GSCN NEWS LETTER No.41 2011.10

Green & Sustainable Chemistry Network

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

Japanese Industrial Society and GSCN

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I would like to extend my sincerest sympathy and condolences to all the people who suffered losses from the earthquake and tsunami in last March. I sincerely pray for their quick recovery.

The disaster stopped the supply of products and components from manufacturers in the disaster-stricken area. This forced a tremendous number of companies in the world to change their production schedules and business strategies. Many chemical companies in the area, both large and medium/small enterprises, also suffered much damages from the disaster. These days, an increasing number of people have stated that the competitiveness of Japan's industries has weakened. The disaster, however, reminds us of the presence of Japanese suppliers in the world economy. I believe that their presence is due to their high-quality products, their high level of responsibility for environmental protection, and their faithful attitude towards partners. This experience teaches us the importance of the Japanese business philosophy that puts a high priority on customer satisfaction and social responsibility.

More than ten years ago, about thirty non-profit chemical organizations worked together and established GSCN. Since then, GSCN has taken the initiative in promoting public awareness of our finite natural resources and the need for environmental protection. I am feeling the increasing importance of these activities in society today and sincerely expect that these activities by chemists will involve scientists and engineers in other fields.

AIST will undertake research and development with a focus on the major goal of "solutions for 21st century issues" and "reinforcing functions of Open Innovation Hub". Green and sustainable chemistry is one of the most important research areas of AIST. We are promoting the R&D in GSC areas by fully utilizing the network with domestic companies and universities and forming international partnerships with overseas public research institutes. We contribute to the realization of a sustainable society together with the Green and Sustainable Chemistry Network, placing the fundamental priority of R&D activities on "Environmental Safety and Human Health".

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

Philosophy behind Establishing the Society to Study Chemistry Education for the Next Generation and Report of Activities

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Looking at current state of secondary education from the classroom, my strong impression is that the number of chemistry teachers who lack experience teaching experiments is growing. I've also felt keenly the risky situation we are in. The generation of teachers who has the know-how to teach students how to conduct experiments safely and successfully is retiring. In response to this situation, we sought to pass down the knowledge that our predecessors have accumulated on how to make lessons come alive. We also sought to cultivate and develop teachers who can research educational materials for the coming society. Thus we established the Society to study Chemistry education for the Next generation (SCN). Here I report on SCN's activities

The establishment of SCN had two causes. One was the end of a longtime study group. The reason was that preparing for the monthly meeting became difficult because its level became more advanced year after year. The teachers who decided to disband the group did not quite realize that young teachers would lose a place to learn. The other reason was the age distribution of physics teachers in Tokyo metropolitan high schools. It resembled a camel's humps. There were few teachers of middle age (in their 30s and 40s) who should be a bridge between soon-to-be-retired teachers and young teachers. This fact indicated that the ability to nurture young teachers was being lost at the school level. Fearing this loss and the loss of a place outside school to train teachers, young teachers and the middle-aged teachers established SCN about five years ago.

SCN's goal is to increase the number of teachers who have the ability to carry the standard high schools experiments safely, as well as have creativity to improve educational materials. We gave our study group the name “SCN” to signify that we must not only break through the current situation, but also seek out what chemical education ought to be.

SCN works on principle of “meeting at the same place at same time” and “holding a meeting even there are zero participants.” We want to establish a sense of security for participants so they can feel, “If I attend today, I can ask questions.” We meet on the first Saturday of every month at Toyama Tokyo Metropolitan High School. Our meeting includes conducting standard experiments, learning about skills to conduct experiments from our older colleagues, and inviting researchers to speak so that we can acquire specialized education. When all the participants join in the standard experiments, in general the young teachers take turn preparing the monthly meetings. We call the person in charge the “experiment provider,” not “teacher.” Besides the monthly activities, we achieved the following pr ojects: distributing educational materials such as silicon wafers, touring company factories, and observing experiments taught in foreign high schools. Also, since the trend these days is to have drills for college entrance exam problems during class or in supplemental classes, we held study groups to review these questions. This activity highly praised by newly-hired teachers.

Besides our monthly meeting, we are also collaborating with junior high schools to hold lectures on experiments called “Kagaku Kan (Chemistry Can)” as a meeting that mixes elementary, junior high, and high school teachers. We are also partnering with universities to hold “chemistry labs for adults” in order to improve science literacy. We publish a newsletter called “Guru Guru Chemia” (“chemistry teachers” in Malay) to inform teachers who could not participate in the monthly meetings about these activities.

We introduced SCN’s activities to teachers in other prefectures in response to their requests. After listening to our introduction, they wanted to launch the same kind of study group. Thus SCN Miyagi and SCN Kanagawa were established. We, SCN Tokyo, focus on experiments; SCN Miyagi meets at a university; and SCN Kanagawa introduces worksheets for classes. Each SCN has its own characteristics, and the activities of the SCNs are reported every month in “Guru Guru Chemia.”

SCN has expanded to include the use of a mailing list called “CHemistry Education Support System” or “CHESS.” Over 500 recipients from Hokkaido to Okinawa, mainly secondary chemistry teachers, have registered on this mailing list. The e-mail messages introduce the various monthly meetings of the SCNs and participants carry out discussions on questions related to chemistry.

If you are interested in SCN or CHESS, please contact me (aaatnk@nifty.com).

Water-splitting Photocatalysts for Solar Energy Conversion

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Using solar energy to split water can provide hydrogen as a green, renewable energy source and chemical resource without generating carbon dioxide. Photocatalytic water splitting reactions may provide large quantities of hydrogen at low cost, and worldwide research on such catalysts is currently underway. Here, we discuss our current research on the development of photocatalysts that can split water under visible light.

The amount of sunlight that falls on the earth carries about 10,000 times the energy we currently consume. Of all renewable primary energy sources, solar energy is by far the most abundant, and it will be highly likely to be the primary energy source used by humankind in the future. However, using sunlight as our primary energy source would require conversion on a large scale, necessitating the development of methods that can convert the solar energy falling upon an area of several hundred thousand square kilometers, an area approximately the size of Japan. In this case, the conversion of solar energy to a transportable, storable form is required, and its conversion to chemical energy is highly desirable.

Photosynthesis in the natural world is a model of such a conversion. The total amount of energy converted by photosynthesis per year is approximately 10 times the energy consumed by humans. Photosynthesis produces carbohydrates and oxygen from H2O and CO2. However, carbohydrates are not necessarily a convenient energy source or chemical resource. Splitting water into hydrogen and oxygen is a similar, but much simpler solar energy conversion. The generated hydrogen can be easily used as an energy source or chemical resource, or it can be reacted with CO2 or nitrogen to produce methanol, hydrocarbons, ammonia, or other compounds. Needless to say, effective catalysts already exist for the latter set of reactions. Therefore, the splitting of water is one key technology that may enable the large-scale utilization of solar energy, and several potential methods are available. For example, using a solar power generator or solar thermal generator, the electrical energy produced can be used to electrolyze water. However, major problems would remain in terms of cost and scale. If granular catalysts could be developed that can efficiently split water using solar energy, these could enable relatively inexpensive large-scale deployment. The main challenges in this case are the development of efficient catalysts and establishing methods of efficiently separating hydrogen from the mixture of water vapor, hydrogen, and oxygen generated by the water splitting reaction.

We will now discuss the state of development of our photocatalysts. Currently, there are two methods of splitting water into oxygen and hydrogen using semiconductor particles (approximately 10 – 1,000 nm in size). The first method produces hydrogen and oxygen on a single photocatalyst. The second method uses two photocatalysts, one to produce hydrogen and one to produce oxygen. We call these methods one-step and two-step water splitting, respectively. Because the latter method resembles photosynthesis, it is called a Z-scheme method.

An example of a photocatalyst used for one-step water splitting is shown in Figure 1. The yellow granules (a few 100 nm in diameter) are a solid solution of GaN and ZnO. The granule surface was modified with transition metal oxide nanoparticles (e.g. Rh2-xCrxO3) that act as active sites for the generation of hydrogen. When these granules are suspended in water and exposed to light, hydrogen and oxygen are generated from the granule surface, as shown schematically in Figure 2. Currently, the highest efficiency of solar energy conversion attained by one-step photocatalysis is 0.17 percent. On the other hand, a solar conversion efficiency of 0.21 percent has been achieved by two-step water splitting, such as by using surface-modified WO3 and TaON photocatalysts to produce oxygen and hydrogen, respectively. Of course, a conversion efficiency of 5 to 10 percent is required for the method to be commercially viable, so an order of magnitude improvement in activity is required. To develop such photocatalysts would require a 600 nm or greater light absorption edge and a water-splitting quantum yield above 30 percent. We have already selected the materials necessary for the development of photocatalysts with such activity. Our next steps include developing methods to prepare these catalysts with fewer defects and the development of highly active sites for producing hydrogen and oxygen. Active research projects addressing these challenges are already underway, and will be reported in the near future.

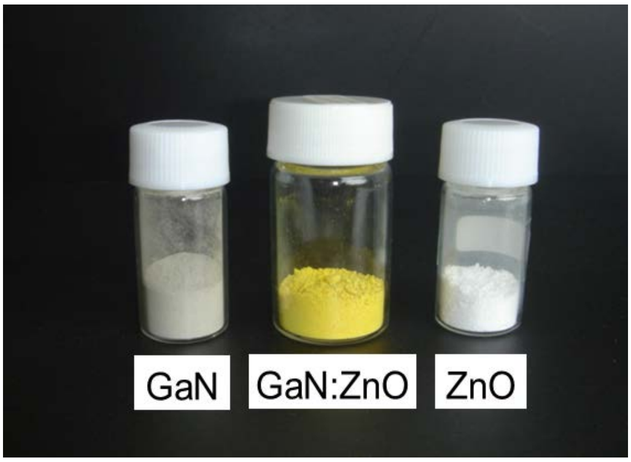

Fig.1 Solid solution of GaN and ZnO

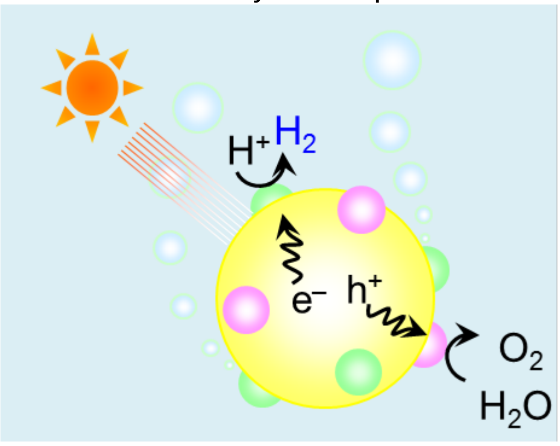

Fig.2 One-step water splitting photocatalyst