January 15, 2021

JGC HOLDINGS CORPORATION

FY2020 Q&A from the Business Activities Briefing Conference (held on January 15, 2021)

This content is based on information available on the date of the business activities briefing conference (January 15, 2021).

1. Functional materials manufacturing

Question	Answer
Please describe the background conditions that have led to nearly double the level of sales in functional materials manufacturing compared to 20 years ago.	Petroleum refining catalysts, chemical catalysts, and fine chemicals have each grown, but the main factor is expanded fine chemicals business. Sales have grown constantly through the practical advantages JGC C&C products offer over those of competitors.
Please tell us the ratio of overseas sales in each segment.	In catalysts and fine chemicals, overseas sales account for about 50% of the total, or slightly more including indirect exports through trading companies. In fine ceramics, overseas sales represent about 10% of the total.
How will the trend toward decarbonization positively or negatively affect petroleum refining catalyst business?	As you suggest, decarbonization is accelerating, and lower demand for gasoline is expected to reduce demand for petroleum refining catalysts. On the other hand, catalyst demand will increase in certain areas－for chemical refineries, carbon recycling, and the accelerating shift to low-carbon petroleum products. These applications involve different types of catalysts from those used in petroleum refining, but by building on our

	core technologies and catalyst materials, we believe we can serve a broader range of applications.
What advantages do JGC C&C's catalysts offer for carbon-free ammonia plants?	Their advantage is in enabling ammonia synthesis at lower temperature and pressure.
Please tell us the sales ratio and profit margin of each type of material in the fine chemicals segment. Additionally, in consideration of the impact of COVID-19 on semiconductor business, can you tell us about recent conditions?	Sales ratios are roughly the same in the three areas of (1) storage devices and industrial materials, (2) displays and semiconductor materials, and (3) optical and cosmetics materials. Profit margins are relatively high, due to the high-mix, low-volume production of display and semiconductor materials. Looking ahead, JGC C&C are optimistic about even higher sales for storage devices and industrial materials in particular. The pandemic has not had any significant impact on semiconductor materials business, which has remained steady. We can expect the expanded semiconductor demand around the world to drive higher demand in polishing materials as well as antistatic materials for carrier tape.
Please tell us about the supply chain (specifically, delivery destinations) for hard disk polishing materials.	JGC C&C supply polishing materials (silica sol) to slurry manufacturers. These manufacturers mix the polishing materials with other chemicals and supply it to HDD manufacturer as abrasive materials for polishing, which forms the supply chain.
In fine ceramics, Japan Fine Ceramics (JFC) established new facilities for volume production of high thermal conductivity silicon nitride substrates in October 2020. Please tell us about any competitive advantages in this segment.	A distinguishing feature of our high thermal conductivity silicon nitride substrates is that JFC have developed and established a new production method for silicon nitride sintering materials that applies reaction sintering from metal silicon powder, rather than using silicon nitride as a starting material as competitors do. This method enables both economical and high-volume substrate production. Moreover, though it is still at the

	laboratory level, we have a proven record of production with a thermal conductivity of 170 W/(m·K). Thus, we believe our competitive advantage lies in easily being able to provide products that meet client needs.

2. Sustainability-oriented business development

Can you comment on the difficulty of producing green ammonia with electricity from renewable energy, which may be affected by factors such as weather fluctuations? Please tell us about any technical advantages the JGC Group may have.	As you suggest, it is true that fluctuating weather conditions affect production of green ammonia. This requires the use of storage batteries, and, for adjustment, buffer tanks, but how economical the system is varies depending on the scale of these facilities. Accordingly, weather conditions must be carefully studied to determine the optimal combination of electrolyzer, buffer tanks, and capacity of the ammonia synthesis plant. When more than a certain amount of hydrogen is produced, optimal system operation is possible by increasing the plant load and storing hydrogen in the buffer tanks, for example. Conversely, for optimal operation when the production volume is low, the plant load can be reduced and hydrogen can be suppled from the buffer tanks. Variable operation is therefore an important feature of ammonia synthesis plants in particular, and we were able to confirm this kind of variable capacity at the Fukushima FREA demonstration plant. Designing plants for this overall optimization and ensuring responsiveness to variable conditions will be the key to one day using zero-emission fuel from renewable energy. Additionally, because hydrogen produced from water electrolysis is low temperature and pressure, the pressure must be raised with existing catalysts, but a new catalyst developed by the JGC Group that is highly

	active at low temperature and pressure is currently being tested, as we seek to establish a more economical green ammonia production process. We intend to establish a competitive advantage in this technology by building and operating a commercial-scale green ammonia plant as soon as possible and collecting performance data.
The scale of the domestic market for ammonia as a fuel has been projected to reach about 3–5 million tons/year by 2030. Please tell us the scale of sales if the corresponding business is developed.	JERA has announced a policy of using mixed combustion with 20% ammonia (about 500,000 tons/year) to generate 1 GW at coal power plants by around 2026. We can anticipate several such projects materializing by 2030, each on the scale of roughly tens of billions of yen. Also accounting for the government's Green Growth Strategy, further introduction of hydrogen and ammonia is expected, and the future scale of the market may be even larger.
Who will bear the cost of introducing hydrogen and ammonia, which is expected to be more expensive to produce than LNG?	Reducing deployment costs will require cost-cutting across the board in production, transportation, combustion, power transmission, and so on. This will probably require some effort by participating companies, with any remaining cost possibly covered by carbon pricing or other measures.
Is ammonia the best option as a hydrogen energy carrier?	Each carrier has advantages and disadvantages, and we believe that there is an optimal carrier for each application. Our preparations will enable us to work with any carrier. Analysis suggests that ammonia holds an advantage as a carrier for large-scale direct use of bulk imports of hydrogen.
Hydrogen has attracted more attention overseas than ammonia. Which is superior for future energy needs, ammonia or hydrogen?	Overseas, progress in introducing renewable energy is underway in Europe and elsewhere, where it is planned that hydrogen produced with surplus electricity will be stored, consumed locally, and transported via existing natural gas pipelines. Thus, there is little need to convert this hydrogen to

	ammonia before use. Meanwhile, the Middle East, Australia, and other LNG exporters concerned about lower LNG demand from the shift toward decarbonization are eager to produce ammonia as an alternative energy source. Ammonia can essentially be viewed as a solution either for energy importers such as Japan, South Korea, and Taiwan or for countries that export energy to these markets. In any case, ammonia (NH_3) contains hydrogen (H), and the two energy sources do not conflict with each other. We therefore promote the use of ammonia as one form of hydrogen.
Is it accurate to estimate the price of ammonia in 2030 at about 20 yen/m^3? Also tell us about any advantages over liquefied hydrogen.	The current price of ammonia per cubic meter is about 20 yen (calorific equivalent of hydrogen), which, assuming potential direct use, is cheaper than other carriers. The government's Green Growth Strategy seeks a level in the high teens by 2030, less than the current price of natural gas, which again targets it as a cheaper hydrogen carrier than others. Unlike the technical development and extensive new infrastructure required to deploy liquefied hydrogen in society, ammonia derived from fossil fuel is already technically reliable, and large-scale supply chains have been established. Thus, we believe that ammonia holds an advantage in mass transportation and consumption.
Please tell us about the market scale and business timeline for waste plastic gasification chemical recycling, SAF, and CO_2 separation with DDR-type zeolite membranes.	We estimate production by waste plastic gasification chemical recycling plants to be on the level of tens of thousands of tons/year, with a scale of business of tens of billions of yen. Now that the Basel Convention is stricter and includes measures against exporting waste plastic, it is expected that each country will conduct pilot programs in line with local production and consumption.

	In SAF business, we expect to serve airlines in Japan, with the prospect of multiple projects on the scale of several tens of billions of yen. More projects may be possible if some of the waste cooking oil currently exported in bulk to Europe for biodiesel is used domestically for SAF. For CO_2 separation with DDR-type zeolite membranes, testing is currently underway at a demonstration plant in the U.S. We have also received inquiries on selling this plant from companies considering CO_2 business. Considerable demand can be expected in the U.S., as an economical approach to expanded crude oil production that applies CO_2 separation with DDR-type zeolite membranes. As for a business timeline, it is conceivable that both waste plastic gasification chemical recycling and CO_2 separation with DDR-type zeolite membranes can be commercialized relatively quickly.
Please tell us about JGC Group competitiveness in CCS. Do DDR-type zeolite membranes have any advantages over approaches using amine adsorption? We would also like to know about any JGC Group initiatives in direct air capture of atmospheric CO_2.	The JGC Group has a proven track record in pre-combustion CCS. CO_2 is separated and captured near natural gas near wells in Algeria and Australia. We believe that we hold a competitive edge. We would also like to be involved in post-combustion separation, where CO_2 emitted after combustion of natural gas is recovered. To this end, we would work with companies or organizations that have processes for separation and recovery. In direct air capture, although we are studying techniques used in the advanced industrialized nation of Germany, analysis suggests that unless there are advances in the performance of solid adsorbents, CO_2 emissions may actually increase, according to life cycle assessment. We believe developments in this area will need to be studied carefully.