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Technology Development to Store Hydrogen in Metal Particles

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1. Governmental Measures

(1) METI

On July 15th, the Minister for Economy, Trade and Industry Toshimitsu Motegi had a test ride on a fuel cell vehicle (FCV) of Toyota Motor to be introduced in FY 2014 at the Head Office of the firm in Toyota City. The president of the automaker and the minister discussed growth of FCVs. "I told Mr. Toyoda, the president, that the Ministry of Economy, Trade and Industry (METI) planned to use FCVs as official cars" said Mr. Motegi after the talk. (Nikkan Jidosha Shimbun, July 17, 2014)

METI has decided to keep the subsidy scheme for the purchase of electric vehicles (EVs) and plug-in hybrid vehicles (PHVs) until FY 2016 and onward. The scheme was planned to finish at the end of FY 2015 when the prices of these vehicles are likely to become affordable and a charging infrastructure is expected to be prepared. Then the ministry was going to focus on helping FCVs with a subsidy. They looked into the recent sales trend of EVs and PHVs, and determined that these vehicles still needed to be supported by the subsidy. The budget and details of the scheme will be sorted out again for these vehicles. The scheme is the "Subsidy for Expenses for Measures to Promote the Introduction of Clean Energy Vehicles" which is partially supplied from the special account of energy measures. (Nikkan Jidosha Shimbun, July 22, 2014)

The ministry will develop a technology to store and transport a large amount of hydrogen at low cost. The aim is to transport "hydrogen in the form of liquid" at -253 °C or as "organic hydride", which is hydrogen combined with another material, to hydrogen filling stations. Related technologies and facilities are also planned to be developed as a whole system by the mid-2020's. These technologies to make hydrogen liquid enable the volume to be reduced to between 1/500 and 1/800, and substantially increase efficiency of storage and transport. METI has determined these technologies as the basic technologies to import a large amount of hydrogen to distribute in Japan, and it will accelerate developments. (Nikkan Jidosha Shimbun, July 24, 2014)

(2) Japanese Government

The Japanese government has decided to use FCVs as official cars from the next fiscal year. On July 25th, Chief Cabinet Secretary Yoshihide Suga ordered the use of FCVs in all ministries and governmental organizations as official cars to support and promote these vehicles, at a cabinet meeting. Currently six FCVs are used as a test in ministries including METI and the Ministry of the Environment (MOE). (The Asahi Shimbun, July 18, 2014; The Sankei Shimbun, Nikkan Jidosha Shimbun & The Japan Agricultural News, July 26, 2014; The Denki Shimbun & The Chemical Daily, July 28; The Nikkan Kogyo Shimbun, July 29, 2014)

On July 18th, Prime Minister Shinzo Abe revealed the government's intension to make a subsidy scheme for FCV purchases as a promotional measure. He indicated "at least ¥2 million for each car" and the "preparation of 100 hydrogen filling stations nationwide". He visited Fukuoka City, and these ideas were announced as an answer to a question at the press conference there. (The Mainichi Newspapers & The Nikkei, July 19, 2014; Nikkan Jidosha Shimbun, July 22, 2014)

(3) MEXT

The Council for Science and Technology of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) has started investigating a new way to use the "high-temperature test reactor" which is expected to be a next generation nuclear reactor to produce electricity and hydrogen. In the new method, the primary heat of the reactor will generate electricity, and the waste heat will produce hydrogen as fuel. This method can produce energy more efficiently than conventional nuclear reactors used only for electricity. (The Nikkei Business Daily, July 29, 2014)

(4) MLIT

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) will compile a "Five-Year Plan of Technology Development" (provisional name) for sewage work including energy related technologies in this fiscal year. A committee will soon launch with sewage treatment departments of local governments, universities, research institutions and private organizations to study actual measures of the plan. The plan will include technology developments for energy saving and creation such as a microbial fuel cell (MFC) and algaculture and energy extraction, and they plan for these technologies to be commercialized. The energy creation area of the plan is likely to have technologies of electricity generation using hydrogen produced by biomass. (The Denki Shimbun, July 30, 2014)

(5) NEDO

The New Energy and Industrial Technology Development Organization (NEDO) considers that a long-term measure is necessary to achieve a hydrogen society, and finished the first "white paper on hydrogen energy" on July 28th. The white paper shows measures to reduce the cost of a whole hydrogen distribution system including production, transport and sales. "Consumer hydrogen businesses have just begun. Technologies need to be established to provide hydrogen at low cost for significant growth." said Dr. Eiji Ohira, a senior researcher. The white paper says that NEDO plans to make hydrogen one of the major energy sources. The hydrogen market in Japan is expected to be ¥1 trillion by 2030 by new usage and growth such as Ene-Farm and FCVs, and to expand to ¥8 trillion by 2050. (The Nikkei, July 29, 2014; The Mainichi Newspapers, The Sankei Shimbun & The Nikkei Business Daily, July 31, 2014)

NEDO has revealed a plan to commercialize a system by which electricity from renewable sources such as wind and solar is used to operate hydrogen production facilities, and hydrogen is provided to FCVs. The project aims to promote FCVs by using renewable energy and to extend the usage of hydrogen as well as efficient energy use at the same time. In early September, the organization will advertise for an operator of the experiment for commercialization of the project to start this year. The experiment period is from three to five years, and the annual cost is expected to be approximately ¥300 million. (The Yomiuri Shimbun, July 26, 2014; The Nikkei, July 31, 2014)

2. Local Governmental Measures

(1) Tokyo

On July 4th, Tokyo held the second meeting of the Tokyo Strategy Committee for a Hydrogen Society, and brought up a draft showing a future hydrogen society in Tokyo. The draft contains actual measures in each area. The city planning area has the development of a hydrogen usage system working in a smart community, which is a part of redevelopment, and optimization of energy efficiency in each area unit by sharing electricity, heat and hydrogen. Transport measures are the promotion of hydrogen filling stations in the urban area, and the use of heavy construction equipment powered by fuel cells (FCs). In the home usage area, they aim for approximately 1 million domestic FCs in Tokyo by 2030. (The Denki Shimbun & Nikkan Kensetsu Sangyo Shimbun, July 8, 2014)

(2) Yamanashi Prefecture

Yamanashi Prefecture had compiled a promotional plan for FCVs, and revealed it on July 8th. Since the University of Yamanashi is going to research FC in cooperation with an automaker, the prefecture will promote itself as an advanced FC base. With actual measures, the plan indicates four core aims including targets such as 800 FCVs and 10 FC busses to be used in the prefecture in the 10 years from 2015 to 2025 and the promotion of FCV purchase and hydrogen filling station preparation. FCVs will be supported by a subsidy scheme and preferential treatment. The subsidy scheme possibly includes financial support, which works with the governmental subsidy, for taxi operators, and for residents. The prefecture considers using FCVs as official cars as a measure. Because FCVs have less impact on the environment, a preferential toll of the Mt. Fuji Toll Road (Subaru Line) and immunity from the private car control of the toll road are under consideration. (The Yamanashi Nichinichi Shimbun, July 9, 2014)

On August 1st and 2nd, Yamanashi Prefecture will exhibit FCVs and offer test rides at Aeon Mall Kofushowa. The shopping mall will display "Toyota FCV Concept", a prototype, and prepare another two FCVs for test rides. Toyota's researcher will visit there to give a talk, and an exhibition of a hydrogen filling facility will also be there. The prefecture aims to be an advanced FC base with targets of 800 FCVs to be used in the 10 years between 2015 and 2025. (The Yamanashi Nichinichi Shimbun, July 23, 2014)

Iwatani plans to install a hydrogen filling station in Yamanashi Prefecture. On August 1st, the firm and prefecture decided the head office of Yamanashi Kotsu, a bus operator, in 3 Chome, Iida in Kofu City as the location for the filling station. Being very convenient, the site was chosen to be a possibility to expand FC bus usage in the future. (The Yamanashi Nichinichi Shimbun, August 2, 2014)

(3) Osaka Prefecture

On July 4th, Osaka Prefecture chose projects for the subsidy to support EV and FCV related technology developments of smaller businesses. Seven applications were sent for this subsidy from businesses in the prefecture. The prefecture selected six applications with a total subsidy amount of ¥27.92 million. According to the prefecture, these projects are close to commercialization as well as highly unique and innovative. The chosen subjects are three EV production and conversion projects, two EV related equipment projects and one FCV related equipment project. (Nikkan Jidosha Shimbun, July 11, 2014)

Osaka Prefecture will put more effort into FCV promotion and infrastructure preparation. From the full introduction of FCVs into the market, they will help the procurement of sites for hydrogen filling stations which are a key to FCV sales, and request more deregulation by the Japanese government. Support will be given to smaller businesses which have hydrogen filling station-related technologies or products in the prefecture in order to reduce installation cost. The "Osaka FCV Promotion Committee" consisting of FCV related businesses, organizations and universities will draw up a road map indicating the FCV sales estimate for FY 2025, and the required infrastructure. (Nikkan Jidosha Shimbun, July 24, 2014)

(4) Aichi Prefecture

On July 22nd, Aichi Prefecture announced that FCV, commercially available soon, would be exempt from the automobile tax. The exemption is up to ¥174,500, and for about five years. The scheme will start when the commercial sales begin. When a new FCV is registered, automobile tax will be exempt for the rest of the fiscal year plus five years. According to the prefecture, automobile tax exemption schemes for FCVs are unusual throughout Japan. For FCV purchases by smaller businesses and taxi operators, the prefecture also decided to support a partial price difference between conventional cars. The rate is expected to be a price difference of about 25%. (The Nikkei & The Nikkan Kogyo Shimbun, July 23, 2014)

(5) Fukuoka City

On July 31st, the research consortium of Fukuoka City and Kyushu University held a groundbreaking ceremony of a hydrogen production plant for its experiment to produce hydrogen from sludge at the Central Sewage Treatment Center in Chuo-ku, Fukuoka City. Approximately 20 people attended from the city office and the Ministry of Land, Infrastructure, Transport and Tourism (MILT). The plant will use sludge from sewage treatment processes to produce high purity hydrogen of over 99.99 %, at a daily rate of approximately 3700 m^3, and sell hydrogen for FCVs. (The Nishinippon Shimbun, August 1, 2014)

3. Microbial Generation Research & Development

(1) The University of Tokyo, Sekisui Chemical, Tokyo University of Pharmacy and Life Sciences & Panasonic

Microbial fuel cells (MFCs), which produce electricity by the digestion of microbes, are under development at a number of organizations. The University of Tokyo and Sekisui Chemical will together install a facility at a chemical plant, and start experiments to supply electricity for a waste water process in the plant in October. In addition, the Tokyo University of Pharmacy and Life Sciences and Panasonic have joined the project. The electricity production uses "Geobacter", a common bacterial species in soil. The bacteria grow on the surfaces of electrodes made of low cost metal in the FC system, and the team made the system more air-tight to improve generation efficiency. In a small scale experiment to process 1 L of waste water, 40% of electricity produced by the bacteria was collected. The team will install a FC system to process 1000 L ($1m^3$) waste water at a plant at Sekisui Chemical, and experiment to supply 80% of energy for the waste water process. For practical use, 1000 m^3 of waste water needs to be processed each day, and they will pick up issues through the experiment. Output level of 10 to 20 kW is expected in the future, and the technology is planned to be commercialized in 10 years. (The Nikkei, July 29, 2014)

(2) Tokyo Institute of Technology

The Tokyo Institute of Technology has succeeded in improving generation efficiency using carbon nanotubes (CNTs), a very fine carbon material. Prof. Naoto Ohtake at The Tokyo Institute of Technology developed a system to achieve highly efficient generation. Baker's yeast grew on a mesh made of dispersed nanometer level CNTs, and organic matter was added for decomposition. The generation efficiency was 10 times that of conventional material. The nanotube mesh appears to improve the efficiency by capturing microbes. Sewage contains plentiful organic matter which can be used as fuel, and the team plans to commercialize the technology as new renewable energy as early as possible. (The Nikkei, July 29, 2014)

(3) Tsinghua University of China

In China, a research team led by the Tsinghua University plans to operate a 1,000 L level experimental MFC facility this year. Although a MFC generates a low voltage, it can be used for a chemical reaction. The facility is expected to make material. The team also plans to research on multifunctional cell system combined with desalting. (The Nikkei, July 29, 2014)

4. Magnesium-Air FC

Nippon Valqua Industries has developed a cathode material which can triple the generation ability of a magnesium-air fuel cell (MAFC). The cathode uses activated carbon inside and carbon black, a carbon material, outside both mixed in fluorocarbon polymer in order to increase the amount of oxygen intake for generation. The manufacturer plans to develop MAFC with the cathode as an emergency power source and introduce it into the market. MAFC is a type of battery and uses a salt solution as its electrolyte. The cathode takes oxygen from the air, and a magnesium alloy of the anode is oxidized to free electrons for generation. The firm made a sheet of the cathode material. A conventional cathode is a single layer of carbon black. On the other hand, the new cathode has two layers, 10 to 20 μm activated carbon mixed with fluorocarbon polymer inside, and 20 to 100 nm carbon black mixed with fluorocarbon polymer outside. Activated carbon particles have numerous holes which make a large surface area once uniformly dispersed on a sheet. Because the cathode takes a larger amount of oxygen than that of conventional products for electricity generation, the current value can be increased from 0.5 A to 1.5A at 1.5 V. (The Nikkei Business Daily, July 29, 2014)

5. Ene-Farm Business Plans

(1) Osaka Gas & Sekisui House

On July 14th, Osaka Gas and Sekisui House announced that their experiment of a “smart house”, a next-generation energy-saving dwelling, with residents, achieved annual zero CO_2 emissions. An Annual 82% of energy saving was made from the combination of a FC, a photovoltaic generator and a storage battery of EV. Also ¥310,000 was saved for spending on utility bills and car fuel. The experimental house is located in Nara Prefecture, and the family of an Osaka Gas’s employee has lived there since 2011 to test and improve the system. (The Mainichi Newspapers, The Nikkei, The Sankei Shimbun & The Nikkan Kensetsu Kogyo Shimbun, July 15, 2014)

(2) The Japan Gas Association

At the end of FY 2013 (the end of March, 2014), the accumulated installed capacity of natural gas cogeneration was 4,912 MW, a 1.9 % increase on that of the previous year. Ene-Farm sales significantly went up by 19.6 % for home use. However the growth rate of business use of FC fell below that of FY 2012. (The Nikkan Kogyo Shimbun, July 24, 2014)

6. Cutting Edge Technologies of FCV & EV

(1) China

On July 13th, the Government Office Administration of the State Council of China revealed a policy in which new energy vehicle purchase was set at over 30% of the whole new vehicle purchase by the government as official cars by 2016. These new energy vehicles are PHVs, EVs and FCVs. On July 9th, the Chinese government also decided on exemption of the automobile purchase tax for the new energy vehicles from this September to the end of 2017 at the Standing Committee of the State Council (equivalent of the Cabinet in Japan). Since gasoline price has been kept low in China, new energy vehicles have not taken off in the market. However, the number of cars has rapidly increased, and exhaust gas is now a cause of air pollution. The government is changing to support more new energy car sales. (The Chemical Daily, July 14, 2014; The Nikkei, July 15, 2014)

The government of Shanghai, China, announced that it would purchase 13,000 of new energy cars by 2015. These new energy cars are EVs, PHVs, and FCVs. In 2014, 4,000 vehicles will be bought and 9,000 vehicles will be obtained in 2015. The details of the total purchase will be 9,500 passenger vehicles, 1,400 busses and 2,100 special vehicles. These vehicles will be used for city public transport, official cars, environmental public health and logistics. (The Nikkan Kogyo Shimbun & The Chemical Daily, July 17 & 22, 2014)

On July 16th, BYD, a major Chinese automaker, announced that an electric bus manufacturing plant would be built in Campinas of São Paulo in Brazil. They will invest 200 million BRL (approximately ¥9 billion) for the plant which is planned to operate from 2015. This plant is the second production base of electric buses after the one in the US for the firm. The production capacity will be an annual thousand level, and the plant will also make core components including batteries. Although consumer EVs have struggled in the global market, the manufacturer aims to expand sales of electric busses for public transport of environmentally conscious countries and regions. (The Nikkei, July 17, 2014)

The State Council of China revealed the "Development Plan of Energy Saving and New Energy Automobile Industry" (for between 2012 and 2020) in June, 2012. The plan shows targets of 0.5 million EVs and PHVs for accumulated production and sales by 2015, 2 million vehicles for production capacity by 2020 and over 5 million vehicles for accumulated production and sales by 2020. Extended range EVs and FCVs are included in the plan as well as the guidance. (The Chemical Daily, July 24, 2014)

(2) Tesla Motors

A US-based EV venture Tesla Motors opened its own shop in Beijing at the end of 2013. The official distribution also started in Shanghai this year, and EVs have been recognized more. "The EV market in China is more likely to take off in 2014" says Huang Leping, an analyst of Nomura International (Hong Kong). (The Nikkei, July 15, 2014)

(3) GML

The electric sports car of EV developer GML, Kyoto City, has been certified for the governmental safety standards. GML has received a notification that the EV "Tommykaira ZZ" is in conformity with the safety standards from MLIT. This is the first time for an electric sports car to be certified in Japan, and allows the car to go on public roads. The firm has already received orders for 99 vehicles, and will start shipping at the end of this month. Tommykaira ZZ was developed by GLM in cooperation with local component manufacturers including Nichicon using study results of the Kyoto University. The advantage is an acceleration performance which allows reaching 100 km/h in 3.9 seconds from a static state. The car drives approximately 120 km continuously on a single charge, and sells for ¥8 million excluding tax. Currently the production is carried out in a plant in Uji City, Kyoto Prefecture, and will move to a plant in Maizuru City in October. The firm plans to obtain a certification from the UK government this year, and to export the car to major European states such as UK, France and Germany. The sales target is 300 vehicles by 2015. The vehicle is planned to go on the Chinese and Taiwanese market in the Asian region next year. The firm started as a venture of Kyoto University to develop EV in 2010, and changed its name from Green Load Motors to GLM in this April. (The Nikkei, July 21, 2014)

(4) Toyota

Toyota Motor has chosen a nickel-metal hydride battery as a storage battery of the FCV which will be available in FY 2014. Primearth EV Energy, a subsidiary in Shizuoka Prefecture, will provide the battery to the automaker. The automaker employed the battery, because the product allows reducing the cost of the vehicle as well as its high reliability. (The Nikkan Kogyo Shimbun, July 24, 2014)

(5) Nichicon

On July 23rd, Nichicon announced that its "EV Power Station" to send electricity to EV and home both ways for Mitsubishi's EV would be available from July 25th. The device operates for three EVs including i-MiEV. The firm prepared three models including a high functional one which can work with Ene-Farm. (The Nikkan Kogyo Shimbun, July 24, 2014)

(6) Koumei Co.

Koumei Co., which produces and sells EVs in Hyogo Prefecture, has developed a three-seater electric three-wheeler "EVK — TRES". The commercial production will start this year, and the firm will sell the product for taxis and transport in tourist areas. The three-wheeler has a pipe frame and no doors nor windows, like an auto rickshaw, with a weight of approximately 286 kg. Each rear wheel has a small motor, which eliminates the need of a shaft to transmit driving force. The standard model drives about 70 km on a single charge, and the maximum speed is 60 km/h. The product meets the standards of MLIT, and is driven with a normal license and a registration plate. The firm will sell it for approximately ¥1.5 million. The three-wheeler can be converted to have a rear deck or an extra seat. Koumei Co. started in 2008 as a venture to convert gasoline cars into EVs. (The Nikkei, July 28, 2014)

(7) Nissan & Mitsubishi

Nissan Motor and Mitsubishi Motors plan to develop and produce a new EV using a 660 cc class car together, and to introduce the EV into the market by FY 2016. They aim for the lowest price range for major automakers of half way between ¥1 to ¥2 million including a subsidy. The electricity required to drive EV 200 km is about ¥300. Since gasoline prices have gone up, EVs get more attention due to their lower running costs; however, EVs have struggled in the market. Both automakers will use cost reduction technologies to keep the EV price down to the range of a small class car, and aim to make the EV an affordable eco car. Although EV have expensive parts inside, using technologies of 660 cc class cars allows EV to be in the range of ¥ about 1.5 million, a small class car price. NMKV, Tokyo, was established with the equal investment of Nissan and Mitsubishi, and has started the development of the new EV. Both automakers will strongly cooperate through the venture, and plan to introduce the EV into the Japanese market by 2016. (The Nikkei, August 4, 2014)

7. Business Plans of Hydrogen Filling Stations

(1) Iwatani

On July 14, Iwatani opened a commercial hydrogen filling station for FCVs in Amagasaki City, Hyogo Prefecture. This is the first construction of a filling station led by a private organization to sell hydrogen. Liquid hydrogen is transported from a plant in Sakai City to the filling station. The facility can charge one vehicle in approximately three minutes. The firm plans to open a total of 20 hydrogen filling stations in FY 2015. (The Yomiuri Shimbun, The Asahi Shimbun, The Mainichi Newspapers, The Nikkei, The Sankei Shimbun, The Denki Shimbun, The Nikkei Business Daily & Nikkan Jidosha Shimbun, July 15, 2014)

(2) Linde & Iwatani

On July 14th, a German-based major industrial gas producer Linde announced a production plan of its hydrogen dispensing system to provide FCVs with hydrogen in Japan. The production will be carried out with a partner Iwatani. On the day, Linde held an opening ceremony of a commercial production facility for a hydrogen dispensing system in Vienna. "We will work globally with other businesses including one from another industry, and the Japanese market is important for us." said Dr. Aldo Belloni, an executive officer, there. However, an actual schedule and location of the production were not mentioned. The firm holds over half the share of dispensing systems for hydrogen filling stations, and has reduced the price for one system to €1 million (approximately ¥140 million) for the European market by sharing parts and procedures. Because Linde imports some core components from Japan, transporting the final product from Austria to Japan push the costs up. The firm determined that producing the system in Japan with Iwatani would be largely effective. Joint production may promote sharing more parts between Europeans and Japanese, and reduce production costs further. (The Nikkei, July 15, 2014; The Nikkei Business Daily, July 16, 2014)

(3) JX Nippon Oil & Energy

JX Nippon Oil & Energy plans to install 100 hydrogen filling stations by 2018. This is a big leap from the current five stations. To achieve the target, the firm will establish a spinoff "ENEOS Hydrogen Supply & Service" to operate filling stations and hydrogen procurement and supply on October 1st. JX Nippon Oil & Energy has already installed hydrogen filling stations in five places in Suginami-ku, Tokyo and Yokohama City. Although the initial target was a total of 15 stations by FY 2014, the number was raised to 19. The firm aims for a total of 40 stations by FY 2015, and then 100 stations within a couple of years from 2015. Hydrogen filling stations will be installed at new locations as well as established gasoline filling stations in the greater Tokyo area and other major cities. A hydrogen filling station has a facility to store compressed hydrogen instead of gasoline, and uses a dedicated dispenser to provide FCVs with hydrogen. Infrastructure preparation is an issue for FCV growth, and the firm will largely advance the preparation. (The Nikkei, July 16, 2014; The Asahi Shimbun, The Mainichi Newspapers, The Sankei Shimbun, The Nikkan Kogyo Shimbun, The Denki Shimbun, The Nikkei Business Daily & Nikkan Jidosha Shimbun, July 17, 2014)

(4) KHI

Kawasaki Heavy Industries (KHI) is processing its hydrogen production plan using the lignite which is lower grade coal produced in Latrobe Valley in the southern tip of Australia. Lignite price is a tenth that of normal coal, and is planned to produce hydrogen. Hydrogen is planned to be transported on a special tanker in a liquid form at -253 °C to Japan. KHI plans to launch an experimental plant in Australia by 2017, and will soon start choosing a location with the local state government. The development of the world's first hydrogen tanker ship will be accelerated. (The Nikkei, July 29, 2014)

(5) Chiyoda Corporation

Chiyoda Corporation has repeatedly tested hydrogen storage and transport at an experimental plant in Yokohama City. This is a process to commercialize a technology to mix hydrogen in an organic solvent, and to transport the liquid in tanker ship or tank truck at normal temperature under normal pressure. The firm has already established a method to extract hydrogen gas from the hydrogen solution easily. The method allows hydrogen to be transported in a liquid form to filling stations, and to be gasified at the stations for supply. The firm expects a great cost reduction in transport. (The Nikkei, July 29, 2014)

8. Hydrogen Production/Refining Technology Developments & Business Plans

(1) Riken & The University of Tokyo

A team of Dr. Shinichiro Nakamura, a head of a research team at Riken, and Prof. Kazuhito Hashimoto at the University of Tokyo has developed a technology to split water efficiently. An efficient technology to split water can be used for hydrogen production and other chemical reactions. The team used manganese as the catalyst to promote a chemical reaction to mimic the photosynthesis of plants, which eliminates the need of a strong acid. Plants break down water using an enzyme containing manganese during photosynthesis, and break down CO_2 using electrons obtained from the previous process. That is, electrons are used with CO_2 to make a carbohydrate such as glucose. A manganese catalyst using the plant mechanism has been studied. Because the catalyst loses its efficiency in water, which is neutral, it needs toxic strong acid or alkali which is harder to handle. The research team observed electron movement in detail when a plant enzyme and a manganese catalyst break down water. Electrons and hydrogen ions moved at the same time in plants, whereas these did not move the same with a manganese catalyst. Although water is neutral, electrons were separated from water with gamma-collidine, an organic compound containing nitrogen. However, gamma-collidine is less efficient than strong acid or alkali for this use now, and easily decomposed by oxidation, which is an issue to be solved. The team aims to find additives for more stable reaction. (The Nikkei Business Daily, July 8, 2014)

(2) Hokkaido University & Tokyo Metropolitan University

A team of Prof. Hiroaki Misawa at Hokkaido University has achieved a simple system of "artificial photosynthesis" to produce hydrogen by splitting water in collaboration with Tokyo Metropolitan University. Gold particles are fixed on one side of a substrate, and a platinum plate is attached on the other side of the substrate. The system uses visible light and near-infrared light, which have difficult wavelengths to use, to produce hydrogen efficiently. Conventional production systems need to extract hydrogen from a hydrogen and oxygen mixture. Photosynthesis of plants converts water and CO_2 into oxygen and organic matter using solar energy. Artificial photosynthesis uses this mechanism with a catalyst to produce hydrogen instead of organic matter. The team attached two types of metals on each side of a strontium titanate substrate. The metal particles fixed on the surface efficiently absorb sunlight. Water is split by the energy of the absorbed light. In the experiment, a reaction tank was divided into two with the substrate in the middle. Oxygen was generated on the particle side, and hydrogen was produced on the platinum side. The team will work on a substrate shape to increase the reaction surface area to improve the hydrogen production rate. (The Nikkei Business Daily, July 11, 2014)

(3) Nippon Seisen

Nippon Seisen and Alumi-Surface Technologies, Ibaraki Prefecture, together have developed a hydrogen extractor, and plan it to be used in hydrogen filling stations. Aluminum coated heating wire with catalyst fixed on is directly energized and heated to minimize energy loss during heating. They plan to make a test product in a year for performance evaluation, and to complete a commercial product which produces 300 m^3 per hour in two to three years. The facility use methylcyclohexane, an organic hydride, to handle hydrogen safer and easier. The platinum catalyst and heating wire are directly heated by electricity to stay at 340 ^{o}C for dehydrogenation to extract hydrogen from methylcyclohexane. The system starts up at a high speed of 150 seconds, a tenth that of a system to heat the organic hydride from outside with a boiler. Hydrogen and energy conversion rates are high, and the system allows a significant reduction in facility size. (The Nikkan Kogyo Shimbun, The Nikkei Business Daily & Japan Metal Daily, July 28, 2014)

9. Hydrogen Transport & Storage Technology Developments & Business Plans

(1) Kyoto University

A team of Prof. Hiroshi Kitagawa at Kyoto University has developed a technology to double the amount of hydrogen captured in metal particles. The technology can be used for FCV tanks to replace high pressure vessels which have risks of explosion. Metal-organic framework (MOF), which is made of organic matter and metal, is fixed on a palladium (precious metal) particle surface. The material stored double the amount of hydrogen gas compared to particles without MOF. MOF seems to concentrate hydrogen and promote the reaction on the particle surface. Because palladium is heavy and expensive, the team will use a lighter and cheaper metal to fix MOF to evaluate performance. The new material stores hydrogen under around 1013hPa, and possibly leads to a FCV, which will drive 400 km on a single charge, a gasoline car driving range. The team plans commercialization of the technology in cooperation with a business. (The Nikkan Kogyo Shimbun & The Chemical Daily, July 14, 2014; The Nikkei, The Denki Shimbun & Japan Metal Daily, July 15, 2014)

(2) KHI

KHI plans to develop a large tank to store liquid hydrogen for 50,000 FCVs, and aims to commercialize the product by FY 2016. The hydrogen tank is fabricated from special stainless steel which is difficult to process. Hydrogen tanks use special stainless steel containing a larger amount of nickel, because stainless steel easily degrades by reacting with hydrogen. The material is hard, which makes the precise process difficult. Due to this, a large tank has not been made. The firm aims to achieve a cocoon-shape tank to take 3500 m^3 of liquid hydrogen using detailed metal process technologies obtained from the production of liquefied natural gas tanks and ships. Currently a storage tank of 1000 m^3 capacity is under development to establish the technology. They also plan to build a ship to carry 1,250 m^3 of hydrogen to be used from FY 2016. The ship is expected to carry cheap liquid hydrogen imported from Australia from FY 2017. They have produced a tank to store 540 m^3 of liquid hydrogen as a rocket fuel which is installed in Tanegashima, Kagoshima Prefecture. However, there is no large capacity hydrogen tank. (The Nikkei, August 3, 2014)

10. FC & Hydrogen Related Measuring & Observing Technology Development and Business Plan

Toray Research Center (TRC) will strengthen its comprehensive degradation analysis business for cells.

For FCs, analysis services will be provided mainly for polymer electrolyte fuel cells (PEFCs) which are used for automobiles. For example, the firm has established a method to quantitatively analyze platinum shells of palladium-platinum core-shell catalysts. This method allows them to obtain a clear elemental map of 5 nm level particles, which was previously difficult. The firm will mainly analyze individual materials such as catalysts and electrolytes or single cells made with these parts at this moment, and consider analysis of cell stacks in the future. (The Chemical Daily, July 16, 2014)

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