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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.

International Year of Chemistry 2011

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The year 2011 was The International Year of Chemistry (IYC 2011). Under the initiative of IUPAC (International Union of Pure and Applied Chemistry), activities for promoting chemistry were carried out around the world under the unifying theme, "Chemistry – our life, our future." The goals of the IYC 2011 were to increase public understanding of chemistry, to elicit interest and aspirations concerning among young people chemistry, to encourage chemists to contribute to the establishment of a sustainable and creative society for the future, and to support the activities of female chemists. Japan celebrated the International Year of Chemistry by establishing the IYC 2011 Japan Committee, chaired by Prof. Ryoji Noyori, which coordinated many events with the help of chemistry-related Societies. It is our hope that the trends fostered by the IYC 2011 will continue through 2012 and beyond, increasing social awareness of chemistry and helping to secure the field's standing in both industry and academia throughout Japan.

I am very optimistic about the future of chemistry in Japan. In recent years, many of Japan's universities have seen an increase in the number of applicants to science-related field wanting to undertake studies in chemistry. This is a significant change from just a few decades ago, when the term "chemistry" vanished from university department names due to the negative image associated with pollution and the term "3K" (*kiken*, *kitanai* and *kitsui*, or dangerous, dirty, and severe). Although lack of interest among young people is still a serious problem, it appears that a general awareness of chemistry is increasing more prominently in Japan than in other developed countries. Some of the factors contributing to this increase are the strength of the job market in chemistry-related fields, the emergence of Japanese laureates of the Nobel Prize in Chemistry, and an increasing public awareness of the need for chemical products in everyday life. Whenever I ride a bullet train, I take great delight in seeing text advertisements of chemical companies running on the ticker above the door. These ads express how important and wonderful chemistry is in a sophisticated way. It may seem trivial, but regular messages like these received on a continuous basis have a tremendous effect; they subconsciously cultivate a standard among members of the public to naturally accept chemistry.

It goes without saying that chemistry is essential in solving environmental problems to ensure the sustainable development of civilized society. To that end, it is very important to promote science and technology rooted in the ingenuity and diverse values of young people. The role played by the GSCN (Green and Sustainable Chemistry Network) – an advocate for green chemistry innovations – will become increasingly vital. I wish the Japan Association for Chemical Innovation, the parent organization of GSCN, every success and I look forward to the growth in the collaborative network among industry, government, and academia.

Action of the recycling of the information and communication equipment

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Since “the Basic Law for Establishing the Recycling-based Society” was promulgated in June 2000, in Japan, laws concerning the 3Rs (reduction, reusing, and recycling) of products have been established or revised. These laws include the Home Appliance Recycling Law (Specific Household Appliance Recycling Act), Containers and Packaging Recycling Law (Law for Promotion of Sorted Collection and Recycling of Containers and Packaging), and the Law for the Promotion of Effective Utilization of Resources (Law for the Promotion of Utilization of Recyclable Resources). NEC, too, has streamlined its system for promoting the 3Rs with initiatives involving personal computers, sealed batteries and other products in accordance with these laws. Information and communication equipment have been collected and recycled nearly 40 years before, since around 1969. This paper introduces NEC’s approach to the recycling of information and communication equipment.

NEC has 29 collection sites and seven recycling sites around Japan, and has been certified as a designated industrial waste processor for wide-area recycling. The company collects used information and communication equipment from customers throughout Japan.

The target equipment includes information processing/computer equipment, including personal computers and servers, peripheral equipment, radio communication devices and switching and transmission equipment. NEC collects and recycles a wide range of information and communication equipment.

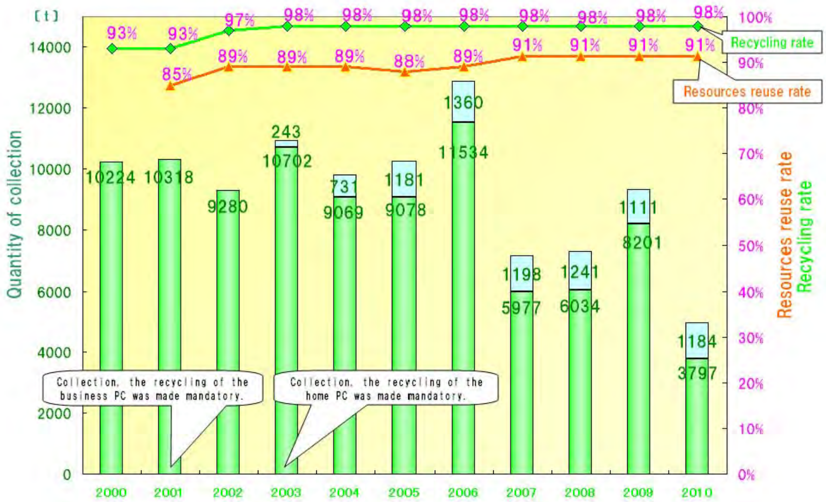
The volume of information and communication equipment collected varies from year to year, but about 5,000 to 10,000 tons are collected annually. Of the items collected, the recycling rate (that is, the resource recovery rate), which includes reuse, material recycling, and thermal recycling, has reached 98%. Fig. 1 shows changes in the volume of information and communication equipment collected and the recycling rate

To recover resources, information and communication equipment is generally dismantled manually and sorted. An alternative method is to process the information and communication equipment using a shredder without dismantling the equipment and separating the iron from the nonferrous metals using a machine. However, a better resource recovery rate is achieved by dismantling the equipment manually and sorting the material into components and materials. After being dismantled, the information and communication equipment is classified into chassis, printed circuit boards, unit components, cables, batteries, plastics, and glass. Almost all of them are recycled and effectively utilized as iron, nonferrous metals, noble metals and rare metals, plastics, glass, and other materials.

Some of the separated components are also reused as spare parts for information and communication equipment. These, in particular, are put to good use in maintaining older models whose components are no longer manufactured. This practice significantly reduces maintenance costs compared to when maintenance is performed using newly created components.

In 2003, NEC was the first manufacturer to market used personal computers under the slogan, “NEC Refreshed PC.” Under this scheme, the company purchased used personal computers from users, refurbished them at the factory, and resold them bearing the manufacturer’s warranty. The refurbishment included deleting the old data, cleaning the machines, re-installing the OS and performing an operation check. By 2010, more than 230,000 personal computers were refurbished and resold.

At the same time, NEC launched its resource conservation initiative for materials used in products. NEC’s proprietary flame-retardant bioplastic material, NeCycle™, features a high-level of environmental compatibility. These attributes include a high plant ingredient ratio and a reduction in the amount of CO_2 released under LCA assessment. NeCycle™ is used for the front covers of personal computers that were released on the market in January 2010.



NEC will consider the overall flow of the life cycle of information and communication equipment from design to production, use, and the 3Rs. The company will continue to promote its positive approach to the 3Rs in the future, too. NEC believes that, to efficiently implement its approach to the 3Rs, it is effective to study the 3Rs and investigate system construction, and that this work should be conducted by NEC in cooperation with other electric appliance manufacturers and manufacturers of chemical and other materials. In the future, it will become necessary to build global collection and recycling systems in cooperation with manufacturers, both in Japan and overseas. To achieve this objective, NEC believes it will be essential for various industry groups and relevant ministries to work together to exchange information in a timely manner and to promote cross-sectional initiatives.

Green Biocatalysts that Function under Extreme Environments

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Extremozymes produced by extremophiles retain their structure and function even under extreme environmental conditions. Many enzymes have been applied to industry as, for example, alkaline enzymes to augment detergents and heat-resistant enzymes for PCRs. However, the mechanism of extreme environment tolerance of extremozymes remains largely unknown. The author and his colleagues have elucidated the alkalitolerant function of polysaccharide hydrolases produced by alkaliphiles and successfully increased their alkalitolerancy.

Extremophiles are known to live under a range of environmental conditions, such as high and low temperatures, high and low pH solutions, and high salinity, where other organisms are unlikely to survive. Extremozymes produced by extremophiles can function under such extreme environmental conditions and, therefore, many of them have been used in industry. Extremozymes have undergone remarkable development in terms of industrial application, but the mechanism by which they resist extreme environmental conditions remains largely unknown. Specifically, the alkalitolerant mechanism of alkaline enzymes produced by alkaliphiles, which is the most commonly used attribute of extremozymes, has not yet been clearly elucidated.

The cell walls of plants consist of polysaccharides such as cellulose and xylan, and lignin. Xylan has a structure that consists of a main chain of β-1,4-linked D-xylose, while xylanase is an enzyme that hydrolyzes β-1,4 bonds. In recent years, xylanase has attracted considerable attention as a green catalyst. For example, it is used as an auxiliary material to bleach pulp in the paper industry. In paper manufacturing, lignin, which is the cause of coloration, is removed from pulp by boiling it under alkaline conditions. The subsequent process, chlorine bleaching, emits dioxins and was therefore regarded problematic. Xylan acts like glue, linking lignin with cellulose. Therefore, xylanase treatment of pulp after alkaline boiling encourages the release of lignin, resulting in a reduction in the amount of chlorine used for bleaching. Xylan is also known as unused biomass that is second to cellulose, which is representative of abundant plant biomass. Cellulose and xylan have attracted attention as raw materials for bioethanol, and increasing efforts are made to study their hydrolases, cellulase and xylanase. In addition, the industrial applications of xylanase, which encompass cosmetics, baking and stock-raising industries, are continually increasing. Xylan is more water-soluble under alkaline conditions. Therefore, xylanase that has higher activity under these conditions is unquestionably advantageous in industrial applications.

Alkaliphilic Bacillus sp. 41M-1, which the author and his colleagues isolated from soil, produces a new alkaline xylanase that responds optimally in the alkaline region. The author and his colleagues have elucidated the tertiary structure of this alkaline xylanase, and compared it to those of neutral and acidic xylanases. It was found that, in the vicinity of catalyst residues of the alkaline xylanase, there are salt bridges that form ionic bonds between acidic and basic amino acid side chains. The salt bridges were not seen in the cases of neutral and acidic xylanases (Fig. 1). Furthermore, the mutant enzyme that broke the salt bridges exhibited an acidophilic shift in optimal pH, indicating that the salt bridges are closely associated with the expression of activity under alkaline conditions. Based on these results, the researchers reinforced the salt bridges in the following way: among amino acid residues that form characteristic salt bridges, the basic amino acid lysine was replaced with arginine having higher basicity. The mutant enzyme with its characteristic salt bridges reinforced exhibited an alkaliphilic shift in pH optimum from pH 8.5, which is of wild enzymes, to pH 9.0 (Fig. 2). Based on the fact that arginines are abundant on the molecular surface of alkaline enzymes, the researchers shifted the pH optimum towards alkaline pH by introducing excessive arginines into the molecular surface of the alkaline xylanase.

While the pH optimum of some acidic xylanases has been shifted to the neutral range by means of protein engineering or directed evolution, this study is the first to shift the pH optimum of an alkaline enzyme toward a more alkaline value. While the alkalitolerant mechanism of the said alkaline xylanase has not been fully explained, this study is a significant step toward further increases in its alkalitolerance.

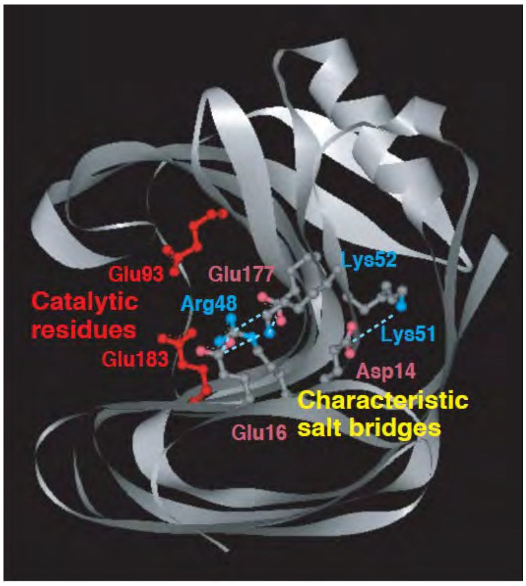

Fig. 1 The tertiary structure of the alkaline xylanase and its characteristic salt bridges in the vicinity of its catalyst residues

In the vicinity of the catalyst residues, the salt bridges between Asp14 and Lys51 and the salt bridge network between Glu16, Glu177, Arg48, and Lys52 were observed.

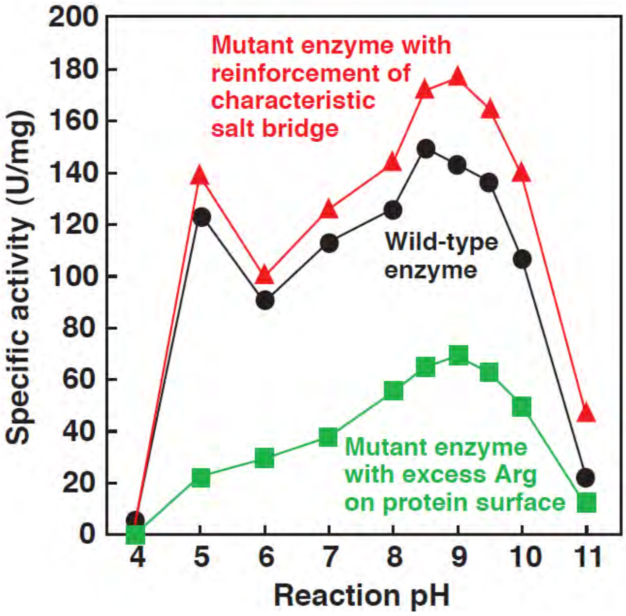

Fig. 2 Reaction pH dependence of wild and mutant enzymes

Shifts in pH optimum were observed in the mutant enzyme with its salt bridges reinforced (by replacing Lys51 with arginine) and the mutant enzyme with its molecular surface modified (excessive arginines are introduced on to the molecular surface by replacing Ser26, Thr34, Asn74, Asn76, and Asn192 with arginine).

Report on the GSC-Focus Session of the 60th Symposium on Macromolecules

Takashi Ushikubo, Japan Association for Chemical Innovation

The Green and Sustainable Chemistry Network (GSCN), Japan Association for Chemical innovation (JACI) has been holding GSC sessions as a part of the three-year plan that started in fiscal 2009 in order to spread the philosophy of GSC. There have been GSC sessions taking place at the annual meetings of the Chemical Society of Japan (CSJ), the Society of Chemical Engineers, Japan (SCEJ), and the Society of Polymer Science, Japan (SPSJ), respectively, in corporation with GSCN. On September 29, 2011, SPSJ held a session titled, the "Focus Session of the 60th Symposium on Macromolecules: Science and Technology of Macromolecules that Promote the Realization of a Sustainable Society" at the Tsushima Campus of Okayama University. On this occasion, four lectures of recent progress in the viewpoints of GSC were given by the polymer researchers or engineers from the chemical industries. And the possibilities were actively discussed by about 90 participants, more than those of last year.

Two lectures were focused on recycling of the used plastics, that is one of the major interests of GSCN. Mr. Noriyuki Yasuo, Panasonic presented the recent progress of recycling technologies for the used plastics in home electrical appliance products. The used polymers were sorted according to the kinds of basic components, such as polystyrene, polyester and polycarbonate. Excellent moving pictures appeared at his presentation. In the meantime, Mr. Takushi Kamiya, the Plastic Waste Management Institute presented the lifecycle of plastics, from manufacture and applivation through disposal or recycling. He emphasized the conditions of recycling were different in the areas of the world. Because Japan is an advanced country in the field of plastics recycling, we would like to provide developing countries our advanced technologies on plastics recycling, and to expand the philosophy of GSC by introducing these countries plastics recycling.

Lecture given by Mr. Noriyuki Yasuo

In addition to these talks, two types of unique macromolecules were introduced. Mr. Yasuharu Mori, Dia-NitriX gave a presentation concerning polyacrylamides and their application to the waste water treatment, e.g. regeneration of sewage to fresh water, thereby contributing to the creation of a sustainable society system. Dr. Atsushi Miyabo, Arkema gave a talk on polyamide 11, an engineering plastic that comes from plants. This nylon has been commercially manufactured from inedible castor oil since 1950s. This product pioneered the development of plastics from biomass. Dr. Miyabo's talk was very impressive, and he stated that this resin was not developed by focusing on biomaterials, but on performances. The resin with the desired performances came from plants accidentally. Although polyamide 11 already has the advantage, the biomass-based plastics, that is a market demand, it is expected that more unique products with unique and excellent functionality will be developed in the future by making progress of the present resin.

Lecture given by Mr. Takushi Kamiya

The participants expressed that they regarded the topics presented by the industries. Also, they indicated their desires the presentations concerning the novel applications of macromolecules and the development aimed at commercialization, especially the resolution of problems. Based on these opinions, we would like to make novel plans for promoting GSC in the future.