Feature Article:

# Realizing a Decarbonized Society through Innovative Technologies

Conversation

## Helping to make fuel cell vehicles (FCVs) a practical reality with the power of catalysts

N.E. CHEMCAT has positioned the Fuel Cell Catalyst Business as one of the important pillars for achieving Vision 2030. We invited Dr. Akihiro Iiyama, a specially appointed professor at the University of Yamanashi and leading authority on the development of fuel cell vehicle (FCV) systems to discuss topics such as trends in the practical use of hydrogen in society and FCVs in Japan and overseas, as well as the challenges of catalysts in the future with Hiroshi Igarashi, Vice President of N.E. CHEMCAT and General Manager of our R&D Center.

**Hiroshi Igarashi**
Vice President, General Manager of R&D Center

**Prof. Akihiro Iiyama**
Specially Appointed Professor, Director of the Hydrogen and Fuel Cell Nanomaterials Center, University of Yamanashi

## Why hydrogen now?

— To begin with, Professor Iiyama, please tell me about the Hydrogen and Fuel Cell Nanomaterials Center where you serve as Director.

**Iiyama:** The University of Yamanashi has put effort into research on catalysts for fuel cells since the 1960s. The university's efforts were recently recognized and the Fuel Cell Nanomaterials Center was established in 2008 as a project of the New Energy and Industrial Technology Development Organization (NEDO). The name was subsequently changed in 2022 in light of the growing importance of hydrogen.

**Igarashi:** Interest in hydrogen has surged globally since the Declaration of the Carbon Neutrality Coalition in 2021, hasn't it?

**Iiyama:** Maximum utilization of renewable energy is necessary to achieve carbon neutrality. The key to that is the handling of surplus electric power.

In Europe, surplus electric power is used to operate water electrolysis equipment. They are gradually installing systems for converting electric power to hydrogen and storing it, and converting it back to electric power when necessary. They are also using hydrogen as alternative fuel, as a heat source for plants and other facilities. Efforts have also emerged to produce synthetic fuel (e-fuel) using hydrogen and atmospheric $CO_2$ as raw materials and use this as a new energy source. Clean hydrogen is the key to both of these efforts.

**Igarashi:** Looking back, Japan pursued research on the use of hydrogen early on, since the Sunshine Project in 1974. They were looking at hydrogen use from the perspective of energy conservation at the time, but hydrogen is now drawing interest as a $CO_2$-free energy source and, unlike electric power, it is viewed as an energy source that is easy to use because it is possible to store and transport it. I think hydrogen is drawing interest as a new energy source due to these advantages.

— How will the world approach hydrogen in the future?

**Iiyama:** Europe is where conditions have changed rapidly with respect to energy sources. Europe was pursuing the introduction of clean hydrogen as part of the trend toward carbon neutrality when Russia suddenly invaded Ukraine. As a result, Europe had to rapidly wean itself from natural gas imported from Russia and transition to new energy sources. The target for introduction of hydrogen has doubled, also out of consideration for energy security.

**Igarashi:** The U.S. has also announced a National Clean Hydrogen Strategy. Just the other day, at the presentation session related to energy that I attended with you in the U.S., I was surprised by the statement that the hydrogen fuel cell market size has increased from the previous level of several tens of millions of dollars to several billions of dollars. A huge budget has also been set for establishing infrastructure and I feel that the budget for hydrogen energy will really increase rapidly and keep pace. Europe and the U.S. are also investing in building a supply chain to sustain a hydrogen-based society.

**Iiyama:** The Japanese government has also reacted to such movements with acute sensitivity and announced an updated Basic Hydrogen Strategy in June 2023. This strategy has set a target of 15 GW for the introduction of water electrolysis equipment for 2030 in companies related to Japan, both in Japan and overseas. It is noteworthy that Japan has set a target in both Japan and overseas, or in other words, a target for Japan's share of the global power generation market. I know the Japanese government is thinking of a plan for expanding the water electrolysis industry in Japan overseas and think companies are probably getting a fresh sense of the enormity of the expectations. Moreover, the Japanese government also announced an additional new intermediate target for 2040, even though they have only set targets for the domestic introduction of hydrogen in 2030 and 2050. The concrete plan, which also includes energy exports from Japan, is an unprecedented move, and it is having a strong impact on hydrogen-related industries.

— How is the industrial world taking the government's activity?

**Igarashi:** As a company, up to this point we haven't known the specific indicators for how far we should proceed on R&D, how much volume to target, by when, and to what level. To be honest, I thought the hydrogen conversion as an energy source would be difficult by only using surplus electric power and renewable energy to produce hydrogen. However, the fact that Japan has determined the policy as a country also clarifies our policy on investment as a company. I see the national strategy as a strong push from behind.

**Iiyama:** Seeing the movement at the national level gives me a strong sense of wanting to develop hydrogen into a competitive industrial field. For example, using the water electrolysis equipment of Japanese companies in the Middle East and other areas with an abundance of renewable energy to produce clean, cheap hydrogen and transport it to Japan. I think movement in that direction will accelerate from this point on.

## Catalysts, the key to the hydrogen value chain

— Catalysts are essential technology in thinking about the value chain for hydrogen, as hydrogen increases in importance. What challenges do catalysts present?

**Iiyama:** Catalysts present the problem of resources for iridium, which is a rare metal. As a catalyst with high oxygen generation activity and high durability, iridium is the first rare metal I would mention. The underground reserves and the amount extracted are both extremely small. I look forward to N.E. CHEMCAT using its technological prowess to make progress on resource conservation, on that point.

**Igarashi:** We, of course, also recognize the problem with using a large amount of iridium. We are therefore developing catalysts that can minimize the amount of iridium used as much as possible, and are also taking on the challenge of open innovation with the National Laboratories in the U.S. It is the role of catalyst manufacturers such as N.E. CHEMCAT to provide a stable supply of high quality catalysts that offer high performance. I am convinced that it will be difficult to develop practical applications of innovative catalysts, including the cost involved, as long as we limit our research to the current trajectory. We are therefore aiming to develop high performance catalysts that have the potential to change the world if we can develop them successfully.

**Iiyama:** Expanding the discussion to the entire hydrogen value chain, how do you think it will develop?

**Igarashi:** The use of ammonia and other hydrogen compounds to store and transport hydrogen, and the use of hydrogen to produce clean fuel are examples. Catalysts play an important role in either case so we are also keeping in mind contributions in these areas.

## Roadmap to developing a hydrogen-based society and practical use of FCVs

— The proliferation of FCVs is a major key to expanding the demand for hydrogen. How do you think it will proceed?

**Iiyama:** We need to divide FCVs into passenger cars and commercial vehicles and think about them separately. In the passenger car category, there are a huge number of competitors such as battery electric vehicles (BEVs) and plug-in hybrid vehicles. The market is also established. On the other hand, we cannot say that a sufficient number of hydrogen stations have been established to provide the infrastructure for FCVs. At present, it is difficult to make progress on establishing hydrogen stations because of the cost, so it is hard to choose an FCV for a passenger car as a practical matter.

**Igarashi:** However, the situation changes completely in the case of commercial vehicles.

**Iiyama:** That's true. For example, BEVs are not practical as large trucks because their continuous driving range is limited. In that case, the competitors in the commercial vehicle category are e-fuel, hydrogen engines, and similar technologies, but FCVs are the most practical option in terms of cost and efficiency in that case. I therefore think that widespread proliferation of FCVs will begin from large commercial vehicles.

**Igarashi:** In the U.S., there is movement toward using FCVs for trans-continental trailers and other transport vehicles. If transport is limited to certain routes, it will suffice to establish hydrogen stations in the necessary locations, so this will likely make practical implementation possible.

**Iiyama:** However, we are not just ignoring passenger cars because of this. Research on FCVs as large commercial vehicles is proceeding at NEDO as well. If this research is successful, it is conceivable that FCVs hold future promise in segments such as large vehicles where they are competing with BEVs, even in the passenger car category.

**Igarashi:** We are also working with the auto manufacturers to develop FCVs, but this is mainly focused on commercial vehicles, and on large passenger cars, after that. If FCVs spread to this genre, I think the means to solve the problem of infrastructure will become clear. In Europe and the U.S., hydrogen stations are being established based on the premise of accommodating long-distance travel. If FCVs begin to become popular as commercial vehicles in Japan, this will likely spur efforts to establish the infrastructure to stimulate demand here as well.

— Catalysts play an important role in practical applications for FCVs. Practically speaking, what technological requirements and standards would suffice?

**Iiyama:** NEDO has created a roadmap for the level of requirements and has disclosed the numerical values that should be met for catalysts used in fuel cells for large commercial vehicles. The values set are on a completely different level than before. The operating temperature was set at 95°C up to this point, but stable operation is now required at 120°C, a far higher level. The target is so high that it strikes catalyst researchers as absurd.

**Igarashi:** It is certainly an inconceivable target, in a sense. In my view, achieving this target will necessitate joint development in which materials manufacturers work with technology manufacturers as a team.

**Iiyama:** I see the establishment of an extremely high target as the flip side of the sense of urgency. In short, pursuing technological development along conventional lines cannot overcome the limitations, so it will require material informatics and other types of disruptive innovation. Innovation is essential in order to achieve the level of practical application we want to see in 2040.

**Igarashi:** I have been involved in fuel cell development for 30 years. At the time, I thought that FCVs would be driving all over the world in 30 years' time. Many researchers held the same view, so much so that the comment "it isn't going as well as we expected and we are really struggling" took the place of the customary greetings when meeting with auto manufacturers overseas. However, just as you stated, we will not aspire to game-changing innovation unless we set a target that strikes us as impractical now. My dream for the future is to make the FCV a car for the general public. I want the presence of the FCV to be high enough so it is the first thing everyone thinks of when they think about buying a car.

**Iiyama:** I look forward to the development of the next-generation catalysts and core-shell catalysts that will make that possible. Use platinum and other materials with high activity on the surface of catalyst particles, or apply in one layer on the shell, and use different materials for the core. This will drastically reduce the amount of platinum, a rare metal, used. Ultimately, how far catalyst development on a monoatomic layer progressed?

**Igarashi:** As I mentioned earlier, we are engaged in joint development with the U.S. National Laboratories and, to be honest, I cannot discuss the details at present. However, I want to create a world in which FCVs are routinely driving around by around 2040. To achieve that, I think our proposal for 2030 needs to be concrete in form.

## Developing human resources for the next generation in the field of hydrogen

— Hydrogen is bursting with potential and it is essential to have the human resources to achieve that potential. How are you thinking of developing human resources?

**Iiyama:** We are implementing two initiatives at present. One is conducting a Hydrogen and Fuel Cell Industrial Technology Human Resources Training Course for technicians in small and medium-sized companies in Yamanashi Prefecture, under contract with the prefecture. This training course provides an opportunity for participants to attend lectures by guest lecturers who are engineers in companies that are at the forefront of the hydrogen fuel cell field and learn new skills, including the actual technology used in fuel cells.

The other initiative is a Hydrogen and Fuel Cell Class designed for local elementary and middle school students. I want the youth who will be responsible for the future to learn what is exciting about hydrogen. In that sense, the new Clean Energy Chemistry Course established in the University of Yamanashi Faculty of Engineering in April 2024 is also one way to develop the human resources who will be responsible for hydrogen energy in the future.

**Igarashi:** I think excellent talent will emerge from those initiatives. N.E. CHEMCAT also has great expectations of your initiatives, Professor Iiyama. As you mentioned, the skills of young people are essential to R&D. There are also cases in which innovative ideas waft in from people outside of specialized areas. We therefore also make a conscious effort to give form to small insights and discoveries. It is extremely important to have an environment where everyone can debate ideas and technology, regardless of their position in the hierarchy, and stimulate one another to innovate. I pay more attention to "creating the environment to develop people" rather than "developing people."

**Iiyama:** Our discussion today has given me a fresh awareness of how catalysts are used in manufacturing and a wide range of other areas in society, in addition to hydrogen, and how essential catalysts are to achieving carbon neutrality. I think there is business for your company at each point, so keep up the good work and do not miss out on such opportunities.

**Akihiro Iiyama**

Joined a major auto manufacturer after graduating from The University of Tokyo. After working on R&D on fuel cells, EV systems, and other topics and serving as the General Manager of the Fuel Cell and EV System Laboratories, he became a specially appointed professor of the University of Yamanashi Graduate School for Engineering in February 2015. Professor Iiyama performs research on automotive fuel cell systems, electrode catalysts, electrolyte materials (membranes), MEA, and other areas. PhD, Engineering.