Initiative GSC-21

- Challenge of Chemical Technology -

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Green & Sustainable Chemistry Network (GSCN)

The Society of Chemical Engineers, Japan
The Society of Polymer Science, Japan
The Chemical Society of Japan
National Institute of Advanced Industrial Science and Technology
Japan Chemical Industry Association
The Association for the Progress of New Chemistry
Japan Association for International Chemical Information
Japan Bio-Industry Association
Chemical Evaluation and Research Institute, Japan
Japan Chemical Innovation Institute

Challenge of Chemical Technology Realizing Sustainable Society

In the twentieth century humanity constructed a civilization of mass production and mass consumption through advanced scientific technologies. Resulting consequences caused fear of environmental problems on a global scale. These apprehensions are represented by depletion of resources (feedstock, energy and food), global warming, destruction of the ozone layer, endocrinological influences and accumulation of non-biodegradable chemical substances in the ecosystem. These problems pose serious questions to the future of humanity. Mankind has exploited large quantities of fossil resources from outside of the ecosystem, depositing the wastes inside the ecosystem after use. A population explosion has been brought about by advanced of technology in medical care and food production. It is now recognized that these influences on the ecological balance have attained a global scale. Although we have recognized this fact, and started to take necessary action, the actions of nations, consumers, industries, and academia are not necessarily synchronized.

We who work in the area of chemistry, established “Green & Sustainable Chemistry Network” (GSCN) two years ago, and have urged the importance of “Green & Sustainable Chemistry” (GSC). This activity has been taken up by OECD (Organization of Economic Corporation and Development) and IUPAC (International Union of Pure and Applied Chemistry), etc., and technological development is being activated globally. Although Japan used to hold a dominant position in the field of pollution prevention and environment control technologies, Japan has now entered a stage of implementing a novel measures to maintain the advantage against strategic initiatives started by many other countries.

GSC is a chemical technology to minimize the consumption of depletive resources (raw material and energy) and the wastes discharged during manufacturing, processing, and use, and to realize the “Health and Safety for Mankind and the Environment” through the whole life cycle including the period of use. As the goals stated above can be realized by application and generalization of excellent technologies, it is urgently desired that the technology developed must be economically feasible. This can be accomplished only through combining the innovative ideas and concepts of academe with the advanced planning and development abilities of industry.

We here propose the necessity of promoting “**Initiative GSC-21**”, being convinced that the practice of GSC, that is, “**Challenge of Chemical Technology”**, is an urgent theme for all industry, especially the chemical industry, aiming at “Realization of Sustainable Society” and “Reinforcement of International Competitiveness of Japan”.

The present proposal includes “Environment”, “Production Engineering”, “Nanotechnology & Material”, “Life Science” and “Energy”, out of eight fields which have been specified as important in the National Strategy. They are important key industrial technologies for the twenty-first century.

1. Green & Sustainable Chemistry (GSC) is a key technology supporting the sustainable development of human society.

Our present standard of living is completely dependent on chemical technologies to provide clothing, food, housing, materials, and medicines. At present, when the depletion of resources is accelerating, it is necessary to shift to a new system of chemical technology as quickly as possible.

To accomplish this, it is important to realize 1) maximum utilization efficiency of depletable resources, 2) maximum utilization efficiency of energy, 3) practical technologies for reusable resources, 4) development of manufacturing & processing technologies minimizing wastes or byproducts, 5) development of materials and products not having a deleterious effect on health and the environment, 6) marginal gains through accomplishing high performance of substances and materials and developing their application technologies, 7) development of technologies to reduce, reuse and recycle consumer products, and 8) remediation technologies for the environment.

2. Green & Sustainable Chemistry (GSC) is a key technology impacting on society and industry and hewing out a new age.

The chemical industry supplies essential products to maintain a clean, safe and comfortable human life, such as food packaging materials, clothing, house-building materials and pharmaceuticals. Furthermore, it supplies indispensable substances, materials and feedstock to all of industry (except the financial and service industries). It is expected that the introduction of GSC into conventional chemical technology will bring about a qualitative change in social life and industrial activities in the new age. GSC provides an innovative technological base so as to harmonize human activities and economic activities with the global environment.

3. Green & Sustainable Chemistry (GSC) requires, as a national strategy, fusion of high-level fundamental, key technology and application technology researches through collaboration between industry and academe and among industries.

It is expected that the key technologies leading the world, can be developed through fusion of the innovative and fundamental chemical technologies possessed by the universities and national institutes, and the advanced application technology development possessed by chemical industries. Further, the effective implementation of GSC will become possible through fusion of chemistry, physics, earth science, biology, agricultural science, medical science, electrical engineering, electronics, mechanical engineering and civil engineering, etc. beyond the disciplinary or technological boundaries., and, furthermore, through collaboration with sociology and economics. It is expected that a quick return of results to society will become possible through utilizing such a new development system for key technologies. The promotion of GSC should be carried out as a national strategy, because of the width of the area covered and the greatness of social impact. We believe firmly that successful development of the original and innovative key technologies through integrating the knowledge of different fields will contribute to the realization of sustainable society in Japan, as well as in the world.

4. Representative examples of key technology development

(1) Maximum utilization efficiency of depleted raw materials and resources

Utilization efficiency of fossil resources (oil, coal, natural gas, methane hydrate, etc)

(2) Maximum utilization efficiency of energy resources

Combustion system, fuel cell, energy storage system, high-efficiency conversion system of solar energy (sunlight, thermal energy, chemical energy, wind power, tidal energy, etc), high-efficiency conversion system of geothermal energy, etc

(3) Practical utilization of renewable resources

Resource production from biomasses, food wastes, agricultural wastes, marine product wastes, livestock wastes, human wastes, etc.

(4) Development of manufacturing and processing technology which minimizes generation of wastes and byproducts

Highly active and selective catalysts, hydrogen peroxide oxidation, bio-mimetic reactions, high- efficiency and high-function separation membranes, micro-reactors, membrane reactors, ionic fluids, supercritical fluids, alternate solvents, novel reaction fields (microwave, supersonic wave, laser, etc)

(5) Human Body

Biocompatible substances and materials, substances and materials being structurally analogous to natural products, and additives, etc

(6) Accomplishment of marginal characteristics through realizing high functions and high performances of substances and materials, and development of their application technologies

Precise control of one dimensional and three dimensional structure of polymer materials, organic/inorganic composite materials, self-organizing materials (including self-remediable materials), structurally gradient materials, interface structure control technology, sensors, LCD/EL devices, DDS, etc

(7) Development of technologies to reduce, reuse and recycle consumer products

Chemical recycle technology of plastics, surface characteristics of plastics (scratch resistance, abrasion resistance, heat, light and weather resistances, etc.), super high-strength materials, super anticorrosion materials, organic solvents, etc

(8) Environment remediation technology

Bio-remediation, chemical remediation, etc

5. Important themes supporting developing key technologies of Green & Sustainable Chemistry

(1) Risk Assessment Technology

In solving problems through GSC, it is important to decide a priority order of the technologies by evaluating the risk of chemical substances and their cost performances. It is desired to promote assessment technology, in parallel with technological development for risk reduction, grasping the barriers to be overcome quantitatively and allocating the funds strategically.

(2) Tool for Greenness Degree Assessment

It is important to evaluate the degree of improvement attained from the conventional technologies quantitatively and objectively. By applying BAT (Best Available Technology), the degree of improvement against the present best technology can be assessed. It is useful for managing the technological advances and is also essential to carry out a successful technological development, effectively and efficiently.

(3) Construction of Base for Information Exchange

More effective and efficient development of GSC-technologies will become possible by exchanging information among researchers and engineers worldwide by use of IT technology. Appropriate publication of information to society is important so as to accelerate the feedback of developed results to society and to amplify the improved effects, by sharing interests in the problems with people including consumers.

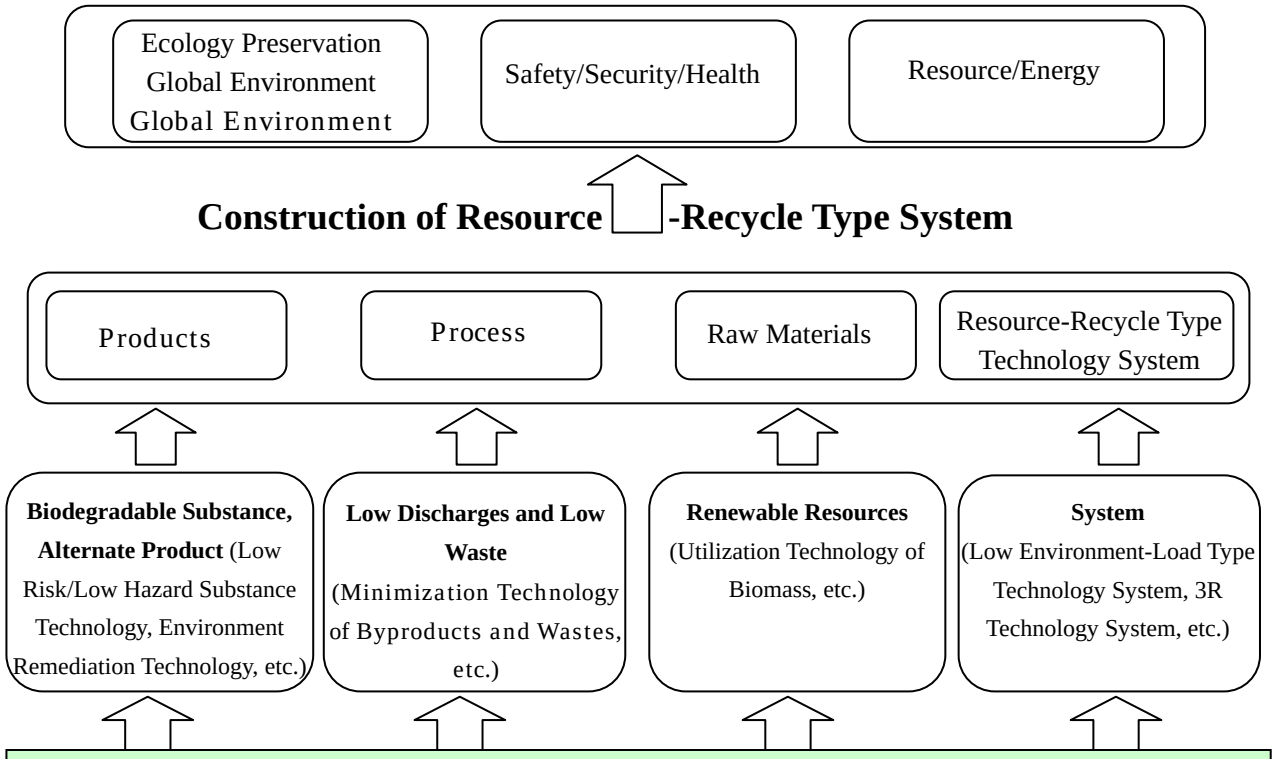
(4) Preparation of Educational System and Teaching Materials

To operate GSC effectively, training of professionals for GSC is urgent. It is also necessary to bring into chemical education a way of thinking where GSC is regarded as important. Recently, elementary school pupils and high school students are apparently less interested in the science education, and particularly, the number of college students majoring chemistry is decreasing. This phenomenon makes it extremely difficult to overcome the problems confronting this country. In the United States, the American Chemical Society has prepared extensive teaching materials for GSC audiences, even including elementary school pupils for enlightenment. In Japan, Green & Sustainable Chemistry Network (GSCN) published teaching materials related to environmental education for freshmen and sophomores for science courses in 2002. Taking this opportunity, one should begin a full-scale preparation project of education materials including children.

(5) Introduction of Sociological and Economic Viewpoints

It is important to construct a system for introducing the fruits from GSC development smoothly into society, For that purpose, it is important to use auxiliary measures to induce social acceptance with certainty, such as publication of information, abolition of regulations and reform of customs preventing introduction, training of researchers applying GSC- developed technologies, and a system to assist in business start-ups. It is also necessary to introduce new action plans based on a wide range of input – not only from technologists, but also sociologists, economists, persons of NGO/NPO and consumers.

GSC-21 Initiative
Sustainable Society



Energy

*Solar Energy (High-Efficiency Solar Cell) *Hydrocarbon (Efficient Utilization of Fossil Energy) *Hydrogen Energy (Hydrogen Production, Storage) *Utilization Technology of Natural Sources of Energy (Wind, Geothermal Heat, Tidal Current) *Storage and Transport of Energy *Utilization Technology of Low-Grade Energy *Energy-Saving Technology

Global Environment

*Global-Warming Prevention Technology *Control Technology of Ozone-Layer Depleting Chemicals *Water-Resource Environment Protection Technology *Radioactive-Waste Disposal Technology *Soil-Contamination Remediation Technology *Materials for Creating Safe & Secure Space

Resource

*Non-Waste/Resource-Recycle Technology *Utilization Technology of Renewable Resource *Utilization Technology of Deep-Sea Water *Marine-Ranch Technology *Utilization Technology of Methane-Hydrate *Time-Limited Degradable Material Technology *Highly-Controlled Biodegradable Polymer Technology *CO_2 Resource-Conversion Technology (CO_2 Separation Membrane)

Life Science

*Bio-mimetic Technology *Development of Micro-Machines Related to Medical Treatment or Living Body *Design Technology of Chemically-Modified Bio-Molecules and Self-Assimilation Technology

Key Technologies

*Advanced Asymmetric Synthesis (100% ee) *High-efficiency/Highly-Selective Catalyst Technology *Alternate Solvent (Solventless Reaction Technology *Solid-State Reaction/Supercritical/Ionic-Fluid Media Technology) *Separation/Recycle Technology *Chemical-Substance Safety Assessment Technology *Chemical-Substance Risk Reduction Technology *Analytical Technology of Environment-Affecting Substances *Standardization of Environment-Affecting Substances *LCA Technology

***Monitoring Technology of Inappropriate Treatment**

Research Themes of GSC (1)

	Environment (Creating Safe, Secure, Comfortable and Health Living Environment)
Themes that require a solution within a short term.	(1) Measures Against Global Warming ① Gas Separation Membrane Technology ② Technology for CO_2 Drastic Reduction ③ Technology for Controlling Ozone-Layer Depleting Substances (2) Water Resource Technology ① Development of Methods for Monitoring and Management of Variations in Water Circulation or Conditions of Water Resources ② Management Technology of Water Quality (3) Remediation Technology of Soil Contamination ① Bio-Methods ② Chemical Methods ③ Electrical-Physical Methods (4) Technological Measures Against Radioactive Wastes (5) Materials for Creating Safe and Secure Space ① Development of Next Generation Structural Materials * High Reliability, High Strength/Long Life, Recycling Ability, Environment Preservation Ability ② Safe and Secure Materials in the Next Generation/Technological Development * Biocompatible Materials * Process Technology of Low Environment-Load Type Production and Non-destructive Evaluation Technology Assuring Safe Usage ③ Sickness-Free Building Material Technology
KeyTechnologies that require continuing study.	(1) Development of Comprehensive Assessment Methods of Risks Related to Chemical Substances. (2) Clarification of Phenomena, Evaluation of Effects, Technological Measures and Assessment of Adaptability to Society. (3) Reduction and Minimization Technology of Discharges and Risk Hazards for All Chemical Substances and Establishing Risk Management System. (4) Standard Substances. (5) Environmental Organism Resources, Environment Monitoring (Total Management Technology of Water and Air). (6) Preparation of Intellectual Research Base (Environmental Statistics, Database, Assessment Method of Environmental Technologies, Information System). (7) Promotion Measures for Utilizing the Intellectual Base. (8) Preparation of Greenness Index (Atom Economy, E-Factor, LCA, BAT) (9) Environmental Effect Assessment Technology of Materials, Processes and Devices. (10) Discharge Reduction Technology of Chemical Substances.

Research Themes of GSC (2)

	Resource/Material and Process (Zero-Waste Type/Resource Recycle Technology/Low Environment Load Processes)	Energy Resource (Diversification, High-Efficiency Conversion/Transport/Storage, Energy-Saving)
Themes that require a solution in the short term.	(1) Resource/Material 1) Carbon Resource ① Efficient Utilization of Fossil Resources and Recycle Technology ② Utilization Technology of Renewable Resource * Utilization of Cellulose, Starch and Vegetable Oils * Reduction of Environment Load by Biomass and Establishing Utilization System * Biodegradable Plastics * Resource Utilization of Household and Industrial Wastes * Recycle Technology of Waste Polymers (Chemistry for Converting Them into Monomers by Depolymerization) * Technology for Converting CO_2 into Carbon Source ③ Marine Resource * Utilization of Deep-Sea Resource (Utilization Technology of Methane Hydrate and Deep-Sea Water, Marine Ranch, and Mineral Resources Such As Manganese Nodules, etc.) 2) Hydrogen Resource ① Method Utilizing Sunlight * Photolysis of Water (Wide Wavelength Active Catalysts, Solar-resistant Materials) * Converting Solar Energy into Electric Energy and Electrolysis (Wide Wavelength Active Catalysts, Solar-resistant Materials) ② High-Efficiency Green Process from Hydrocarbons (2) Inorganic Resource Alternate Technology to Depleted Precious Metals/Nonferrous Metals (3) Process ① Engineering Utilization Technology of Biological Functions Related to CO_2 Selective Separation Membranes, etc. ② Technology for Creating Bio-Utilizing Polymers and New Substances ③ Process Technology of Soft Solutions Reaction Medium Technology of Ionic Fluid, Water, Supercritical Fluid, etc. ④ Solventless Process ⑤ Micro-Reactor Technology ⑥ ECO-Device Technology * Pb-Free Piezoelectric Element * As-Free Luminous Element * Low Power Consumption Devices ⑦ Technology for Decomposing Toxic Substances so as to Make Them Harmless ⑧ Establishing Recycle Systems for Sustained Utilization of Resources ⑨ Bio-mimetic Technology Aimed at 100% efficient Synthesis ⑩ Technology for Designing Recyclable Materials ⑪ High-Efficiency/High Function Catalyst * Bio-Catalyst * Solid Acid * Basic Catalyst, Oxidation (H_2O_2, O_2) * Fixed Catalyst Technology * Environment-Receptive Catalyst ⑫ Technology for Polymer Processing /Producing Structural Members of Framework * Reactive Molding Technology * Highly-Oriented and ControlledProcessing Technology * Production technology of Alloy/Composite Materials *Adhesion/Interface/Joining/Coating Technology * Processing Technology Without Auxiliary Materials	(1) Solar Energy * High-Efficiency, Low Cost Solar Battery Process * Wide-Wavelength Utilizing Ultra-High Efficiency Sunlight Power Generation * Utilization Technology of Wide-Wavelength Light Energy * Sunlight Hydrogen Production Technology (Conversion Efficiency Over 15%) (2) Hydrocarbon ① Technology for Making Fossil Energy Resources Harmless ② High-Efficiency Utilization Technology of Fossil Energy Resources ③ Efficient Transport, Storage and Utilization of Fossil Energy Resources and Material Related Technology for Safety ④ Fuel Cell * High-Efficiency Conversion Catalyst for Fuel Cell (All Solid Polymer Electrolyte Type) (Solid Oxide Electrolyte Type) (3) Hydrogen Energy (4) Material Related Technology for Diversification of Primary Energy Sources ① Natural Source of Energy (Wind , Geothermal Heat, Tidal Current) ② Technology Contributing to Low Cost and High-Efficiency Utilization (5) Bio-Energy Technology * Ethanol Synthesis Technology from Biomass as Raw Material (6) Storage/Transport Technology ① Superconductive Cable for Long-Distance Power Transmission ② Material for Storage/Conversion of Superconductive Electric Power ③ Hydrogen Storage Material ④ Chemical Energy Storage Technology ⑤ High-Output, Long-Life Secondary Battery (7) Energy-Saving ① Materials Technology For Energy Efficiency ② Development of Next Generation, High-Efficiency, Complex Power Generation Material ③ Highly Resistant Base Material (High Temperature, High Stress, Corrosion Resistance, Friction and Abrasion Resistance, etc.) ④ Thermoelectric Conversion Material (Development of New Material with Superior Performance to that of SiGe Series) ⑤ Technology Related to New Refrigeration Material ⑥ Super-Light, High-Strength Material, etc.

Themes and Prospect of GSC