2 fabricated by atomic layer deposition (ALD)(ALD-ZrO_2/IrO_2) on the oxygen evolution reaction (OER). As a result, the ALD-ZrO_2/IrO_2 with heat treatment has higher OER activity and durability than that without heat treatment.

(12) "**Electrochemical properties of titanium oxide-based catalysts for cathode of low-temperature fuel cells**"

Momo Obata (Yokohama National University)

Abstract We have focused on group 4 and 5 oxides as alternative catalysts to platinum for oxygen reduction reaction (ORR). We have found that Fe and Zn co-doped Ti oxide-based catalysts, which were obtained by heat-treatment under low oxygen partial pressure from carbon and nitrogen containing organo-cyclic complexes, had excellent ORR activity in acidic solutions. In this study, the effects of Fe and Zn additions on the ORR activity were investigated. The addition of Fe was found to promote the formation of $TiC_{0.3}N_{0.7}$ and TiO_2 rutile and to increase in the number of active sites. The addition of Zn caused an increase in the electrochemically effective surface area. These results indicated that the simultaneous addition of Fe and Zn increased the number of active sites that could work effectively.

(13) "**Oxygen evolution activity of Zr oxide-based film coated on Ni for alternative anode of AWE with high durability**"

Kazuya Hirose (Yokohama National University)

Abstract Alkaline Water Electrolysis (AWE) is a core device for the production of Green Hydrogen. The Ni as a conventional anode of AWE is highly active and durable under rated operation, but has an issue against fluctuation operation from variable renewable energies (VRE). In order to improve the VRE durability, we have investigated the coating effect of ZrO_2 film by atomic layer deposition (ALD) on the oxygen evolution reaction (OER) of Ni. As a result, the OER activity of ALD-ZrO_2 coated Ni with heat treatment was higher than without heat treatment.

(14) "**Modification with amidine group molecular for Pt/C catalyst with different Pt loading ratio**"

Kaito Iwanami (Oita University)

Abstract Aiming to improve the oxygen reduction reaction (ORR) activity and durability of the polymer electrolyte fuel cell (PEFC) cathode catalyst, we demonstrate the chemical modification of Pt/C with grafting amidine function groups, 2-methylpropionamidine, using an azo radical initiator. In this study we prepared two type of Pt/C catalysts with different Pt loading ratio and performed the chemical modification with 2-methylpropionamidine. The modification was revealed from the results of EPMA, XPS and TPD-MS. ECSA was decreased after the modification; on the other hand, ORR specific activity was drastically increased.

(15) "**Chemical modification PtCo/C catalyst with amidine group molecule**"

Fumiaki Nagayoshi (Oita University)

Abstract To improve the oxygen reduction reaction (ORR) activity and durability of the polymer electrolyte fuel cell (PEFC) cathode catalyst, we demonstrate the chemical modification of PtCo/C with grafting amidine function groups, 2-methylpropionamidine, using an azo radical initiator. We used PtCo/C catalysts with different metal loading and demonstrated the chemical modification with 2-methylpropionamidine. The modification was revealed from the results of EPMA, XPS and TPD-MS for the catalysts. Both of ECSA and the current for Pt oxide formation was decreased after the modification; on the other hand, ORR specific activity as well as durability was increased.

(16) "**Molecular dynamics analysis of the scattering phenomena of oxygen molecules of an ionomer surfaces in catalyst layer of fuel cell**"

Keisuke Mizuki (Tohoku University)

Abstract The purpose of this study is to clarify the effect of surface diffusion, which is the behavior of gas molecules on ionomer thin films, on the transport properties of oxygen in fuel cell catalyst layers. To this end, Monte Carlo (MC) and molecular dynamics (MD) methods were used in our simulations. The results of the MC method showed that the overall transport is strongly affected by the behavior of surface diffusion. It was found that the surface diffusion model used in the MC method needs to be examined by the result in MD method that oxygen tends to reflect in the direction of travel.

(17) "**Impact analysis of bilayer electrolytes on system efficiency for protonic ceramic fuel cell**"

Shun Yamate (The University of Tokyo)

Abstract The effect of suppressing leakage current using proton-conducting bilayer electrolytes on the efficiency of power generation systems is investigated. Cross-plane resistances were obtained from two-probe electrical and EIS measurements to assess bilayer electrolyte candidates. Furthermore, protonic ceramic fuel cell (PCFC) power generation systems were also designed based on the transport properties of monolayer and bilayer electrolytes. As a result, the system efficiency of a $BaZr_{0.8}Y_{0.2}O_{3-\delta}$(BZY20) / $La_{1.9}Ca_{0.1}Zr_2O_{7-\delta}$ (LZC) cell was 7% higher than that of a monolayer BZY20 cell under the operating temperature of 600°C, the external current density of 300 mA/cm², and the fuel utilization of 95%.

3. Topics related to fuel cell, hydrogen energy and renewable energy: from 27th March to 27th May, 2023

<Government/Kantei, NEDO, JOGMEC>

1) "**Ministerial Council on renewable energy, hydrogen and related issues**", 4th April, 2023
URL: https:// japan.kantei.go.jp/101_kishida/actions/202304/_00003.html
In English

2) "**Integrated electrochemical systems for scalable CO2 conversion to chemical feedstocks by Chiyoda Corp. Regime in moonshot annual report 2021**", 22nd April downloaded, 2023

URL: https:// www.nedo.go.jp/content/100953788.pd

In English

3) "**The Signing of agreement of joint study to verify GHG emissions of clean ammonia production project in UAE**", 18th April, 2023
URL: https:// www. jogmec.go.jp/english/news/release/news_10_00033.html
In English

<Business Papers and Sites>

1) "**Compact hydrogen FCs for industrial applications/NEXTY Electronics**", 1st April down-loadedFeb., 2023
URL: https://www.nexty-ele.com/english/actual/detail/hydrogen-fuel-cell/
In English

2) "**Japan companies applaud EU deal that allows e-fuel car sales after '35**", 31st March, 2023
URL: https://www.asahi.com/ajw/articles/14872848
In English

3) "**Even the food trucks are different in Fukushima -- fueling and feeding the local community**", 5th April, 2023
URL: https://toyotatimes.jp/en/newscast/012.html
In English

4) "**Japan seeks to increase hydrogen supply by six times by 2040"**, 8th April, 2023
URL: https://japannews.yomiuri.co.jp/politics/politics-government/20230408-102115/
In English

5) "**Japan to update hydrogen energy strategy in push for carbon neutrality**", 4th April, 2023
URL: https://www3.nhk.or.jp/nhkworld/en/news/20230404_13/
In English

Japan will revise its basic strategy on hydrogen, with the aim of sharply increasing the use of the climate-friendly fuel to speed up the shift to a carbon-neutral society. Prime Minister Kishida Fumio held a meeting of relevant cabinet ministers on Tuesday. He said that he plans to revise the strategy, drawn up six years ago, by the end of May. The revised document is expected to call for a six-fold increase in the use of hydrogen to around 12 million tons by 2040. Officials are also considering introducing hydrogen subsidies to cover the difference in market prices with coal and natural gas. Another idea is to develop an industrial complex that would use hydrogen on a mass scale. To fund these measures, the revised strategy is expected to call for public and private investments worth around 15 trillion yen, or about 113 billion dollars, over the next 15 years. Kishida said he will promote Japan's de-carbonization at a time when the United States and Europe are heavily investing in hydrogen and other renewable energy sources. He urged the ministers to work together to produce concrete results.

6) "**Toyota vows to expand EV lineup, boost sales by 2026**", 7th April, 2023
URL: https://mainichi.jp/english/articles/20230407/p2g/00m/0bu/046000c
In English

TOKYO (Kyodo) -- Toyota Motor Corp. said Friday it will expand its all-electric vehicle lineup by launching 10 new models and aim to sharply increase its EV sales to 1.5 million units annually by 2026, accelerating efforts to prop up its sluggish battery-driven car business under the leadership of new President Koji Sato. "We will do our utmost to push forward with electrification," Sato said at his first press conference after taking the helm of the world's largest automaker on April 1. "We will ramp up our efforts to achieve carbon neutrality." The new EV sales target represents a significant jump from the 24,000 units the company sold in 2022. Including gasoline-powered vehicles and other vehicles, it sold more than 10 million units in the same year. The automaker also revealed a plan to start producing all-electric sport utility vehicles in the United States in 2025 as well as battery-driven pickup trucks in emerging countries later this year. All-electric models offered by Toyota include the bZ4X, its first mass-produced EV model, and UX300e under its upscale Lexus brand. There is no change in its existing plan to sell 3.5 million EVs by 2030, the company said.

While expanding the EV business, the developer of the Prius, the world's first mass-produced hybrid passenger vehicle, said it will work to maintain its lineup, including hybrid and fuel cell vehicles. "We will continue to pursue diverse options" to reduce carbon emissions, Sato said, adding that the company will ramp up sales of hybrid and plug-in hybrid cars and also aim to expand the use of hydrogen-powered cars. His remarks came after the company pledged to develop next-generation electric vehicles by 2026 in an apparent effort to catch up with overseas rivals, which bet on the potential of all-electric cars earlier on. The company also said it will set up a new unit to develop the next-generation EVs and is considering building a battery factory to catch up with the speed of EV production. Sato, the 53-year-old former Lexus division head, succeeded founding family scion Akio Toyoda in the first change of guard at the company in 14 years. Toyoda became chairman of the company. In the press conference, Sato emphasized the company will be run as a team under his leadership rather than employing a management style in which a leader decides everything.

"I hope to be a president who continues to be involved in the production of cars," Sato said, as he vowed to keep improving the quality of Toyota's cars together with Toyoda.

7) "**JR West considers hydrogen utilization plan, development for introduction of 'fuel cell train'**", 12th April, 2023
URL: https://portalfield.com/en/news/vehicle/4768860
In English

8) "**Toyota to launch new hydrogen-powered fuel cell 'Crown' model**", 13th April, 2023
Photo available
URL: https://japannews.yomiuri.co.jp/business/companies/20230413-103330/
In English

9) "**Idemitsu lunches feasibility study in Japan into clean hydrogen production from waste**", 13th April, 2023
URL: https://www.idemitsu.com/en/news/2023/230413.html
In English

10) "**World first FC powered rubber tire gantry crane(RTGC) demonstrated** ", 20th April, 2023
Photo available, more detailed (refer to "https://www.nedo.go.jp/news/press/AA5_101637.html)
URL: https://motor-fan.jp/tech/article/32983/
In Japanese

11) "**Toyota focuses on emission cuts rather than on EV sales: new president K. Sato**", 21st April, 2023
URL: https://mainichi.jp/english/articles/20230421/p2g/00m/0bu/058000c
In English

12) "**"Let's change the future of cars!" Press Q&A helps illuminate two new principles**", 17th April, 2023
URL: https://toyotatimes.jp/en/toyota_news/new_management_policy/002.html
In English

13) "**G-7 to agree no need to diversify fuel sources, push decarbonization**", 16th April, 2023
URL: https://mainichi.jp/english/articles/20230416/p2g/00m/0na/008000c
In English

14) "**Honda aims for early EV release in North Amerika**", 26th April, 2023
URL: https://www3.nhk.or.jp/nhkworld/en/news/20230426_35/
In English
Honda Motor has announced plans to launch an electric vehicle model in North America in 2025, a year earlier than initially scheduled
as it accelerates its shift to EVs. Honda Motor's President and CEO Mibe Toshihiro says, "Our revenue from internal combustion engines, including hybrids, is being actively reinvested in fields such as electric vehicles and software so that we can speed up the change to these new technologies." Mibe also says a strategic cooperative agreement has been reached with Taiwan Semiconductor Manufacturing Company, or TSMC, as Honda expects it will need more chips for its EV models. Honda says it is focusing on its goal of all new models being electric or fuel cell powered by 2040. It also aims to produce more than two million EVs per year globally by 2030.

Honda last week unveiled the goal of making all new models for China electric by 2035, which is five years sooner than an earlier plan.

15) "**Liquid hydrogen car gears up 24-hour race--Comment after Suzuka opener withdrawal**", 27th April, 2023
URL: https://toyotatimes.jp/en/report/hpe_challenge_2023/002.html?padid=ag478_from_pickup
In English

16) "**Toyota's hydrogen fuel cell trucks receives zero emission certification in California**", 4th May, 2023
URL: https:// m.energytrend.com/news/20230504-31985.html
In English

17) "**Zero-emissions ships using new fuel to get safety guidelines**", 1st May, 2023
URL: https://japannews.yomiuri.co.jp/politics/politics-government/20230501-106868/
In English

18) "**Japan transportation firms test fuel-cell truck**", 8th May, 2023
URL: https://www3.nhk.or.jp/nhkworld/en/news/20230508_34/
In English

Officials at Japan's transportation firms are looking at ways to support a government campaign for a carbon-free society. On Monday they tested out a vehicle that could make a big difference -- a hydrogen-powered fuel-cell truck that emits no carbon dioxide. Company representatives put the vehicle through its paces at the event, organized by the industry ministry and other parties. The truck is the creation of Japanese automakers Isuzu and partner Toyota. The firms say it can get 260 kilometers on a 10-minute charge. Fuel-cell vehicles have a longer cruising range than EVs and are expected to play a big role in long-distance trucking.
One attendee said he's impressed by how smooth the truck feels. He said it puts less stress on the driver's body, and hopefully will help reduce accidents involving truck drivers who work long hours. Japan's energy conservation law says that by 2030, 5 percent of trucks at big transportation firms should be hydrogen fuel cell or electric. Government officials say there are currently plans to put about 300 fuel-cell trucks on the road this year in areas that include Tokyo and Fukushima prefectures.

19) "**Supply fuel cell system for its FC-powered heavy-duty truck scheduled to be launched in 2027**", 18th May, 2023
URL: https://www.isuzu.co.jp/world/newsroom/details/20230515_1.html
In English

20) "**Japan auto group: EVs not the only way forward**", 18th May, 2023
URL: https://www3.nhk.or.jp/nhkworld/en/news/20230518_39/
In English

Representatives from Japan's top auto industry body says EVs are not the only way to reduce carbon emissions from vehicles. They say auto makers should use every clean technology at their disposal to cut their carbon footprint. Officials from the Japan Automobile Manufacturers Association shared their view at a news conference on Thursday, the day before the opening of the Group of Seven summit in Hiroshima. Chairman Toyoda Akio said each country and region faces a different set of circumstances. He said the

world needs a variety of technologies to account for these differences. G7 leaders are split on the question of setting targets for EV numbers.
The industry group will exhibit a range of Japanese EVs, hybrid cars and fuel cell vehicles in the host city during the summit.

21) "**Toyota, Subaru to jointly develop electric SUV as early as 2025**", 17th May, 2023
URL: https://mainichi.jp/english/articles/20230517/p2g/00m/0bu/002000c
In English

22) "**Japanese motorcycle makers to jointly develop hydrogen engine**", 17th May, 2023
URL: https://www3.nhk.or.jp/nhkworld/en/news/20230517_26/
In English

Four Japanese motorcycle manufacturers are teaming up to develop a hydrogen-powered engine that could help cut carbon emissions and contribute to Japan's goal of carbon neutrality. Honda Motor, Yamaha Motor, Suzuki Motor and Kawasaki Motors unveiled a plan to jointly set up a body as early as this month to research and develop hydrogen engines for motorcycles.
Each company will work on a different research area. They hope to apply their findings to mini-vehicles and drones as well.
Honda says "the use of hydrogen poses technical challenges, including fast flame speed and a large region of ignition, which often result in unstable combustion" and "limited fuel tank capacity in case of use in small mobility vehicles." The four companies have already worked together on other carbon-neutrality projects, such as providing a service for sharing replaceable batteries for electric motorcycles. Yamaha President Hidaka Yoshihiro told reporters there needs to be a wide range of technological potential to achieve carbon neutrality, and hydrogen is one focus of attention. Hydrogen-powered engines are already being tested in automobiles. Toyota Motor has installed one in a racing car.

23) "**Honda, others to launch joint research on hydrogen engines**", 18th May, 2023
URL: https:// jen.jiji.com/jc/eng?g=ind&k=2023051800301
In English

24) "**Yusen Logistics (Europe) introduces FC truck**", 22nd May, 2023
URL: https://www.lnews.jp/2023/05/p0522503.html
In Japanese

25) "**100kW hydrogen fuel cell-digital twin in operation-using green hydrogen and waste plastic hydrogen**", 14th Feb., 2023
URL: https:// www.titech.ac.jp/english/news/2023/066737
In English

26) "**Komatsu develops medium-sized hydraulic excavator equipped with hydrogen fuel cell**", 20th May, 2023 Photo available
URL: https:// www.asia-manufactures.com/?p=1379
In English

27) "**Honda to return to Formula One in 2026**", 24th May, 2023

URL: https:// www3.nhk.or.jp/nhkworld/en/news/20230524_19/
In English

Honda says it will return to Formula One racing in the 2026 season, after withdrawing in 2021. The automaker has a deal to provide Aston Martin with hybrid engines. The team will be called Aston Martin Aramco Honda. Honda Motor President and CEO Mibe Toshihiro said, "The technology and know-how gained from F1 could be directly used in future mass-production electric vehicles, including our flagship sports models." Honda more recently said it would concentrate its managerial resources on its de-carbonization efforts, and formally withdrew in 2021. The automaker aims to shift its global new car sales entirely to EVs and fuel cell vehicles by 2040. Honda says it decided to return to the race because rules starting in the 2026 season are in line with the company's policy to pursue de-carbonization. Honda explained that F1 will require use of sustainable fuel and that a race vehicle get at least half of its power from a source other than a combustion engine.

28) "**Yamanashi's 'green hydrogen' powers Tokyo exhibition site**", 26th May, 2023
URL: https://www3.nhk.or.jp/nhkworld/en/news/20230526_39/
In English

A major exhibition venue in Tokyo started to power some of its facilities on Thursday with hydrogen generated in the nearby prefecture of Yamanashi. The clean energy source is seen as a key element in efforts to achieve carbon neutrality. The prefecture signed an agreement with the Tokyo Metropolitan Government last year to expand the use of its so-called "green hydrogen." Yamanashi has been carrying out trials to produce the fuel from renewable energies, such as solar and wind, since 2016. Yamanashi Governor Nagasaki Kotaro said that the cooperation with Tokyo will effectively demonstrate the viability of the prefecture's green hydrogen. The prefecture aims to introduce its hydrogen production system in other parts of Japan as well as abroad.

<General papers & other publications>

1) "**Asymmetric behavior of solid oxide cells between fuel cell and electrolyzer operations** ", 15th April down-loaded, 2023
Journal published on April 12, 2023 Abstract available
URL: https://repository.kulib.kyoto-u.ac.jp/dspace/handle/2433/279846
In English

2) "**A novel Pt nanocluster for improved ORR in FC by Prof. Y Negishi (TUS)**", 17th April, 2023
URL: https://www.tus.ac.jp/en/mediarelations/archive/20230417_1268.html
In English

3) "**Current status of hydrogen energy and strategies of hydrogen-based society**", 22nd April down-loaded, 2023 Free access
URL: https://www.jstage.jst.go.jp/article/jime/54/5/54_668/_article/-char/en
In English (article written in Japanese)

4) "**Nagoya University researchers develop a new ultra-high-density sulfonic acid REM for FCs**", 19th April, 2023
URL: https://www.nagoya-u.ac.jp/researchinfo/result-en/2023/04/20230419-01.html

In English

5) "**"Colloidal Pt nanoparticles dispersed by polyvinylpyrroridone and ply(diallyldimethylammonium chloride) with high catalytic activity for hydrogen reduction based on formate decomposition", Matsubara,Y. et al, Sustainablr Energy Fuels, 2022,6, 3717-3721 ; Research center for Artificial Photosynthesis, Osaka Metropolitan Univ.**", 29th April down-loaded, 2023
URL: https://www.omu.ac.jp/orp/chem-rxn-field/articles.html
In English

6) "**Breaking the barrier: Low-temp. ammonia synthesis with iron catalysts and barium hydride--Abstract and some Figures available**", 25th April, 2023
URL: https://www.titech.ac.jp/english/news/2023/066600
In English

7) "**Ammonia borane for hydrogen source as a mobile power system by T. Nakagawa, Ryukyu Univ.**", 8th May down-loaded, 2023
URL: https://www.jstage.jst.go.jp/article/jieenermix/100/6/100_726/_article/-char/en
In English (Mr. Nakagawa presented in the 30th Symposium, refer to 2.9.(1), abstract available)

8) "**Clarifying the origin of dominant gas transport resistance in fuel cell**", 19th May, 2023
Journal published in March, Toyota Central R&D Labs
URL: https://www.tytlabs.co.jp/en/cms/news/topic-20230516-2618.html
In English

<Press Releases by FCDIC members*>

*Member list: https://www.fcdic.jp/member-list/

1) "**Hazer, Chubu Electric and Chiyoda Joint Forces for first Hazer facility in Japan**", Chiyoda Corporation, 11th April, 2023
URL: https://www.chiyodacorp.com/media/230411_e_1.pdf
In English

2) "**Kobe Steel to accelerate feasibility study of low-CO2 iron metallics project in Oman**", Kobe Steel, 10th April, 2023
URL: https://www.kobelco.co.jp/english/releases/1211747_15581.html
In English

**The URLs are not always permanent. The article and its URL are examined this month.*

4. Future Events

The 3rd H_2 & FC EXPO 2023, Autumn (Title changed from FC EXPO to H_2 & FC EXPO by addition H_2)

The 3rd H_2 & FC EXPO Autumn is scheduled to be held at Makuhari Messe in Chiba Prefecture from 13st to 15th September. Details will be announced later; URL: https://www.wsew.jp/hub/en-gb/about/fc.html

21st International Conference on Solid State Proton Conductors (SSPC-21)

Held on 17th to 22nd September 2023 in Fukuoka.
URL: https://q-pit.kyushu.ac.jp/yamazaki/sspc21.html

MRM2023/IUMRS-ICA2023, Symposium B-2 "Advanced analysis for fuel cell materials and technologies"

Held on 11th to 16th December 2023 in Kyoto.
URL: https://mrm2023.jmru.org