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Green & Sustainable Chemistry Network

GSCN was established in 2000 to promote research and development for the Environment and Human Health and Safety, through the innovation of Chemistry.

Our great hopes for the role of GSCN

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After the accident at the Fukushima Daiichi Nuclear Power Plant in March of last year, it was decided that Japan's Basic Energy Plan should be revised, and this summer three proposals were presented for the degree of dependence on nuclear power (as of 2030: ① zero, ② 15% and ③ 20–25%), which have been spurring nationwide debate. Thus, we are presently (as of September 1) in the process of drawing a portrait of Japan's future, regardless of which selection is made, and there is no doubt that the center of gravity of the energy policy will shift toward renewable energy, clean energy and energysaving. And not all, but mostly the costs of the development and popularization of these technologies will be superimposed upon electricity charges. As a result, burdens on homes and enterprises that use electricity will be unavoidable. However, in order to maintain the international competitiveness of Japanese industry, we should not just idly wait for the burdens to increase.

"**Chemistry"** has been an academic and industrial field that has continued to bring us changes and innovations, so we believe that **chemistry** itself will be the last resort that will give us solutions for the major difficult problems we are currently facing. In this sense, we also believe that now is the time when the true value of GSCN will be asked. This is because the significance of GSCN's role of "contributing to the achievement of sustainable society through chemical technology" has gained more importance after the earthquake disaster.

As for the government, the "GSC Awards" have continued to be awarded by three government ministries, including the Ministry of Economy, Trade and Industry (METI), so we expect that through the influence of GSC, an even more positive image of chemistry than in the past (that it is academia and industry in the field of chemistry that can be expected to offer major contributions in overcoming environmental and energy constraints) will permeate society. In addition, the chemical industry is working to reduce the amount of energy used in chemical manufacturing processes and to develop and supply materials for products that contribute to energy saving, energy creation and energy storage, and the METI continues to make various efforts for the chemical industry, including the support of research and development, based on the situation surrounding us.

Finally, by making stronger connections among industry, government and academia and through the active efforts of the GSCN, we strongly wish that **chemistry** will serve as an engine for a sustainable society.

Sincerely,

Please see **URL http://www.gscn.net/** about GSCN

Efforts of Cooperative Education and Research Center for Green Chemistry of Niigata University

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“Core Station” system of Niigata University authorizes the education and research activities of the groups beyond the existing organizations such as departments and graduate courses aiming at the development of the advanced education program and the formation of the prominent research center. Chemistry division at the Faculty of Science (Department of Chemistry and Department of Environmental Science) in cooperation with some chemists from the Faculty of Engineering and the Faculty of Education, played a key role to establish Cooperative Education and Research Center for Green Chemistry as a “Core Station”. In this center, various activities related to the research, the education, and the contribution to society are performed.

The harmony of the chemistry and the environment is recognized as a universal and permanent theme in a chemical field. In Niigata University, Green Chemistry Forum of Niigata University was launched in 2006 from the idea with providing the opportunity for the chemists to exchange information and opinion in a common key word “Green Chemstry (GC)”. Afterwards, this activity has been succeeded by Cooperative Education and Research Center for Green Chemistry (henceforth the center) set up in 2010.

Three major missions of the center are 1) the development of an environment for effective research cooperation between different fields of chemistry, the promotion of a variety of GC related researches, and the training and education of students through those research activities; 2) the performance of the classes about GC depending on the field of the students and their levels; 3) the introduction and the explanation of GC to junior and senior high school students and the citizens. It is three years from the establishment of the center by the end of this year, the representative previous activities are introduced below.

As research activities, the lectures by the center members were carried out at the start symposium of the center in the first year. Subsequently, the more expanded research symposium was held in the next year. In this symposium, there were two invited lectures, "Invention and reaction of rio-inspired catalysts utilizing photosensitizers "provided by Dr. Hisashi Shimakoshi (assistant professor of Kyushu University) and " Harvesting near-IR light of polymer solar cells" provided by Dr. Hideo Okita (associate professor of Kyoto University), the lectures by the center members, and the poster presentations of undergraduate and graduate students of Niigata University last year (see right photo).

In the educational activity, it is five years since a class "Introduction to green chemistry” (mainly for liberal arts students), which chemistry professors of the Faculty of Science are in charge of, started. Every year, there are participation applicants that greatly exceed capacity, which suggests that the liberal arts students and the non-chemistry majoring students have a strong interest in GC. Moreover, a class "Topics in green chemistry" was established for the students of the Faculty of Science two years ago. We also have a plan to establish a new class for the graduate students in the future.

As activities for the contribution to society, the public lecture meeting entitled "How is the environment going now?" for junior and senior high school students, university students, and the citizens was carried out two years ago. In the meeting, the lectures "Introduction to environmental problem" by Dr. Masaru Kitano (professor of Meiji University), “Introduction of green chemistry” and “Activities of green chemistry in Niigata University” were delivered, and which was introduced in the local newspaper (Niigata Nippo). In the last year, The open lecture on the theme of "Micro-scale chemical experiment" and related demonstrating experiments were provided by Drs. Kazuko Ogino and Hiroshi Ogino (professors emeritus of Tohoku University). The teachers of high schools and the students of Niigata University participated in the experience of micro-scale experiments.

Information on the other activities (a Niigata University lecture, a study seminar, co-hosting lecture meetings, open lectures of chemical experiments, etc.) is posted in the homepage of the center (http://chem.sc.niigata-u.ac.jp/~gc-center/).

As above, the efforts of Cooperative Education and Research Center for Green Chemistry are introduced. The center will continue to work in a variety of activities in collaboration with inside and outside the university in the the future.

Research Symposium（3/8,9/2012）

Carbon Alloy Materials for a Low-Carbon Society
– Carbon alloy catalysts as promising candidates for PEM fuel cell cathode catalysts –

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The development of new energy systems in order to achieve a low-carbon society is an important issue now that nuclear power has lost societal trust and credibility. The ultimate form of such a society is a hydrogen-based society which utilizes the cleanest form of energy – hydrogen. The quantity of hydrogen in its elemental form is very small, and it has the property of not being easily condensed. Therefore, technologies for producing and storing hydrogen should be developed, and at the same time, technologies for converting chemical energy to easily utilized electrical energy are also required. To wit, technologies for "making," "storing" and "using" hydrogen are essential to build a hydrogen-based society.

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In the author's research lab, research is proceeding with the purpose of "building a low-carbon society with carbon materials." We are focusing on techniques for introducing into carbon materials different elements and carbon atoms having different electron configurations, to obtain carbon alloys aimed at achieving new functions. We are utilizing these techniques to conduct research on carbon materials for the purpose of "making," "storing" and "using" hydrogen. In this paper, I shall present a summary of carbon alloy catalysts to be used in place of the platinum cathode catalysts used in solid polymer fuel cells as a technology for "using" hydrogen.

We developed two types of carbon alloy catalysts. These two types are nanoshell carbon alloys and nitrogen- and boron-doped carbon alloys. Let me first describe nanoshell carbon alloy catalysts. A nanoshell is a carbon nanocarbon 20–50 nm in diameter having a spherical shell structure composed of stacked carbon layers as shown in Fig. 2. Nanoshells are formed in a self-organized manner by the catalytic action of metal elements added to the polymer serving as the carbon raw material. We proceeded with the research focusing on the fact that this carbon acts as an electrode catalyst which promotes an oxygen reduction reaction. And based on the study of several model substances, we concluded that the activity of this catalyst arises from "defects " introduced into the surface of the nanoshell structure.

Next, I will introduce the nitrogen- and boron-doped carbon alloy catalysts. It has been reported in the past that introducing nitrogen increases the oxygen reduction activity of carbon. In contrast, we found that by introducing boron in addition to nitrogen, the activity is further increased. By analyzing the structure of nitrogen- and boron-doped carbon alloy catalysts, we concluded that one of the causes of increasing the activity due to the introduction of different elements is the introduction of "defects" into the carbon structure in the same manner as in the nanoshells. We are currently performing analyses of the states of the nitrogen and boron, and are studying details of the effects of their states on the carbon structure. Naturally, we have also confirmed that the combination of these elemental technologies of nanoshell structure and nitrogen and boron doping result in increased activity.

In the future, we plan to clarify the chemical mechanisms of their activity as cathode catalysts and to improve their performance, and in the process thereof, I would like to write a new page in catalytic chemistry on the catalytic effects involving s orbitals and p orbitals. In addition, we plan to proceed with developing materials for "making" and "storing" hydrogen.

Acknowledgements

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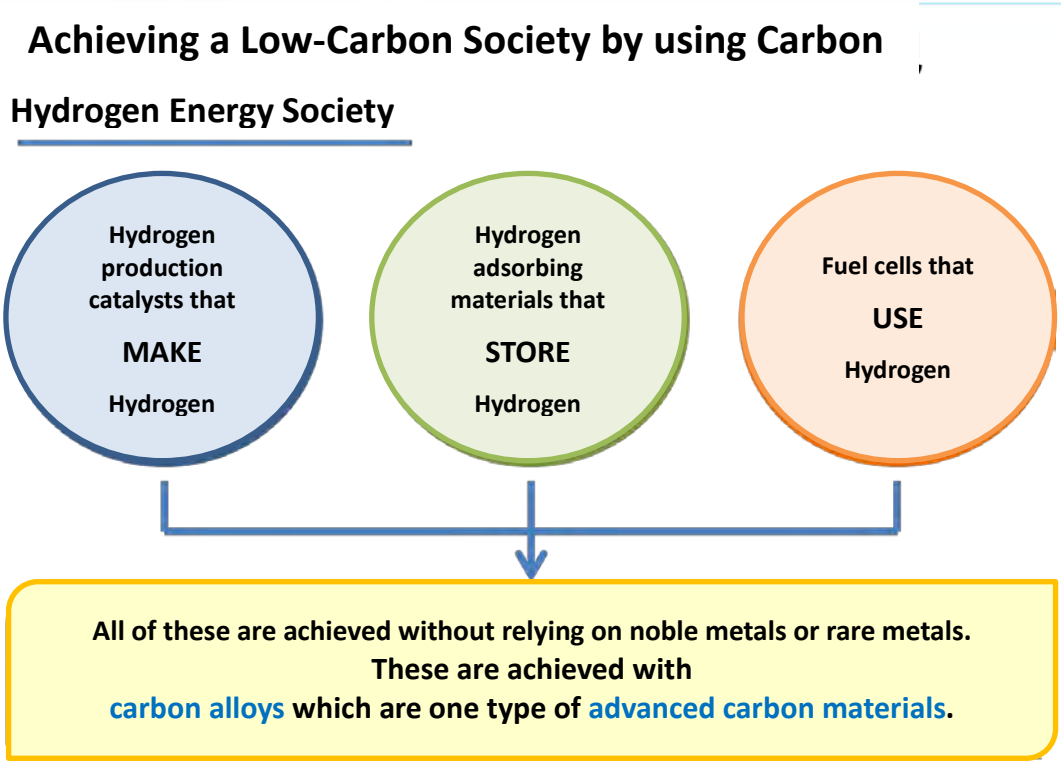

Fig. 1 Elemental technologies for a Hydrogen Society by the Carbon Alloy Technology

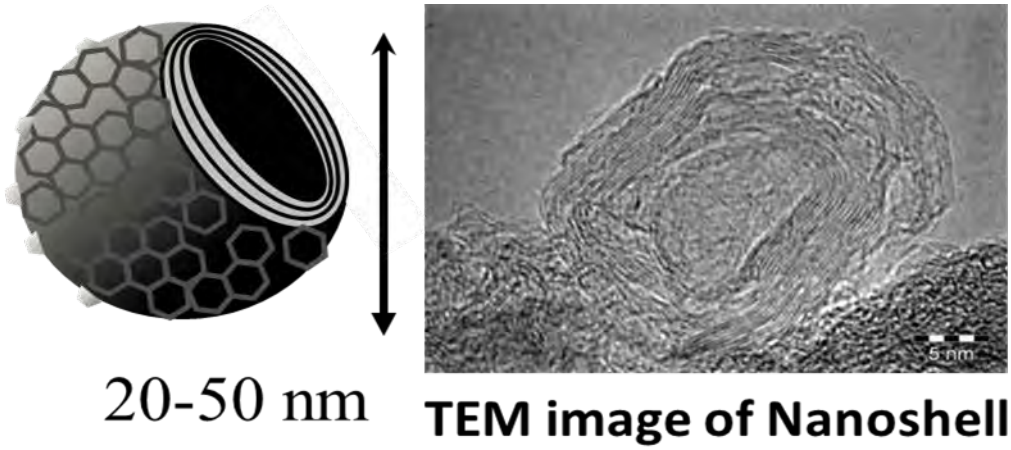

Fig. 2 Schematic Structure and Transmission Electron Microscope Image of a Nanoshell