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Research Institute of Innovative Technology for the Earth

If Not Led by Technology, a Decarbonized Society Can Never be Realized

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The issue of global warming has attracted worldwide attention. Last year, the IPCC pointed out in its Fourth Assessment Report that global warming caused by human factors has advanced so far as to threaten the survival of civilization. Former U.S. Vice President Al Gore promoted a rather obsessional campaign toward enlightenment and, together with the IPCC, was awarded the Nobel Peace Prize.

In order to peak out and then reduce greenhouse gasses emissions which are increasing at an accelerated pace year by year, it is an essential element to drastically change lifestyles on a global scale. However, it discomforts me to see that the international debate is overheated departing from primary purposes, and has developed into political shows in which unreasonably high emission reduction targets have been paraded without confirming the ground we are standing on, or which campaign is being run as much as to say that a country would be environmentally-disqualified if it failed to accept the EU style emissions trading system.

First, for the realization of a decarbonized society, it is essential to intensively develop and widely disseminate the technology which is efficient enough to support such a society. What Japan now needs most will be rational and steady development of a policy that develops environmental infrastructure technology further having lead thus far, and guides the world to build a consensus based on such technology.

For a decarbonized society, the active utilization of powerful non-fossil energy, i.e. nuclear energy is obviously an essential choice because of its unrivaled high power density and energy production efficiency. Furthermore, the practical application of technology for Carbon dioxide Capture and Storage (CCS) which enables gradual transition from an era of fossil fuels to an era of decarbonization preventing the accumulation of carbon dioxides into the atmosphere is an important challenge. Without networking all of the high-efficient clean energy measures by, for example, development and diffusion of plug-in hybrid cars and heat pump houses using highly decarbonized electricity is a "carbon dioxide emission reduction by half-society" which was called for in the Gleneagles Summit in 2005 will be a pie in the sky.

Due to reckless policies, Biomass which comprises the essential components of renewable energy sources often results in the loss of activity and diversity of ecosystems in many places. There is an urgent need to restore the function of the ecosystem to self controlling the climate which has been deteriorated due to the folly of civilization over the years. In the medium- and long-term, it will become important to breed and diffuse plant species which have high capability to absorb carbon dioxide and may respond to future climate change as well as to develop highly-efficient energy conversion measures so as to increase the utilization of biomass while fitting into the rhythms of ecosystems.

The Research Institute of Innovative Technology for the Earth (RITE), since its foundation in 1990, has been squarely working on the development of various technologies necessary for the realization of a decarbonized society and has been steadily and continuously achieving results. Such steady efforts which are not affected by the trends of the day are key to succeed the realization of a decarbonized society. Expecting and looking forward to greater progress in the future, I would like to send out a great cheer to RITE.

Systems Analysis Group

Toward Post-Kyoto Regime

1. Introduction

International frameworks on climate change beyond 2012—the Post-Kyoto Regime—have been discussed extensively. In the COP13 (13th Conference of Parties) to the UNFCCC (UN Framework Convention on Climate Change) in December 2007, a decision was taken to establish a new Ad-hoc Working Group (AWG) comprising all the UNFCCC members for discussion on the framework to be implemented after 2012 and to complete its work in 2009. The framework should provide real benefits not only at the global level but also at the country level.

This paper reports our studies on the desirable long-term global targets for the reduction of greenhouse gas (GHG) emissions, the targets and actions for the reduction of regional emissions, and the sectoral approach, which have been focused upon by the AWG.

2. Toward global agreement on long-term stabilization of GHG concentrations

Article 2 of UNFCCC stipulated "to achieve […] the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." The UNFCCC did not decide the specific levels for achieving climate stabilization.

Combating global warming entails a long-term approach, the development and diffusion of innovative technologies for energy saving and low carbon emissions, and drastic changes in social systems. However, these require a long time period. The global sharing of clear long-term targets on global warming will lead to strategic developments and the diffusion of technologies and changes in social systems.

With regard to the long-term targets on global warming, the EU has consistently asserted since 1996 that the global mean temperature should not exceed 2℃ as compared to the preindustrial level. The Japanese government has presented the first long-term strategy on global warming, which aims to "halve greenhouse gas emissions by 2050 relative to the current levels." The G8 Summit in Heiligendamm has agreed on a policy agenda to "consider seriously" the decisions that include at least the halving of global emissions by 2050. However, a global agreement on the concrete long-term targets for the reduction of global emissions is expected to be difficult to be reached in the new AWG. We have conducted a project called PHOENIX (Pathways toward Harmony of Environment, Natural Resources and Industry Complex) during the period from FY 2002 to FY 2006. The project has confirmed several important findings on the global long-term targets with regard to global warming.

Although we recognized the importance of desirable concrete long-term targets for climate stabilization, surprisingly, there were few studies that determined the desirable levels of stabilization through comprehensive analyses and evaluations of the various damages of and the mitigations on global warming. Because of the limitations on resources potentials, considerations on the target levels of CO_2 stabilization should assess the desirable levels in view of the optimal allocations for each resource for the mitigation of global warming; such an assessment should be based on a comprehensive cost-benefit analysis of the costs required for the achievement of each target level and the benefits obtained from the achievement. The determination of the long-term target of CO_2 stabilization also requires value judgments such as the judgment of the allowable level of precaution for warming damages because of relative comparisons between the warming impact events, equity between future generations, and uncertainties in the warming damages. The usual cost-benefit analysis has a limitation. The procedure in the PHOENIX project was as follows. Firstly, the project performed a quantitative analysis and evaluations of warming damages (including increases in the temperature and sea level), agricultural products, human health, terrestrial biodiversity, ocean thermohaline circulation, water resources, etc. and mitigation costs for each CO_2 stabilization pathway (650, 550, and 450 ppmv stabilization); subsequently, a judgment process was performed by experts on the basis of the results of the evaluation of the damages and mitigations. Figure 1 shows the results of the evaluations on global warming by considering distinctions between the scientific evaluations and the value judgments.

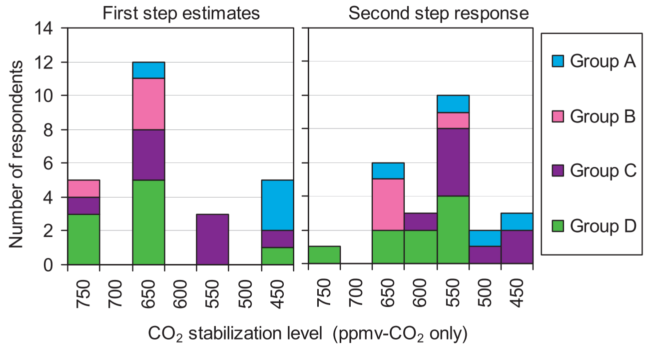


Fig. 1 Desirable CO_2 stabilization levels evaluated in the PHOENIX project

The first step is to obtain quantitative evaluations on the basis of the cost-benefit analysis of impacts on the five factors—sea level rise, agricultural products, human health, terrestrial biodiversity, and ocean thermohaline circulation—and mitigation costs. From the result of the first step, the most desirable level of stabilization obtained by the experts is 650 ppmv (CO_2 only). The second step is to obtain the expert judgments on the desirable level of stabilization by providing all these evaluation results on impacts and mitigation costs and their own preliminary judgments obtained in the first step. From the result of the second step, the average of the desirable level of stabilization obtained by the experts is 550 ppmv (CO_2 only).

At the same time, the real achievement of the long-term targets require the emission reduction agreements to be signed by not only the developed countries but also the developing countries associated with high GHG emissions. Therefore, the targets also seriously consider the acceptability of the commitments of the developing countries. For example, with regard to the target of halving global emissions in 2050 relative to the emissions in 2000, both the developed and developing countries have the same reduction rates of CO_2 emissions from the BaU (Business as Usual) case in which the developed countries have a 60-70% reduction in emissions relative to the emissions in 2000, as shown in Figure 2. In the same case, even when the developed countries achieve zero emissions relative to the BaU emissions, the developing countries have to achieve an approximately 60% reduction relative to the BaU emissions. The results indicate that it is difficult to achieve this level of global emissions. The global target in the case of the 550 ppmv CO_2 stabilization case (corresponding to an approximately +35% increase in global CO_2 emissions in 2050 relative to the emissions in 2000) can easily be agreed to by all the countries because the target has the acceptable concept of burden sharing on the basis of the principle of "common but differentiated responsibility."

These studies provide useful information on the agreements resulting from international negotiations on the long-term targets relating to climate changes.

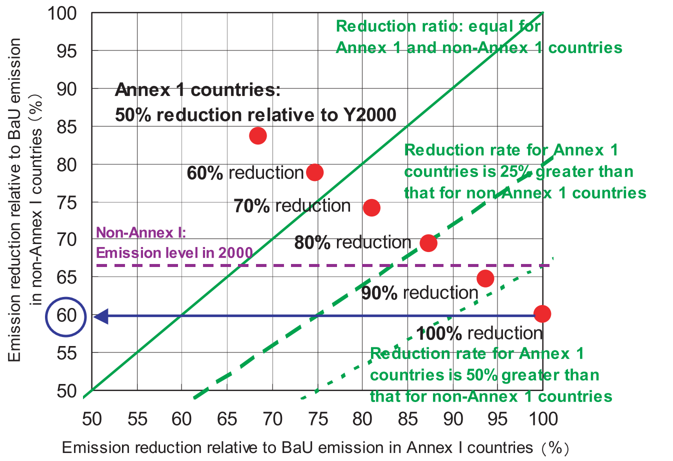


Fig. 2 Burden sharing of the reduction in CO_2 emissions in 2050 relative to 2000 between developed and developing countries

3. Propositions of the middle-term targets and international framework: Sectoral approach

Following the agreements on the long-term global targets on GHG emissions, the middle-term target around 2020 and the international framework to achieve it should be discussed in the new AWG. These discussions require the sectoral approach. Although the sectoral approach has an unclear definition and multiple interpretations, it has the following four advantages:

1) High availability because of the global implementation of the policies for concrete actions on the reduction of GHG emissions.
2) High capability to pursue technological developments, including relatively stringent targets, because of the technological targets in the sector levels.
3) Considerable satisfaction or equity for most of the countries despite stringent reductions in the emissions because of the technological targets in the sector levels.
4) High capability to construct a framework to ensure participation from many countries because of the reasonable harmony with the "pledge and review approach"; this approach allows countries to set individual targets and action plans to decrease CO_2 emissions coupled with a review system.

The achievement of large reductions in CO_2 emissions requires all the above advantages. By the adoption of the sectoral approach, Japan can take the lead in combating global warming because of having "manufacturings" by using technologies with high energy efficiencies and energy-saving products. Therefore, the international framework should focus on the sectoral approach. However, it was difficult to comprehensively estimate the net effect of the sectoral approach on the reduction in CO_2 emissions, and there were few studies on the sectoral approach. The Systems Analysis Group developed the DNE21+ model that models various technologies for the emission reductions by employing the bottom-up approach; we also analyzed and evaluated the sectoral approach for an international framework by using the DNE21+ model.

Figure 3 shows an example of a comparison of the regional energy efficiencies in the year 2000, which is the base for evaluations with the sectoral approach. The figure is based on various statistical and technological data. Based on such bottom-up data, we have developed the DNE21+ model that can evaluate the regional and sectoral reduction potentials in the future. From the result, Japan is observed to have high energy efficiencies in the iron and steel and cement sectors. Figure 4 shows an example of the evaluations of the effects of reductions in global emissions in the case of the achievement of the intensity targets (benchmarks) for each sector. The result of the evaluations indicates the significant effects of the intensity targets on emission reductions. This approach has a relatively high satisfaction level (equity), high capability for ensuring the participation of many countries, and realistic targets. Thus, studies of the Systems Analysis Group strongly support the framework of the post-Kyoto Regime and the practical targets on the basis of a scientific analysis.

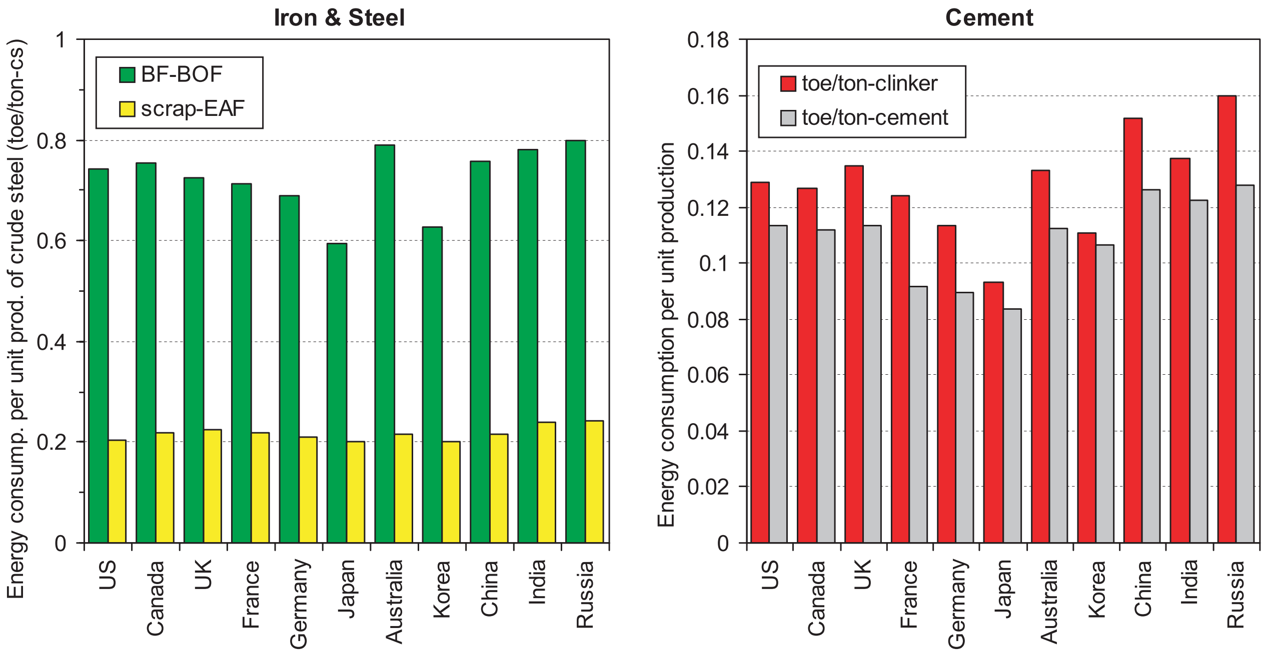


Fig. 3 Comparisons of regional energy efficiencies in iron and steel and cement sectors in the year 2000 (example)

Note: Energy consumption equivalent of electricity is assumed as follows: 1TWh = 0.086/0.33 Mtoe.
The energy consumption of the waste is excluded in the figure.

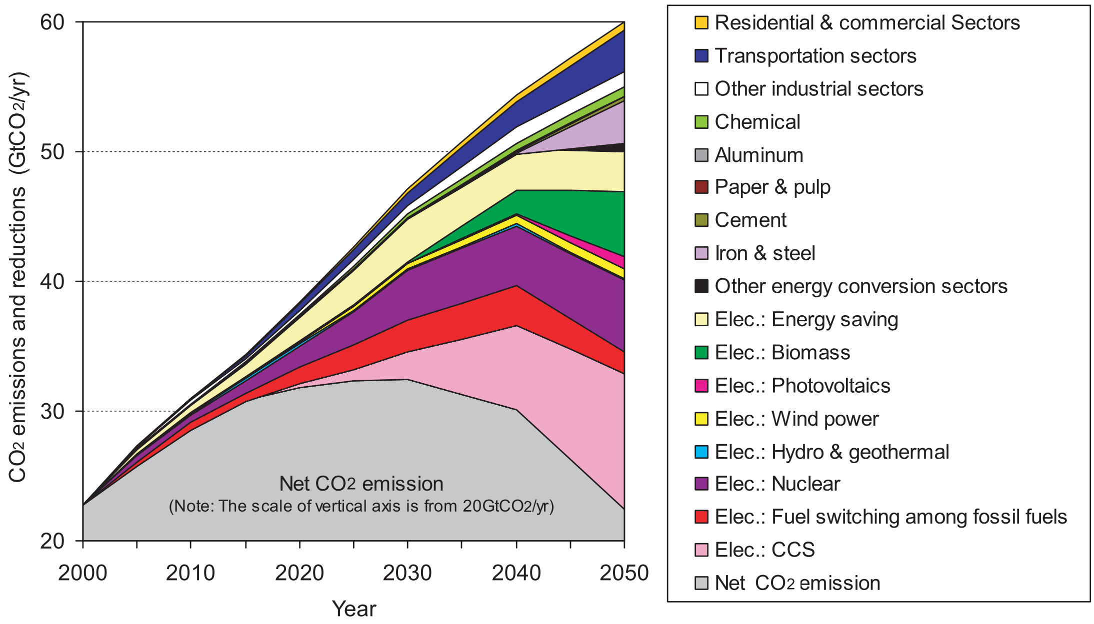


Fig. 4 Effects of reduction in CO_2 emissions on achievement of sectoral intensity targets (example)

Note: This target is that the energy supply and demand sectors can achieve the targeted intensities of CO_2 emission and energy, respectively. In this simulation study, the marginal costs in the region and sector levels are the same.

4. Conclusions

The Systems Analysis Group has conducted studies from a scientific viewpoint for supporting the establishment of the post-Kyoto Regime, which is an urgent global issue. However, the world faces not only the issue of global warming but also many other important issues at the global level. The issue of global warming is one of the significant factors preventing the achievement of a sustainable society. We should deal with this issue in a large context in order to achieve a sustainable society and consider the synergy effects between policies on global warming and a sustainable society; otherwise, we cannot win the long-term fight against global warming. Therefore, in FY 2007, the Systems Analysis Group undertook a new project on sustainable society and climate stabilization, which is called ALPS (Alternative Pathways toward Sustainable Development and Climate Stabilization). The purpose of this project is to develop several descriptive scenarios on a sustainable society and climate stabilization, carry out quantitative and comprehensive evaluations (including the use of indicators of a sustainable society and global warming), and finally provide policies to achieve both climate stabilization and a sustainable society.

As described above, the Systems Analysis Group is carrying out the analysis and evaluations of global warming by using systematic approaches. Our researches offer to help solve important issues regarding climate policies.

Chemical Research Group

Looking ahead to Future CO_2 Separation Technologies and their Challenges

The cessation of thermohaline circulation in the ocean because of global warming, which will have a destructive influence on the Earth's environment, is an issue that needs to be addressed. We need to determine to what extent the CO_2 concentration in the atmosphere should be controlled scientifically to prevent this phenomenon. The probability of cessation of thermohaline circulation in the ocean is several percent at a CO_2 concentration of 550 ppm, and this probability increases by several tens of percent at a CO_2 concentration of 650 ppm.

In the Stern Review released in 2006, although the above catastrophic phenomenon was not taken into consideration, it was predicted that all countries in the world will suffer a 5% gross domestic profit (GDP) loss due to global warming if the global warming problem is not addressed. The review stated that a contribution of 1% of GDP to combat global warming is reasonable from an economic point of view. The Japanese government recently moved to build a new framework to reduce global CO_2 emission after the signing of the Kyoto Protocol.

A CO_2 concentration of 550 ppm is twice the concentration that was present during the Industrial Revolution. If we set a target CO_2 concentration of 550 ppm for 2100, it has been predicted that not only energy savings, fuel switching, renewable energy sources (solar cells, wind power and biomass) and nuclear energy, but also CO_2 capture and underground storage will be necessary to achieve this goal. As the cost of CO_2 capture from CO_2 sources is estimated to be 70% of the total cost of CO_2 capture and underground storage, it is important for the commercialization of this technology that the CO_2 capture cost for CO_2 capture and storage (CCS) is reduced.

Conversion technologies of fossil energy will progress, and we consider the power generation system of a boiler steam turbine evolving into a combined cycle with a gas turbine for power generation and a combined cycle with a fuel cell. Various CO_2 capture technologies such as chemical absorption, physical absorption, membrane separation, and the oxy-fuel method have been developed.

Progress in these technologies will result from development of the best combination of fuel conversion processes and CO_2 capture processes, so that CO_2 capture technologies that have economic benefits, as shown in Figure 1, are developed.

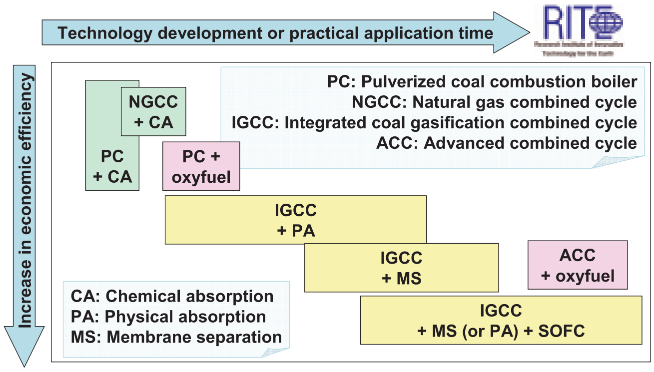


Fig. 1 Vision of power plant and CO_2 capture

Our chemical research group studies various CO_2 capture technologies, with an emphasis on chemical absorption and membrane separation methods. We use chemical absorption to reduce the CO_2 capture cost for flue gas in an ironworks factory to 3400 JPY/ton-CO_2. We are developing a chemical absorbent to reduce this CO_2 capture cost to 2000 JPY/ton-CO_2. Moreover, we have discovered an excellent membrane material for the separation of CO_2 from H_2-containing gas. We are engaged in the development of the structure of a new membrane composed of this material and are developing a membrane module for demonstration with real coal gasification gas.

CO_2 capture technology with chemical absorbents

The chemical absorption process, where amine solvent selectively absorbs CO_2 in flue gas and desorbs CO_2 with heating, has the potential to capture CO_2 at large and atmospheric stationary emission sources in practical applications. The most important issue in the chemical absorption process is the development of new solvents to reduce the CO_2 capture cost.

The Research Institute of Innovative Technology for the Earth (RITE) has promoted a project named "A Cost-effective CO_2 Capture System Using Low-grade Waste Heat" since 2004 as a five-year project, with the RITE being responsible for the development of new solvents. The objective is to reduce the CO_2 capture cost in removing CO_2 from the blast furnace gas stream in integrated steel works by almost half compared to the cost of current technology (Figure 2).

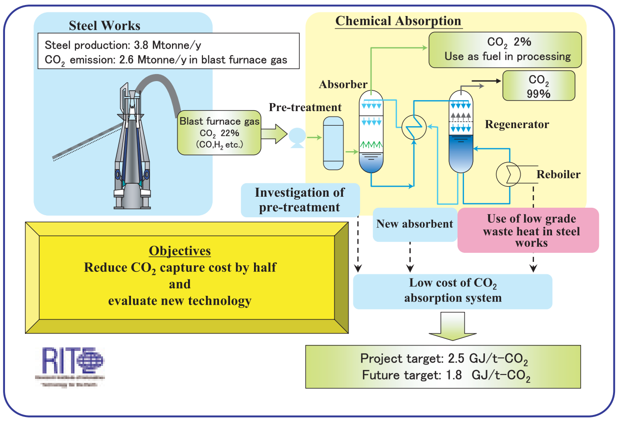


Fig. 2 Outline of cost savings in the CO_2 capture system (COCS project)

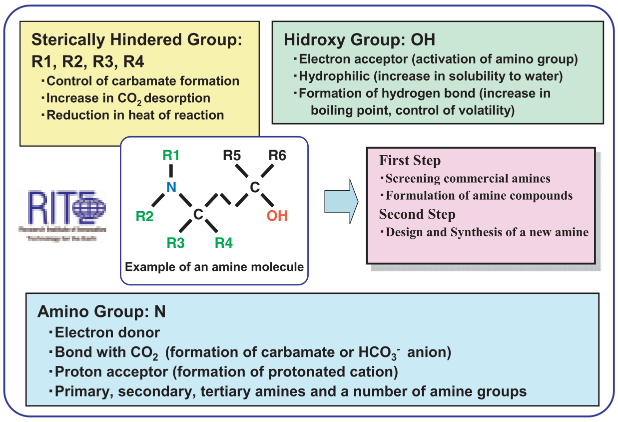


Fig. 3 Development of new absorbents

Desirable performances of the new solvent are low reaction heat, fast CO_2 absorption rate, and large separation capacity for CO_2. Through these performances, CO_2 has been separated from a gas stream using less energy. Figure 3 shows a scheme for the development of new solvents. Initially, we investigated reaction characteristics of several hundred commercial amine solvents that have good CO_2 capture performances. We then measured the reaction rate with CO_2, CO_2 absorbance capacity and the reaction heat using laboratory apparatus. Furthermore, we attempted to create a novel mixture of several amines in which each amine compensates for their deficiencies of others. We made a new solvent and repeatedly improved its performance. In this way, three types of high performance solvents (RITE-3,-4 and -5 Series), which have different characteristics, have been developed to date. Furthermore, high-performance solvents (RITE-5 and -6 series) have been developed from our experimentally formulated database and a theoretical approach to determining the molecular structure of new amine compounds using quantum theory analysis. The best energy performance for CO_2 capture among these solvents was 2.7 GJ/ton-CO_2, which is very low compared to the 4.0 GJ/ton-CO_2 of the standard MEA (monoethanolamine) solution. It is estimated these absorbents can achieve a 40% reduction in CO_2 capture costs.

Future work will be an experimental study of the high performance absorbents and to find optimum conditions for the absorbents in building the most cost-effective CO_2 capture system.

Chemical absorbent under high pressure

Based on current knowledge of solvents in CO_2 capture from a gas stream under atmospheric pressure, a research and design program for new solvents suitable for a high pressure gas stream has been running since 2007. In general, amine solvents for an atmospheric pressure condition can easily react with CO_2 independent of reaction temperature. However, we have confirmed that some amine solvents have large CO_2 capacity depending on reaction temperature under a high-pressure condition; nevertheless, they cannot react under atmospheric pressure (Figure 4). We intend to propose a new system for CO_2 capture from pressurized point sources through the development of these solvents.

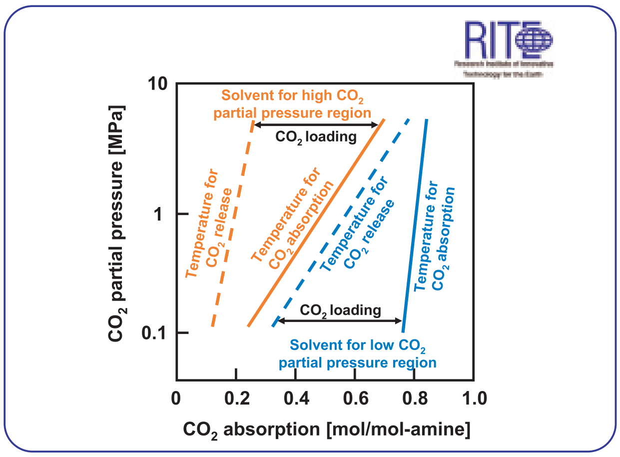


Fig. 4 Comparison of characteristics of chemical solvents applicable in high and low ranges of CO_2 partial pressures

Novel techniques for regenerating the chemical absorbent

We are developing a regeneration technique for accelerating CO_2 desorption with a pressure difference to reduce the energy consumption in a chemical absorption system. To date, the following observations have been made. Desorption can be accelerated by flashing the solution into a reduced pressure space, which can reduce electric energy consumption by more than half in comparison with the conventional method that uses high temperatures. Moreover, by using low-temperature waste heat, as shown in Figure 5, it is possible to achieve an electric energy consumption about 1/4 (0.1 kWh/kg-CO_2) of that of the conventional chemical absorption method. We will attempt to apply this method to the separation of CO_2 from flue gases, chemical processes, bioprocesses, etc., while efforts are made to further reduce energy consumption.

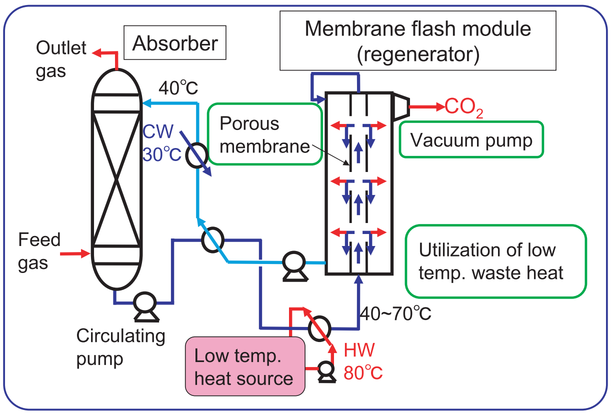
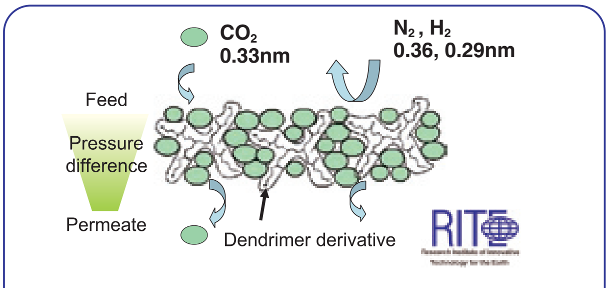


Fig. 5 Example of membrane flash flow with heating

CO_2 and H_2 separation with a polymeric membrane

One promising means of decreasing the cost of CO_2 separation is the development of new, high-performance CO_2 separation membranes that allow CO_2 recovery via membrane separation from pressurized gas streams. An integrated gasification combined cycle (IGCC) with CCS such as the FutureGen project in the USA provides a pressurized gas stream containing about 40% CO_2 with H_2. CO_2 would be separated with a membrane injected under the ground for the CCS, and H_2 would be used as a clean fuel. The cost of CO_2 capture from the pressurized gas stream with a membrane might be 1500 JPY/t-CO_2 or less.

We are currently developing a CO_2 molecular gate membrane with the goal of producing a new, high-performance separation membrane. Figure 6 shows the basic outline of the CO_2 molecular gate function. The pathway for gas molecules is occupied solely by CO_2, which acts as a gate to block the passage of other gases. Consequently, the amount of N_2 or H_2 permeating to the other side of the membrane is greatly limited and high concentrations of CO_2 can be obtained. The RITE dendrimer having excellent CO_2/H_2 selectivity is fixed stably in a cross-linked polymer matrix to form the active layer of a resulting composite membrane. The composite membrane showed a record CO_2/H_2 selectivity of at least 20 at an elevated pressure. The RITE is now improving the selectivity and developing practical membrane modules of the dendrimer composite membrane.



The pathway for gas molecules is occupied solely by CO_2, which acts as a gate to block the passage of other gases. Consequently, the amount of N_2 or H_2 permeating to the other side of the membrane is greatly limited and high concentrations of CO_2 can be obtained.

Fig. 6 Conceptual diagram for the CO_2 molecular gate

In developing this CO_2 molecular gate membrane, the RITE conducted joint research with the US Department of Energy's National Energy Technology Laboratory (NETL) as a recognized project of the Carbon Sequestration Leadership Forum (CSLF). Testing of the dendrimer composite membrane module developed by the RITE (Figure 7) was carried out at the NETL (Figure 8).

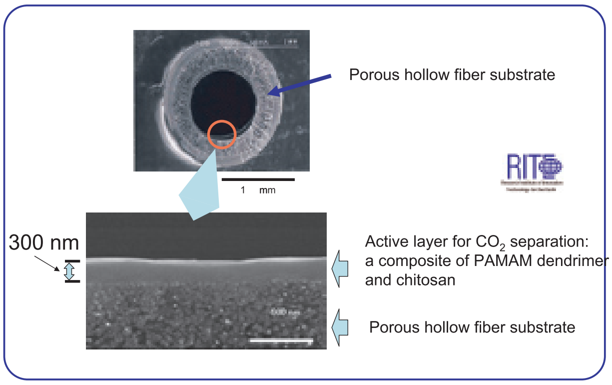
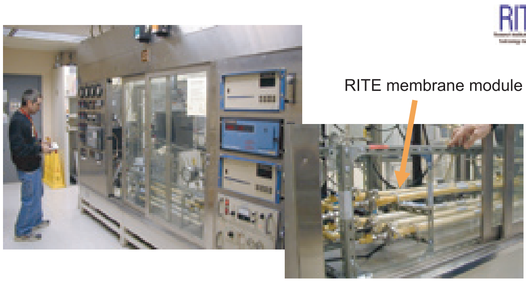


Fig. 7 Dendrimer composite membrane at ambient pressure



RITE's membrane module was tested at the USA Department of Energy / National Energy Technology Laboratory in May, 2006. The test was performed as a CSLF recognized project entitled the "CO_2 separation from a pressurized gas stream".

Fig. 8 RITE's membrane module test at USA DOE/NETL

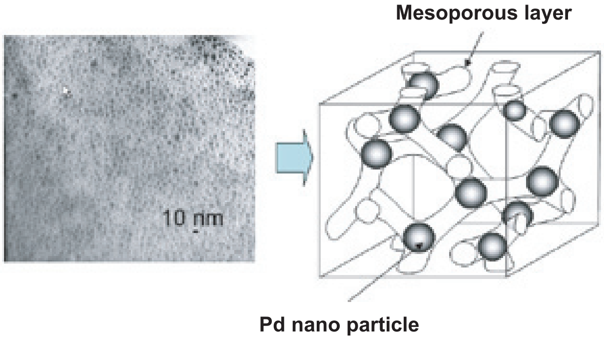


Fig. 9 Hydrogen separation membrane with Pd nano particles within mesopores

Inorganic membrane for the catalytic membrane at high temperature

Because zeolite and mesoporous silica possess well-defined micro/mesopores with low thermal expansion/mobility of the framework, considerable attention has been focused on the production of membranes that are capable of separating gases with high selectivity. Based on the simulation results, we selected candidate zeolite structures for CO_2 separation and have begun synthesis of new zeolite membranes.

On the other hand, since mesoporous silica has uniform, large pores as well as a high surface area, a variety of guest molecules can be introduced into the pores. A new hydrogen separation membrane was prepared by the impregnation of Pd salt in the mesoporous silica membrane and the additional growth of Pd nanoparticles by electroless plating. As shown in Figure 9, it was found that Pd nanoparticles seeds for electroless plating, which were of almost equivalent size to the mesopores, were successfully prepared into the pores by impregnation of Pd salt and the membrane showed H_2 selectivity from a mixture of H_2 and CO_2. We are now planning: (1) improvement of the performance of the membrane, (2) evaluation of its durability, (3) production of a larger module and (4) application of the membrane reactor under changing reaction conditions.

Plasma PM removal system for diesel vehicles

Recently, the emission control for particulate matter (PM) from diesel vehicles is becoming extremely severe, although no satisfactory PM removal technologies have yet been developed. The plasma PM removal technology has potential as an innovative technology for the after treatment of exhaust gases from diesel vehicles. This project (Comprehensive technological development of innovative, next-generation, low-pollution vehicles, and R&D of innovative after-treatment systems) is a joint study with Daihatsu Motor Co., Ltd., which is supported by the New Energy and Industrial Technology Development Organization. RITE is 1) to investigate the mechanisms of plasma discharges and plasma PM oxidation and 2) to develop a PM removal system that can be loaded onto a small diesel vehicle. The PM removal system includes a power supply and a small plasma reactor of high PM removal ability and low pressure loss (Figure 10).

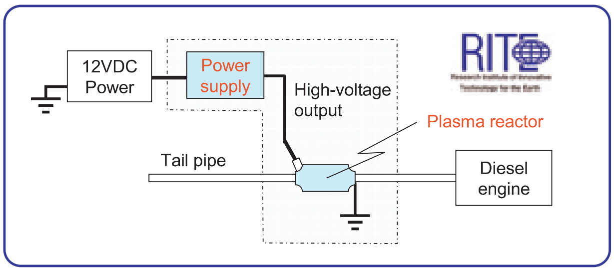


Fig. 10 Plasma PM removal system

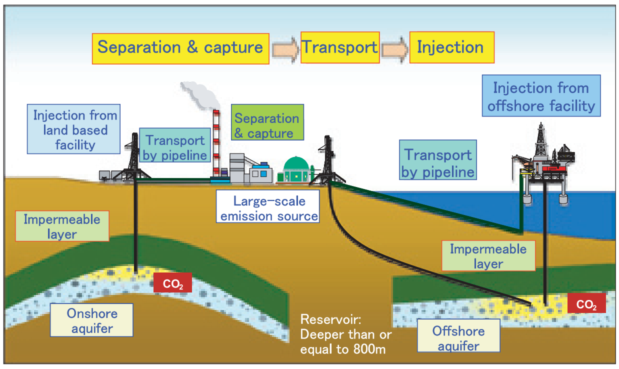
CO_2 Storage Research Group

CO_2 Storage Technology Development for Practical Application

CO_2 Geological Storage Project

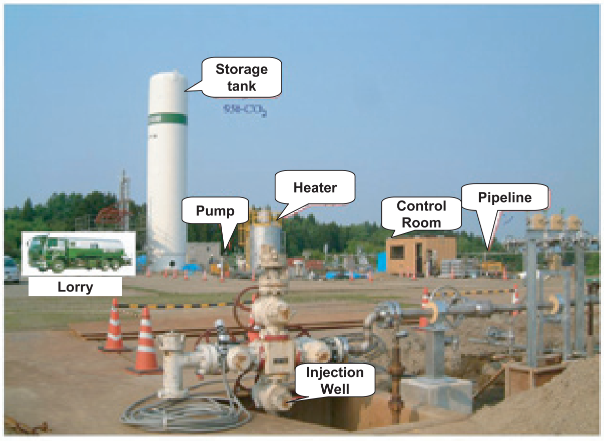
The CO_2 geological storage technology is a technology for safely and securely trapping CO_2, a greenhouse gas, into subsurfaces without releasing it into the atmosphere. There are various methods for the storage, including EOR, which injects CO_2 into depleted oil fields and recovers the enhanced oil; isolation of CO_2 in depleted gas fields; ECBM, which injects CO_2 in coal seams and recovers methane; and storage of CO_2 in highly porous sandstone aquifers, containing formation water.

RITE has been working on aquifer storage, which enables stable storage of CO_2 over long periods because there is a gas- and water-impermeable sealing layer on top of the aquifer where CO_2 is stored. Since technology of underground natural gas storage can be applied, this method is thought to be the most immediately effective and closest to practical use.



Concept of CO_2 geological storage

"R&D project of CO_2 Geological Storage Technology" was launched in 2000 to scientifically verify the feasibility of CO_2 storage in subsurface aquifers in Japan, focusing on its effectiveness as a global warming countermeasure. In particular, for the CO_2 injection demonstration test conducted at the Iwanohara site in Nagaoka City, Niigata Prefecture, 10,400 tons of CO_2 were injected in the aquifer of 1,100m depth below the ground during the period from July 2003 to January 2005. The underground behavior of CO_2 was observed by cross-well seismic tomography and well loggings, and a behavior prediction simulator was developed, based on the observation data. Besides, during testing, the Chuetsu Earthquake took place in Niigata Prefecture, approx. 20km away from the Iwanohara site, but no abnormalities were found in the injected CO_2, the aquifer, and the well, confirming the safety of the storage. In 2007, the CO_2 stored underground were monitored to improve the accuracy of the prediction technique.



Iwanohara demonstration test site

Our activities have clarified the scientific feasibility of geological storage in Japan. On the other hand, CO_2 geological storage technology development and demonstration is steadily progressing and is closer to practical use as a CO_2 emission reduction measure around the world. Therefore, it is necessary to clarify the effectiveness of CO_2 geological storage and issues for its practical application, and develop a social system.

RITE has performed a comprehensive research & development and assessment of CO_2 geological storage through effectiveness assessment studies; drawing up a road map of technological demonstration / practical use; investigation of the suppositional points; survey on the potential capacity of CO_2 aquifer storage nationwide; related and peripheral studies, including domestic and international policies and technological trends; preparation of information dissemination functions; and safety studies. In addition, to establish safety and security assessment techniques, we have conducted monitoring of injected CO_2 at the Iwanohara site, basic studies of geological storage mechanisms, and studies to promote the accuracy of CO_2 behavior prediction techniques.

In future research and development, in addition to clarifying issues in promoting CCS (Carbon dioxide Capture & Storage), we will develop technology required to turn it into a reality, survey of CO_2 storage potential and conduct basic studies for a larger scale demonstration test of the governmental target of 100,000 tons of CO_2 storage per year.

We held the "CCS Workshop 2007 ~ The forefront of CO_2 Separation, Recovery and Storage Technology~ ” in the Keihanna Plaza, Kansai Science City in February 2007 and the “CCS Workshop Tokyo 2007~ As a Core Technology of CO_2 Emission Control Measures~ ” in November 2007. In these international workshops, we introduced the research achievements of the Nagaoka project as well as future research plans. For details, see page 19 of this document.

CO_2 Ocean Sequestration Project

The ocean dissolves a large quantity of CO_2. Since there is sufficient potentiality to dissolve CO_2 in the middle and deep layers of the ocean, which is rapidly increasing in the atmosphere, CO_2 ocean sequestration technology has been considered. This technology captures CO_2 from large emission sources and directly injects it into deep-sea areas without passing through the ocean surface. RITE has been developing technology for CO_2 dilution and injection to middle ocean layer using a Moving Ship method, as shown in the following figure. According to chapter 6 of the IPCC special report “Carbon dioxide Capture and Storage” in 2005, ocean sequestration is evaluated as an effective technology to mitigate climate change. The challenge in preparing this technology for practical use lies in controlling the impact of CO_2, which is injected directly into the ocean, on marine species. Development of environmental impact prediction technology is our immediate challenge.

In phase 1 of this project, which was implemented from FY1997 to FY2001, we conducted a CO_2 macroscopic behavioral study, an analysis of CO_2 behavior behind the release nozzles, and predictions and investigations of biological impacts. In the following phase 2 (from FY2002 to FY2011), we are developing and assessing technology aimed at “Study of environmental impact assessment for CO_2 ocean sequestration for mitigation of climate change”

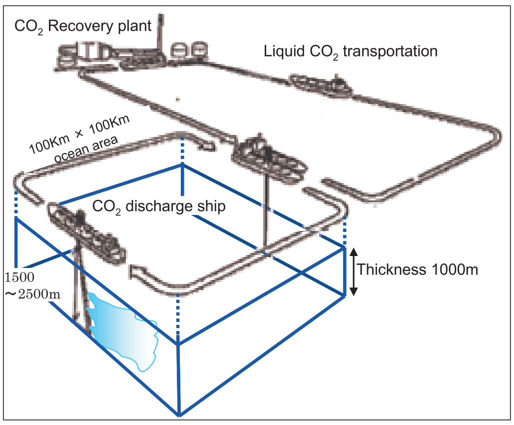


Fig. 1 Image of ocean sequestration using a Moving Ship

As a result, for CO_2 discharge using a Moving Ship method, the simulation predicted that within a few hours, the CO_2 concentration is lower than the natural fluctuation range and the acute impact on marine living species is negligible. To clarify the image of ocean sequestration in practical use, the engineering study of its implementation was carried out under the case which is the ocean sequestration of about 50 million tons of CO_2 annually into the ocean near Japan, and got the result that the CO_2 concentration can be reduced to below the level of the predicted no-effect concentration. These results were reported in the special symposium of Japan Ocean Society “CO_2 ocean sequestration: what is the appropriate assessment for the environmental impact”and promoted scientists’ understanding.

We reviewed R & D themes to be developed in 2007 and conducted the following activities: (1) Study on trends in CO_2 ocean sequestration technology (1. Preparing the base to promote understanding and 2. Establishing a global network), (2)Study on biological impact assessment for CO_2 ocean sequestration (1. Developing biological impact assessment techniques, 2. Collecting biological impact data in the actual ocean, and 3. Studying the CO_2 impact on deep-sea living species) and (3) Development of CO_2 behavior technology (1. Developing CO_2 behavior observation and prediction technology, and 2. Potential ocean sequestration assessment).

In future development, we will proceed with development of ocean sequestration technology for practical application by developing a more accurate CO_2 behavior prediction technology, as well as biological models of the middle and deep layers of the ocean and long-term impact prediction technology, by taking advantage of achievements such as environmental impact assessment technology and CO_2 dilution technology. However, to put the ocean sequestration technology into practical use in the future, it is necessary to demonstrate developed technology by conducting experiments in the actual ocean, and ultimately, to trace the CO_2 behavior in several 100 km scale, and to investigate the biological impact. In addition, since the ocean is a human common property, international consensus to implement the ocean sequestration test is essential. Therefore, we will make efforts to establish a global network not only to promote scientists’ understanding of ocean sequestration but also to acquire agreement to experiment via international treaty.

FutureGen Project

Fossil fuels account for approximately 80% of global energy sources and the long-term use of coal is expected in the future. Clean coal power generation in particular attracts a lot of attention. From the perspective of global warming, it is necessary to combine coal gasification power generation technology and CCS technology that separates, recovers, and stores the emitted CO_2 in the earth in order to achieve this goal. It is through the FutureGen program that the United States aims at practical use of zero emission clean energy power generation to meet these expectations.

FutureGen is a system to gasify coal using pure oxygen, generate power using the hydrogen gas obtained, capture the CO_2 generated, and store it in geological formation (see Figure 2).

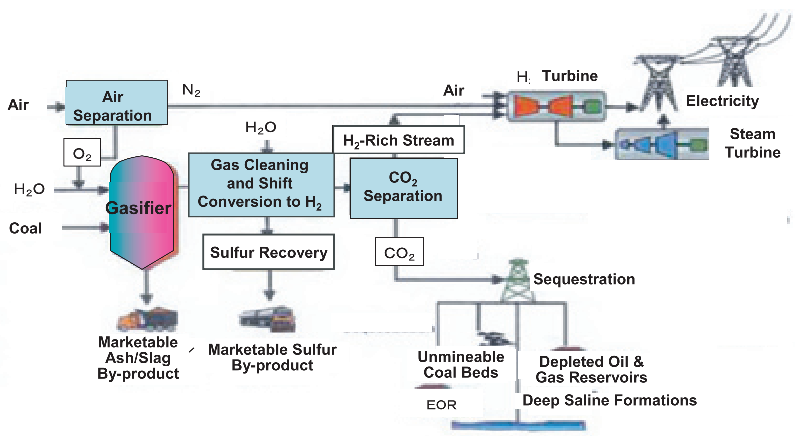


Fig. 2 FutureGen system outline

On the other hand, Japan has reached the global level in the coal gasification technology, and achieved world-class results in CCS technology, especially in CO_2 separation and recovery technologies and CO_2 geological storage technology development. We are now in the stage of developing a technology by integrating these technologies, focusing on zero emission clean energy power generation similar to that of the FutureGen program.

To demonstrate zero emission, consolidation of a broad range of technologies and strong financial resources are required. Thus, participating in an international cooperation framework lead by the United States is of great significance in obtaining technological information of this innovative zero emission coal gasification power generation technology, considering our comprehensive strategy for its practical use and promoting and enlightening public awareness for the technology..

Reflecting the above, RITE proposed the “Coal Gasification Technology Demonstration and Deployment Project” in 2007 and has just launched the FutureGen project. The major work will be

(1) Collecting and sorting information related to the FutureGen project;
(2) Assessing the development of FutureGen;
(3) Comprehensive strategy planning and investigation;
(4) Operating the FutureGen Domestic Industrial Cooperation Promotion Association (tentative name);
(5) Providing CCS technology information, popularizing and enlightening public awareness for CCS technology.

We are conducting several surveys with regards to information collection and development status assessment related to the FutureGen project, including investigating the site selection method implemented by the FutureGen Alliance (FG industrial alliance) and studying the up to date information of candidate technologies for the FutureGen Process, such as the coal gasification power generation and CO_2 separation & recovery technology. For popularization and enlightenment, we are now preparing a Web site for the FutureGen progress & enlightenment and will introduce the project schedule, plant image schematics, and alliance members in Japanese. In addition, we will hold the “FutureGen Workshop 2008” in February 2008.

For our future projects, we will conduct coal gasification and CCS related field surveys in the US, Europe, and Australia, and a domestic study based on information obtained from the field survey. Through these activities, our goals are for FutureGen project achievements to contribute to the development of global warming countermeasure technologies in Japan, and the incubation of new business in Japanese industries to serve our national benefits. We also plan to deliver and publicize the project achievements through our website, brochures, and reporting sessions.

Microbiology Research Group

The Current Status of Biofuels and Research Outline of the Microbiology Research Group

1. Research into biofuels

In the year 2007, the world's attention was focused on the climate change and biofuels. Since biofuels are produced from renewable biomass and are carbon neutral, competitive R&D has been carried out around the globe to establish an efficient biofuel production technology. Although the U.S.A. has shown a negative attitude towards the global effort to cut the green house gas emission, its government is leading active involvement in the biofuel production research to ensure the country's energy security. The "Twenty in Ten" objective, aiming to cut gasoline consumption by 20% in ten years, has been proposed by President Bush and the Energy Independence and Security Act of 2007, signed into law in December 2007, sets a national Renewable Fuel Standard (RFS) requiring 36 billion gallons of renewable fuels by 2022. Twenty one billion gallons will be provided in the form of advanced biofuels produced from unconventional biomass resources including cellulosic ethanol. In Europe, biodiesel has been attracting attention as transport fuel though the bioethanol market is gradually increasing. The EU is currently debating to set an objective to increase biofuel share to 5.75% by the end of 2010 or 10% by 2020. In Asia, biofuel introduction is actively progressing in China, the 3rd largest bioethanol producer, Thailand and India.

In Japan, it is planned to "provide 0.5 million KL of biofuel by 2010" as transport fuel in order to meet the target to reduce green house gas emission set by the Kyoto Protocol. Furthermore, the government aims to provide 10% of gasoline with domestic biofuels by 2030. To achieve this, 6 million KL of biofuels, including bioethanol, is required and biofuel production with a distinctive feature of the production site has already been in progress in Hokkaido and Okinawa. In addition, the ministries of agriculture, forestry and fisheries and economy, trade and industry jointly held "innovative biofuel technology council" comprised of those from industry, academia and government in November last year. The council aims to develop an innovative cellulosic biofuel technology which does not compete with food resources and plans will be illustrated at the end of March this year.

2. Biofuels and environmental issues

Bioethanol production in the U.S.A. is on the increase and the amount produced is expected to reach 26 million KL in 2007. This led to sharp rise in corn price and the increase in production revealed various concerns associated with biofuels. The main problems are increasing competition for resources with food supply and environmental destruction (BJT/Green Innovation 2007.8.23 Vol. 1 Nikkei Business Publications, Inc). In order to solve the former problem, it is essential to achieve early bioethanol production from non-food based biomass (cellulosic biomass) and making such production process widely available. Additionally, large amount of subsidy will be provided to build a cellulosic ethanol plant. Environmental destruction resulted from biodiesel production from vegetable oils, on the other hand, requires significant technological reform, hence butanol can replace conventional biodiesel, its production is currently attracting attention. The most notable feature of butanol as alternative fuel is that it can be easily mixed with light oil. Our achievement made with biobutanol production technology from cellulosic biomass is explained in detail in Topics.

3. Research and development at RITE and the future

We are carrying out technological development on efficient biomass utilization technology with our novel technology using "Growth-arrested bioprocess" with Coryneform bacteria as the core technology (Figure 1).

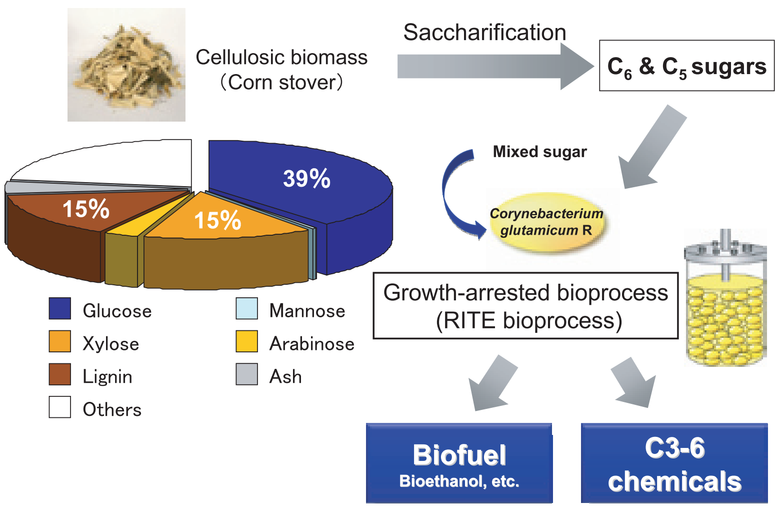


Fig. 1 Growth-arrested bioprocess

The details of the process are illustration in RITE-Today issued last year. As for biofuel production, we are currently carrying out a collaborative research with car manufacturer (Honda) on highly efficient ethanol production system from cellulosic biomass. This system is barely influenced by the fermentation inhibitors produced during the pre-treatment process and has other remarkable features. To produce chemicals of use from biomass, we are taking part in the NEDO project, “Biorefinery technology research and development”. A production host used in the “Growth-arrested bioprocess” has been assigned and the biosynthesis pathway in the Coryneform bacteria has been optimized using the genome information to create strains which efficiently produce organic acids, alcohol, dioles and amino acids (Figure 2).

Furthermore, in the context of CO_2 fixation technology and its effective use, fundamental research and development is conducted by focusing on individual projects including next-generation biofuel production from biomass resources (hydrogen and butanol) and technology to utilize wood-biomass (hard biomass). Among these, collaborative research is carried out with house-hold appliance manufacturer (SHARP) on hydrogen production process from biomass resources. In such process, hydrogen is continuously produced from biomass-derived sugars by genetically modified *Escherichia coli* to efficiently produce hydrogen, which is considered to be clean-energy. We endeavor to carry out collaborative research with industry to apply our “Growth-arrested bioprocess” to broader chemicals and biofuels production in the future.

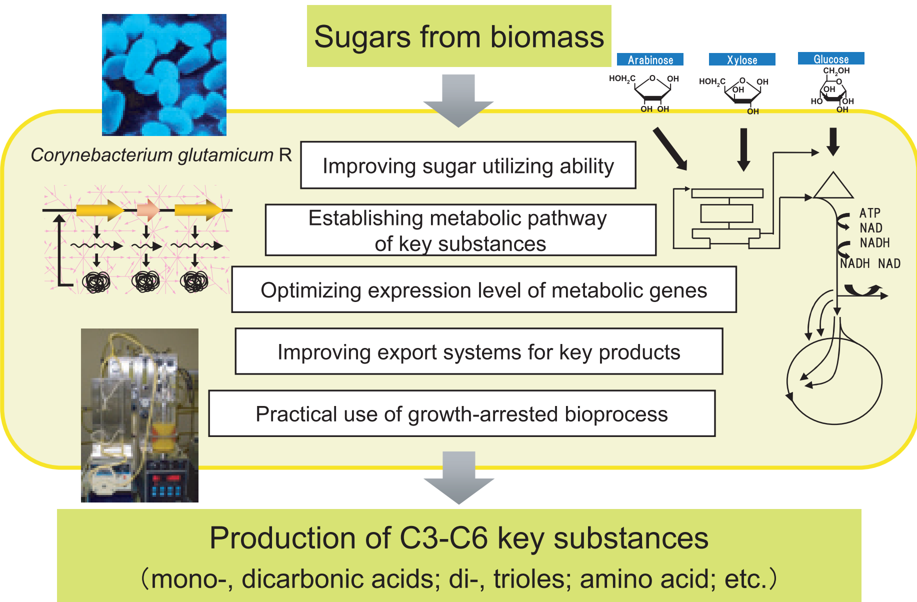


Fig. 2 Biorefinery technology research and development

Plant Research Group

Developments of Afforestation and Metabolic Engineering in Plants for Supply of Alternative Energy

Plant Research Group aims at sequestration of CO_2, the main cause of global warming, and develops the techniques for both afforestation and Metabolic Engineering in Plants for Supply of Alternative Energy. In the techniques for afforestation, the group tries to enhance the growth of plants/trees by both strengthening photosynthesis and tolerance against environmental stress under semi-arid lands with their genetic modification. Furthermore, on the contrary to these GM-strategies, the group tries to make molecular markers which give trees tolerance to environmental stress, using elite trees of Eucalyptus sp. obtained in semi-arid land of western Australia. The usage of the markers could increase the efficiency of selection of elite trees in the field and contribute to the sequestration of CO_2 through the expansion of afforestation area. On the other hand, Plant Research Group tries to modify metabolic profiles in plant cells for the supply of alternative bioenergy to petroleum source one through GM-technologies, which could contribute to the suppression of CO_2 emission in industrial activities. Followings are the introduction of projects in Plant Research Group.

Afforestation project

The greenhouse effect on the Earth by increased atomospheric CO_2 is the most important environmental problem. This problem is taken as a political issue in many countries. However, it is true that practical solutions for the problem are not actually executed because of a bad influence to their economy. In this project, we try to develop technologies for improving photosynthetic activity of plants and afforestation in unstable area for vegetation, such as a semi-arid area to reduce atmospheric CO_2. For this purpose, we planned to reveal the function of photosynthesis related genes by physiological and molecular biological methods. It is known that a plant photosynthetic rate is mainly determined by three factors; carboxylase reaction for CO_2 fixation, electron transport in photosystems, and recovery of phosphate into chloroplasts. It is necessary to release these rate limiting steps of photosynthesis for improving CO_2 fixation activity of plants. We obtained some Arabidopsis photosynthetic mutants by chlorophyll fluorescence analysis. Now we have detected three mutated genes in these mutants. We are going to throw light on the mechanism of rate limiting factors in photosynthesis and produce plants that have higher CO_2 fixation activity in the future.

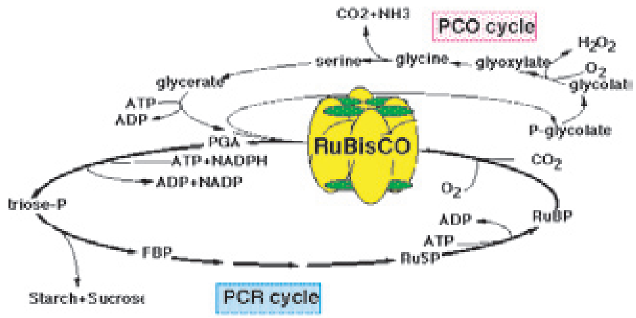


Fig. 1 Photosynthesis in higher plants

Developing a new procedure selecting stress tolerant *Eucalyptus* elites

Elite trees, which survive in infertile areas such as dry and salty lands, are potentially useful materials to increase terrestrial areas absorbing CO_2. Nippon Paper Group, Inc. has *Eucalyptus* afforestation of about 40,000 ha in Western Australia, and so far has selected about 70 *Eucalyptus* (*E. globulus*) individuals that can be candidates for the elite trees. They are maintained as clones by cutting and grafting.

However, it takes more than 10 years to access whether those elite candidates are effective with certainty. RITE has started evaluating drought/salt stress tolerance of the elite candidates and also clearing the physiological mechanisms in collaboration with Nippon Paper and Tokyo University. Our final goal is to develop a new procedure selecting the elite trees with certainty and rapidity, which would bring about effective afforestation in the infertile areas.

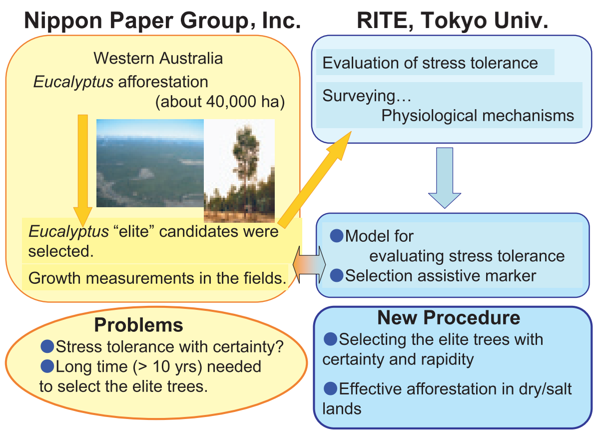


Fig. 2 Collaboration with Nippon Paper and Osaka Univ.

ROS -regulation project-Enhancement of HDP-and APX -systems by chloroplast engineering-

Extension of vegetation area to the unused lands is thought to be an actual and effective method to reduce the level of atmospheric carbon dioxide. In many cases, plants suffer severe growth inhibition due to abiotic stress, such as drought, salinity, cold and high temperature, in the unused areas. Under such abiotic stress, plants close their stomata to avoid the loss of water by transpiration. However, the close of stomata leads to decrease CO_2 influx to chloroplasts, and decline in the rate of photosynthesis. As the result, absorbed photon energy, which is usually consumed by photosynthesis, becomes excess, and the excess photon energy stimulates the production of reactive oxygen species (ROS) by reduction of dioxygen in chloroplasts. Furthermore, ROS induce oxidative damage, i.e. "sunburn", to cellular components of plants, and finally lead plants to death.

We have studied intensively the mechanisms of protection of cellular components from ROS attack. We clarified that two mechanisms, those are called "HDP system" and "APX system", play significant roles in the protection of chloroplasts against ROS attack. In HDP system, excess absorbed photon energy is converted to heat, and the production of ROS in chloroplasts is repressed. In APX system, H_2O_2 produced in chloroplasts is immediately converted to water by an enzyme, ascorbate peroxidase (APX).

In this project, we are trying to develop the fundamental technology to produce stress-tolerant transgenic arabidopsis and tobacco plants by chloroplast transformation as the model systems. Now, three research subjects aimed to enhance the abilities of HDP-and APX systems in chloroplasts are carried out as described below:

(1) Clarification of the molecular mechanism to drive HDP system and identification of a gene encoding master protein in the regulation of HDP system
(2) Localization of H_2O_2-insensitive ascorbate peroxidase from red alga Galdieria partita to thylakoid membranes in chloroplasts to scavenge H_2O_2 produced immediately.
(3) Production of oxidative-stress tolerant transgenic plants by introducing genes for master protein in HDP system and Galdieria APX into chloroplasts

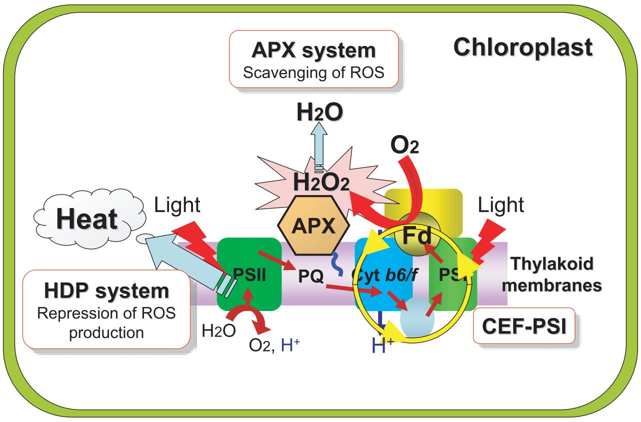


Fig. 3 Fundamental Technology for Controlling the Material Production Process of Plant Chloroplasts

Industrial utilization of material production functions of higher plants is one of the promising technologies that can alternate energy-intensive petrochemical process. The purpose of this project is to identify substance production process and to improve the capacity of useful material production by using gene-recombination technology in plants.

A chloroplast is the center of photosynthesis, which converts CO_2 to various substances by using light energy. We have already established the systems of both proteome analysis that covers chloroplastically-located proteins and metabolism analysis that enables to exhaustively profile metabolic compounds produced in plants by collaboration with Osaka University. In 2007, we also succeeded in the establishment of new metabolic analysis system which makes it possible to observe production rate of metabolic intermediates.

Chloroplast transformation, one of the key technologies in this project, is developing, which has potential to exceed the ability of conventional gene-recombination technique. In fact, we succeeded in producing high-value added compound, astaxanthin, in tobacco plants by using chloroplast transformation. Now we are developing the technology for controlling gene expression in chloroplast to produce high levels of useful materials in a tissue-specific manner by collaboration with Kyoto Prefectural University and Nagoya City University.

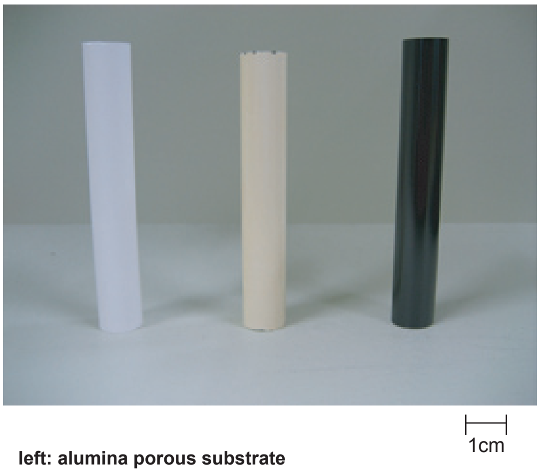
Global Climate & Energy Project (GCEP)

Chemical Research Group

The RITE has received an award for its developmental work "Sub-nano structure controlled materials: development of innovative gas separation membranes" from the Global Climate and Energy Project of Stanford University, USA. In this project, the synergy of research into both organic and inorganic materials will lead to innovative materials for gas separation membranes.

Carbon membrane

In the organic materials approach, sub-nanostructure controlled carbon membranes are now under research. The RITE's novel carbon membrane would have an ideal molecular gate function, showing excellent separation performance in the wide range of feed gas conditions. The surface and/or micropores of the carbon membrane are modified with materials possessing CO_2 affinity such as metal carbonates to obtain the molecular gate function. Figure 1 shows a photograph of the carbon membrane that was made from cardo polyimide as a precursor on a porous alumina tube.



left: alumina porous substrate
center: after cardo polymide application on the substrate
right: after carbonization

Fig. 1 Carbon membrane

Inorganic membrane (zeolite membrane)

We are now investigating an optimum zeolite structure and preparation of a grain-boundary/pinhole free zeolite membrane by molecular simulation. Based on the simulation results, we have selected new candidate zeolite structures for CO_2 separation and have begun synthesis of a new zeolite membrane. Synthetic conditions for zeolite seed crystals have been studied and, recently, we have successfully synthesized a hydrophobic zeolite seed crystal that has never previously been used as a zeolite membrane (Figure 2). In addition, a new preparation method for the zeolite membrane for growing zeolite crystals inside the pores of porous alumina substrate has been proposed and it was found that the new preparation method was effective in improving the CO_2 permselectivity.

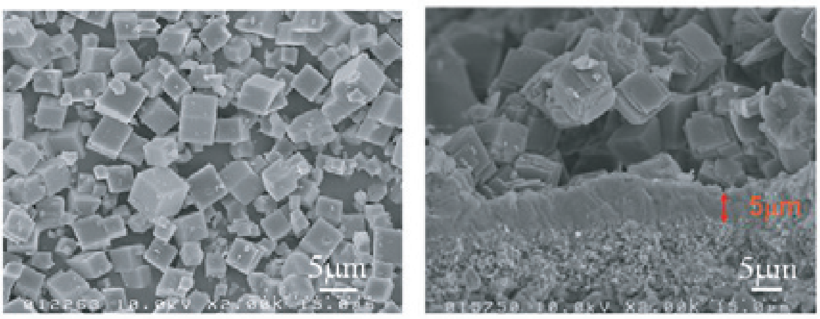


Fig. 2 Newly synthesized zeolite seed crystals and zeolite membrane

Development of biobutanol production technology

Microbiology Research Group

We, Microbiology research group, are currently developing microbial butanol production technology from cellulosic biomass. Butanol has been attracting attention along with ethanol as biofuels and the significant feature differing from ethanol is that it can be mixed with light-oil, which is fuel for diesel engine. In recent years, biodiesel production from vegetable oil has been active, however, biodiesel production is often associated with environmental destruction resulting from developing cultivation land. This led to growing anticipation for butanol production, which can be used as an alternative fuel to biodiesel. History of microbial butanol production is long, and the industrial production started as Acetone-Butanol-Ethanol (ABE) fermentation method at the beginning of 20th century. Although the production declined for a period of time owing to advance in petrochemical industry, active research has been carried out again as biofuel production from renewable resources is currently growing. However, as anaerobic microorganisms (*Clostridium* spp.) are employed as before, it is difficult to achieve a dramatic improvement in productivity. This led to growing interest in introducing butanol synthetic function (gene) from *Clostridium* into an industrially favorable microorganism by biotechnology.

We have introduced genes involved in butanol synthesis into industrial microorganism, *Escherichia coli*, and have confirmed their function in the host as well as butanol synthesis. Our achievement has been published in "Applied Microbiology and Biotechnology" (Vol.77:1305-1316, 2008) and we are aiming to further improve the productivity.

Expression of *Clostridium acetobutylicum* butanol synthetic genes in *Escherichia coli*

Masayuki Inui · Masako Suda · Sakurako Kimura · Kaori Yasuda · Hiroaki Suzuki · Hiroshi Toda · Shogo Yamamoto · Shohei Okino · Nobuaki Suzuki · Hideaki Yukawa

Systems biology of the RITE strain (Coryneform bacteria)

Microbiology Research Group

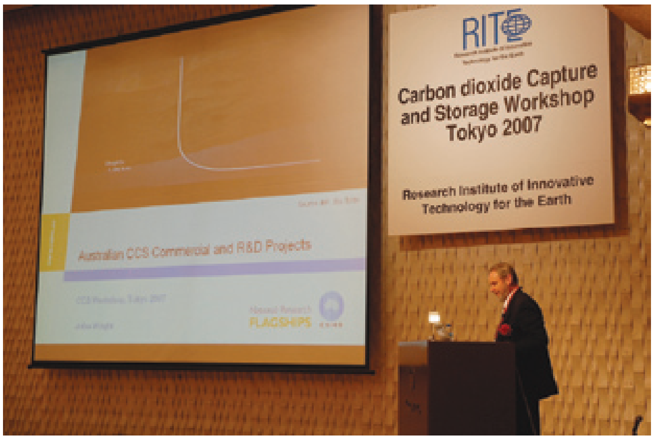
The microbiology group is involved in developing biorefinery technology to produce biofuels and chemicals of use using "Growth-arrested bioprocess" with Coryneform bacteria. "Growth-arrested bioprocess", which is our unique core-technology, employs growth-suppressed microbial cells as chemical catalyst for production and is innovative production technology differing from the conventional methods. Currently, we are conducting analyses on the cell metabolism and gene-networks under various conditions to apply the valuable information gathered by the analyses to further improve the productivity and to increase the variety of chemicals produced by the process. The genome sequence of the RITE strain has already been analyzed (Microbiology Vol.153, p1042-1058, 2007) and, with that information, we are carrying out investigations into expression control mechanisms of specific genes and interactions among genes and proteins by proteome and transcriptome analyses. As stated above, we are conducting research in the field of systems biology which elucidates cell activity of the RITE strain as gene-networks and systems. Our research achievement, which illustrated one aspect of cell division mechanism of RITE strain, has been published in a scientific journal recently, and the image of RITE strain undergoing the cell division was shown on the front cover (Molecular Microbiology, Vol. 67, p597-608, 2008).

International Workshop "Carbon Dioxide Geological Storage"

CCS Workshop 2007
CCS Workshop Tokyo 2007

CO_2 Sequestration Research Group

The workshops, where the test results of and trends related to the carbon dioxide storage technology demonstration were reported, were held in the Keihanna Plaza, Kansai Science City over two days, February 15 and 16, 2007, and in the Hotel Grand Palace, Tokyo, on November 19, 2007. The CSS related laboratory tour was also held at the RITE Kyoto Headquarters on February 16.



These workshops were held by RITE with the purpose of promoting understanding as a part of our carbon dioxide geological storage technology research and development, and approximately 200 and 300 people from both home and abroad participated in the respective workshops. The participants came mainly from companies and research institutions, and about 20 individuals from abroad, as well as environmental NGOs and NPOs, attended the workshops.

In the workshops, invited speakers from home and abroad introduced commercial projects, experimental projects, collaborative capture & recovery projects in the Europe, CCS project status and perspectives in China, Norway, and Australia, as well as Japan's CCS related policies and technology development status. A panel discussion was conducted by foreign invitees and Japanese researchers under the theme of "Goals and Challenges of Large Scale Demonstration Projects", which invited proactive opinions from the floor.

For detailed information, see the event report on the RITE home page.

2008 RITE International Symposium
- IPCC 4th assessment report and challenges to mitigate global warming -

Planning, Survey, and Public Relations Group

The symposium entitled "2008 RITE International Symposium - IPCC 4th assessment report and challenges to mitigate global warming -" was held on 24 January 2008, at Nadao Hall in Tokyo.

This symposium was organized by RITE, co-organized by NEDO (New Energy and Industrial Technology Development Organization), and supported by METI (Ministry of Economy, Trade and Industry), SCEJ (The Society of Chemical Engineers, Japan), JSER (Japan Society of Energy and Resources), JIE (The Japan Institute of Energy), JSBBA (Japan Society for Bioscience, Biotechnology, and Agrochemistry).

There was a high attendance of 437 at this symposium, including participants from the press, various ministries such as Ministry of Economy, Trade and Industry, Ministry of the Environment, Ministry of Land, Infrastructure, Transport and Tourism, Ministry of Agriculture, Forestry and Fisheries, Ministry of Education, Culture, Sports, Science and Technology, and also participants from embassies and foreign organizations from Australia, Finland, France, Holland, South Korea, Sweden, the U.K., and the U.S.

In the symposium, Dr. Leo Meyer, the head of the Technical Support Unit of the Working Group 3 of IPCC from the Netherlands Environmental Assessment Agency, Dr. Sally M. Benson, the executive director of the Global Climate and Energy Project (GCEP) at Stanford University, Dr. Itaru Yasui, senior fellow at the Center for Research and Development Strategy of Japan Science and Technology Agency, and Mr. Nobukichi Nakamura, project general manager at BR Energy Affairs Department of Toyota Motor Corporation, delivered their updating lectures.

Dr. Hideaki Yukawa, the leader of Microbiology Research Group of RITE, presented "Current World-wide Status of Biofuels and Research and Development at RITE". And Mr. Yasunobu Mizuno, the leader of CO_2 Geological Storage Project of RITE, presented "Geological CO_2 Storage Technology Issues to be Solved towards Practical Application". Dr. Yoichi Kaya gave his lecture entitled "Long Term Strategy for Mitigating Global Warming" at the end of the symposium.

Symposium on Innovative Environmental Technologies
- Research and development in anticipation of the Post Kyoto Protocol -

Planning, Survey, and Public Relations Group

The symposia entitled "the Innovative Environmental Technology - Research and development in anticipation of the Post Kyoto Protocol - " were held on 20 September 2007 at Hotel Nikko Osaka in Osaka , and 2 November 2007 at Nadao Hall in Tokyo.

The symposia were organized by RITE, and supported by METI, NEDO, METI Kansai, CSJ (The Chemical Society of Japan), SCEJ, JSBBA, JSER, Kankeiren (Kansai Economic Federation).

We had 282 attendances in Osaka and 338 in Tokyo, total of 620 which emphasizes the great interest in our activities, including participants from METI, Ministry of the Environment, Ministry of Agriculture, Forestry and Fisheries and various fields of industry and academia.

The symposium started with Dr. Yoichi Kaya's keynote speech on the outlook on the technologies counteracting against the global warming and then the experts from each research groups reported the outcome of their researches, such as scenarios for mitigating global warming, CCS technology, biorefinery technology, and the technologies for the forestation by elite plants, with the current trends of the world.

System Analysis Group

■2007 Paper

	Title	Researchers	Journal
1	Economic Evaluation of the Geological Storage of CO_2 Considering the Scale of Economy	K. Akimoto, M. Takagi T. Tomoda	International Journal of Greenhouse Gas Control, Volume 1, No. 2, Pages 271-279 (April 2007)
2	Public Perceptions on the Acceptance of Geological Storage of Carbon Dioxide and Information Influencing the Acceptance	K. Tokushige, K. Akimoto T. Tomoda	International Journal of Greenhouse Gas Control, Volume 1, No. 1, Pages 101-112 (April 2007)
3	Evaluation of Energy Saving and CO_2 Emission Reduction Technologies in Energy Supply and End-use Sectors Using a Global Energy Model	J. Oda, K. Akimoto F. Sano, T. Homma T. Tomoda	IEEJ Transactions of Electrical & Electronic Engineering, Volume 2, No. 1, Pages 72-83 (January 2007)
4	Diffusion of Energy Efficient Technologies and CO_2 Emission Reductions in Iron and Steel Sector	J. Oda, K. Akimoto F. Sano, T. Tomoda	Energy Economics, Volume 29, No. 4, Pages pp. 599-998 (July 2007)
5	Public Acceptance and Risk-benefit Perception of CO_2 Geological Storage for Global Warming Mitigation in Japan	K. Tokushige, K. Akimoto T. Tomoda	Mitigation and Adaptation Strategies for Global Change, Vol.12, No.7, 1381-2386, 2007.
6	Economic Evaluation of the Geological Storage of CO_2 in Japan	K. Akimoto, M. Takagi	Shigen Sozai Gakkai, 「Journal of the Mining and Materials Proceeing Institute of Japan」 (in Press)

■2007 Oral Presentaion

	Title	Researchers	Forum
1	Evaluation of Impacts on Water Recourses due to Global Warming	A. Hayashi, F. Sano K. Akimoto, S. Mori T. Tomoda	23rd Conference on Energy, Economy, and Environment 25-26, January, 2007
2	Evaluation of technological options for mitigating climate change in transportation sector with world energy systems model	F. Sano, K. Akimoto J. Oda, T. Tomoda	23rd Conference on Energy, Economy, and Environment 25-26, January, 2007
3	Evaluations of CO_2 Emission Reductions in Power, Steel and Cement Sectors under the Asia-Pacific Partnership	J. Oda, K. Akimoto F. Sano, T. Tomoda	23rd Conference on Energy, Economy, and Environment 25-26, January, 2007
4	Evaluations of global warming mitigation policies considering changes in structures of sectoral and regional production and trade	T. Homma, S. Mori K. Akimoto, Y. Murota T. Tomoda	23rd Conference on Energy, Economy, and Environment 25-26, January, 2007
5	Evaluation of CO_2 emission reduction effect of energy efficiency improvement in transport sector	F. Sano, K. Akimoto J. Oda, T. Tomoda	26th Annual Meeting of Japan Society of Energy and Resources 13-14, June, 2007
6	Evaluations of CO_2 Emission Reductions in Steel Sector under frameworks related to the Asia-Pacific Partnership	J. Oda, K. Akimoto F. Sano, T. Tomoda	26th Annual Meeting of Japan Society of Energy and Resources 13-14, June, 2007
7	Desirable long-term stabilization targets -An expert judgment of quantitative and qualitative aspects-	J. Oda, K. Akimoto, A. Hayashi T. Homma, F. Sano T. Tomoda, S. Mori	SRA-JAPAN Annual Conference, Volume20 17-18, November, 2007
8	Sectoral economic impacts of CO_2 mitigation policies under different levels of stabilization targets:A study with the hybrid model DEARS	T. Homma, K. Akimoto T. Tomoda, S. Mori Y. Murota	10th Annual Conference on Global Economic Analysis (GTAP2007 Conference), 7-9, June, 2007
9	CO_2 Emission Reduction Effect and Cost of Diffusion of Energy Efficient Technologies in Transport Sector	F. Sano, K. Akimoto J. Oda, T. Tomoda	International Energy Workshop 2007, 25-27, June, 2007

■2007 Non-Journal Publication

	Title	Researchers	Magazine, Newspaper, etc.
1	Outlook of Global Warming Impacts, Mitigations and Adaptations and the Suggestions	K. Akimoto	The Japanese Geotechnical Society, 「Soils and Foundations」
2	Consider also Mitigation Costs - Global Agreement is a Top Priority	K. Akimoto	Nihon Keizai Shimbun, June 2007

Chemical Research Group

■2007 Original Paper

	Title	Researchers	Journal
1	PAMAN Dendrimer Composite Membrane for CO_2 separation:Formation of a Chitosan Gutter Layer	T. Kouketsu, S. Duan, T. Kai, S. Kazama,K. Yamada	Journal of MEMBRANE SCIENCE 287 51-59 (2007)
2	Preparation and CO_2 separation properties of amine-modified mesoporous silica membranes	Y. Sakamoto, K. Nagata, K. Yogo, K. Yamada	Microporous and Mesoporous Materials101 303-311(2007)
3	Experimental Investigation on Diesel PM Removal Using Uneven DBD Reactors	S. Yao, K. Madokoro, C. Fushimi, Y. Fujioka	AIChE JOURNAL VOL.53, No.7 1891-1897 (2007)
4	Stability of Gel-supported Facilitated Transport Membrane for Carbon Dioxide Separation from Model Flue Gas	K. Okabe, N. Matsumiya, H. Mano	Separation and Purification Technology 57 242-249 (2007)

■2007 International Oral Presentation

	Title	Researchers	Forum
1	Recent Development of CO_2 Separation technologies for CCS	Y. Fujioka	Gordon Research Conference, Hydrocarbon Resources,Venture 11 January 2007
2	Development of Molecular Gate Membrane for CO_2 Capture	S. Kazama	CSLF Workshop Paris 27 March 2007
3	Evaluation of Absorption Characteristics of Single Amines and Development of New Amine Blends	K. Goto	10th International CO_2 Capture Network,Lyon 24 May 2007
4	A Single Channel Discharge Reactor for the Diagnosis of Dielectric Barrier Discharge Reactors	S. Yao, Y. Fujioka S.Yamamoto, K. Madokoro, C. Fushimi, Y. Fujioka	The 34th IEEE International Conference on Plasma Science, Albuquerque 19 July 2007
5	PAMAM Dendrimer Composite Membrane for CO_2 Separation : Addition of Hyaluronic Acid in Gutter Layer and Application of Novel Hidroxyl PAMAM Dendrimer	S. Duan, F. A. Chowdhury, T. Kai, S. Kazama, Y. Fujioka	4rd Conference of Aseanian Membrane Society, Taipei 16 August 2007
6	Influence of Pulse Voltage Waveforms on Ozone Generation	S. Yao, S. Kodama,	20th Pulsed Power Symposium, Didcot 18 September 2007
7	Development of Innovative Gas Separation Membranes through Sub-Nanoscale Materials Control-Development of Novel Carbon Membranes	T. Kai, S. Kazama, Y. Fujioka	GCEP Research Symposium, Palo Alto 3 October 2007
8	Development of Innovative Gas Separation Membranes through Sub-Nanoscale Materials Control-Inorganic CO_2 separation membranes-	K. Uoe, M. Miyamoto, N. Yamamoto, K. Yogo, Y. Fujioka	GCEP Research Symposium, Palo Alto 3 October 2007
9	Development of Innovative Gas Separation Membranes Through Sub-Nanoscale Materials Control	Y. Fujioka	GCEP Research Symposium, Palo Alto 3 October 2007
10	CO_2 Molecular Gate Membrane Challenge to CO_2 Capture from Pressurized Gas Stream	S. Kazama, T. Kai, I. Taniguchi, S. Duan, F. A. Chowdhury, Y. Fujioka	4th Trondheim Conference on CO_2 capture, Transport and Storage, Trondheim 16 October 2007
11	Separation and recovery of carbon dioxide by a membrane flash process	K .Okabe, H .Mano, Y. Fujioka	4th Trondheim Conference on CO_2 capture, Transport and Storage, Trondheim 16 October 2007
12	A New Uneven Dielectric Barrier Discharge Reactor for Removal of Diesel Particulate Matter	S. Kodama, S. Yao, C. Fushimi, S. Yamamoto, C.Mine, Y. Fujioka, K. Madokoro, Y. -H.Kim, K. Naito	2007 AIChE Annual Meeting, Salt Lake 6 November 2007
13	Novel Polymeric Gas Separation Membranes for CO_2 Capture	S. Kazama	International Symposium on Environment,Energy and Materials(KIFEE) Otsu,Japan, 6 December 2007

CO_2 Storage Research Group

■2007 Original Paper [CO_2 Geological Storage Project]

	Title	Researchers	Journal
1	Seismic monitoring and modelling of supercritical CO_2 injection into a water-saturated sandstone:interpretation of P-wave velocity data	Ji-Quan Shi, Ziqiu Xue, Sevjet Durucan	International Journal of Greenhouse Gas Control, Vol. 1, No.3, October, 2007
2	Economic Evaluation for the Geological Storage of CO_2 Considering the Scale of Economy	Keigo Akimoto, Masato Takagi, Toshimasa Tomoda	International Journal of Greenhouse Gas Control, Vol.1, No.2, April, 2007
3	Case study of geochemical reactions at the Nagaoka CO_2 injection site, Japan	Saeko Mito, Ziqui Xue, Takashi Ohsumi	International Journal of Greenhouse Gas Control, in press
4	Pressure transient analysis of a long-term supercritical CO_2 injection experiment at Nagaoka Japan	Ronald Horne, Ziqiu Xue	Energy Conversion and Management, 査読中
5	Modeling and Analysis of the Pressure Response in the CO_2 Injection Experiment Conducted at Iwanohara, Niigata Prefecture, Japan	Sephen White, Ziqiu Xue, Tetuya Saito	International Journal of Greenhouse Gas Control, 査読中
6	Case Story: Time-Lapse Seismic Crosswell Monitoring of CO_2 injected in an Onshore Sandstone Aquifer	Jespe Spetzler, Ziqiu Xue, Hideki Saito, Dai Nobuoka, Hiroyuki Azuma, Osamu Nishizawa	Geophysical Journal International, in press

■2007 Articles [CO_2 Geological Storage Project]

	Title	Researchers	Journal
1	Japan's first pilot-scale saline aquifer CO_2 injection experiment	Ziqiu Xue	Greenhouse Issues, Vol. 86, June, 2007
2	Development of CO_2 geological storage technology	Shigeo Murai	Economy, Culture & History JAPAN SPOTLIGHT Bimonthly, Setember/October, 2007

■2007 Oral Presentation [CO_2 Geological Storage Project]

	Title	Researchers	Forum
1	Pilot CO_2 injection into an onshore aquifer in Nagaoka, Japan	Susumu Kimishima	Sour Oil & Gas Adbanced Technology 2007, 3rd International Conference, Workshop & Exhibition, incorporation the International CO_2 Forum, April, 2007
2	Evaluation of CO_2 geochemical reactions at an onshore saline aquifer, Nagaoka, Japan	Saeko Mito, Ziqui Xue, Takashi Ohsumi	European Geosciences Union General Assembly, April, 2007
3	Experimental study of residual CO_2 saturation in the sandstones with different pore structures	Keigo Kitamura, Ziqiu Xue	Sixth annual conference of carbon capture & sequestration, May, 2007
4	Laboratory measurements of resistivity and SP for monitering of CO_2 storage	Kenji Kubota, Koichi Suzuki, Ziqiu Xue	SEG Conference, November, 2007
5	Japanese CO_2 Storage initiatives and J-Power's R & D activities	Shigetaka Nakanishi	Callide Oxyfuel Project-CO_2 Storage Site Selection Workshop, Maech, 2007
6	Time-lapse CO_2 monitor logging at the first pilot-scale CO_2 injection site in Japan	Ziqiu Xue, Daiji Tanase, Jiro Watanabe	The Challenges in ,Seismic Rock Physics, June, 2007
7	Assessment of geochemical reactivity of rocks at the Niigata CO_2-injection test site, Niigata, Japan	Masao Sorai, Yasuko Okuyama, Toshiyuki Tosha, Saeko Mito, Takashi Ohsumi	Water Rock Interaction, July, 2007
8	Formation-water database on saline aquifers in Japan: toward geochemical modeling in underground sequestration of CO_2	Y. Okuyama, M. Sasaki, M. Sorai, N. Kaneko, H. Muraoka, N. Yanagisawa, T. Tosha	WRI-12(12th international symposium on water-rock interaction), August, 2007
9	Assessment of geochemical reactivity of rocks at the Nagaoka CO_2 –injection test site, Niigata, Japan	M. Sorai, Y. Okuyama, T. Tosha, S. Mito, T. Ohsumi	WRI-12(12th international symposium on water-rock interaction), August, 2007
10	Hot-springs associated with calcareous deposits in Japan, and their implications for future CO_2 underground geological storage	M. Sasaki, Y. Okuyama, M. Sorai, N. Kaneko, N. Yanagisawa	WRI-12(12th international symposium on water-rock interaction), August, 2007

■2007 Others [CO_2 Geological Storage Project]

	Title	Researchers	Forum
1	Overview of Japan's First Pilot-Scale Saline Aquifer CO_2 Injection Experiment	Ziqui Xue, Hideaki Saito, Jiro Watanabe	Post-Convention Workshop (CO_2 Sequestration Monitoring) SEG 2007, September, 2007
2	CO_2 Saturation and Movement during Post-Injection Period, Nagaoka Project	Tsukasa Yoshimura, Koji Kano, Jiro Watanabe, Hiroyuki Azuma, Ziqui Zue, Saeko Mito	4th Monitoring Network Meeting of IEA, November, 2007
3	Monitoring Concept for the R&D CCS in Japan	Daiji Tanase, Koji Kano, Hironori Furukawa	4th Monitoring Network Meeting of IEA, November, 2007

■2007 Original Paper [CO_2 Ocean Sequestration Project]

	Title	Researchers	Journal
1	CO_2 tolerance of juveniles of three marine invertebrates,Sepia lycidas,Sepioteuthis lessoniana,and Marsupenaeus japonicus	Takashi Kikkawa, Yuji Watanabe, Youichi Katayama,Jun Kita, and Atsushi Ishimatsu	Plankton and Benthos Research,submitted
2	A numerical study with an eddy-resolving model to evaluate chronic impacts in CO_2 ocean sequestration	Yoshio Masuda,Yasuhiro Yamanaka, Yoshikazu Sasai, Michimasa Magi	International Journal of Greenhouse Gas Control 2007

■2007 Oral Presentation [CO_2 Ocean Sequestration Project]

	Title	Researchers	Forum
1	CO_2 Ocean Sequestration by Dissolution Method-Biological Impact Modelling and Trial of Risk Communication	Toru Sato	International Symposium on CO_2 Storage 2007.3
2	Time Domain VIV Analysis of Inclined Towed Pipe Based on Lookup Table of VIV Hydrodynamic Force	Hideyuki Suzuki,Junichi Minamiura, Masahiko Ozaki	Fifth Conference on Bluff Body Wakes and Vortex-Induced Vibrations, 2007, Brasil
3	Emission of CO_2 from seafloor hydrothermal systems at Mariana Trough	K.Shitasima, and Y.Maeda	2007 AGU Fall Meeting

Microbiology Research Group

■2007 Original Paper

	Title	Researchers	Journal
1	Synthesis of *Clostridium cellulovorans* minicellulosomes by intercellular complementation.	T. Arai, S. Matsuoka, H-Y. Cho, H. Yukawa, M. Inui, S-L. Wong and R.H. Doi.	Proc. Natl. Acad. Sci. USA. 104:1456-1460. 2007.
2	Efficient induction of formate hydrogen lyase of aerobically grown *Escherichia coli* in a three-step biohydrogen production process.	A. Yoshida, T. Nishimura, H. Kawaguchi, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 74:754-760. 2007.
3	Effect of lignocellulose-derived inhibitors on growth of and ethanol production by growth-arrested *Corynebacterium glutamicum* R.	S. Sakai, Y. Tsuchida, H. Nakamoto, S. Okino, O. Ichihashi, H. Kawaguchi, T. Watanabe, M. Inui and H. Yukawa.	Appl. Environ. Microbiol. 73:2349-2353. 2007.
4	Random segment deletion based on IS*31831* and Cre/*loxP* excision system in *Corynebacterium glutamicum*.	Y. Tsuge, N. Suzuki, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 74:1333-1341. 2007.
5	Comparative analysis of the *Corynebacterium glutamicum* group and complete genome sequence of strain R.	H. Yukawa, C.A. Omumasaba, H. Nonaka, P. Kós, N. Okai, N. Suzuki, M. Suda, Y. Tsuge, J. Watanabe, Y. Ikeda, A.A. Vertès and M. Inui.	Microbiology. 153:1042-1058. 2007.
6	Anaerobic growth of *Corynebacterium glutamicum* using nitrate as a terminal electron acceptor.	T. Nishimura, A.A. Vertès, Y. Shinoda, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 75:889-897. 2007.
7	Expression of *Corynebacterium glutamicum* glycolytic genes varies with carbon source and growth phase.	S.O. Han, M. Inui and H. Yukawa.	Microbiology 153:2190-2202. 2007.
8	Transcriptional profiling of *Corynebacterium glutamicum* metabolism during organic acid production under oxygen deprivation conditions.	M. Inui, M. Suda, S. Okino, H. Nonaka, L.G. Puskás, A.A. Vertès and H. Yukawa.	Microbiology 153:2491-2504. 2007.
9	Isolation of a new insertion sequence, IS*13655*, and its application to *Corynebacterium glutamicum* genome mutagenesis.	Y. Tsuge, N. Suzuki, K. Ninomiya, M. Inui and H. Yukawa.	Biosci. Biotechnol. Biochem. 71:1683-1690. 2007.
10	Alternative technologies for biotechnological fuel ethanol manufacturing.	A.A. Vertès, M. Inui and H. Yukawa.	J. Chem. Technol. Biotechnol. 82:693-697. 2007.
11	Transcriptionally regulated *adhA* gene encodes alcohol dehydrogenase required for ethanol and *n*-propanol utilization in *Corynebacterium glutamicum* R.	A. Kotrbova-Kozak, P. Kotrba, M. Inui, J. Sajdok and H. Yukawa.	Appl. Microbiol. Biotechnol. 76:1347-1356. 2007.
12	Synergistic interaction of *Clostridium cellulovorans* cellulosomal cellulases and HbpA.	S. Matsuoka, H. Yukawa, M. Inui and R.H. Doi.	J. Bacteriol. 189:7190-7194. 2007.
13	Analyses of the acetate-producing pathways in *Corynebacterium glutamicum* under oxygen-deprived conditions.	K. Yasuda, T. Jojima, M. Suda, S. Okino, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 77:853-860. 2007.
14	Site-directed integration system using a combination of mutant *lox* sites for *Corynebacterium glutamicum*.	N. Suzuki, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 77:871-878. 2007.
15	Effect of the multiple copies of cohesins on cellulase and hemicellulase activities of *Clostridium cellulovorans* minicellulosome.	J. Cha, S. Matsuoka, H. Chan, H. Yukawa, M. Inui and R.H. Doi.	J. Microbiol. Biotechnol. 17:1782-1788. 2007.
16	Regulation of the expression of phosphoenolpyruvate: carbohydrate phosphotransferase system (PTS) genes in *Corynebacterium glutamicum* R.	Y. Tanaka, N. Okai, H. Teramoto, M. Inui and H. Yukawa.	Microbiology 154:264-274. 2008.
17	Engineering of an L-arabinose metabolic pathway in *Corynebacterium glutamicum*.	H. Kawaguchi, M. Sasaki, A.A. Vertès, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 77:1053-1062. 2008.
18	DivS, a novel SOS inducible cell-division suppressor in *Corynebacterium glutamicum*.	H. Ogino, H. Teramoto, M. Inui and H. Yukawa.	Mol. Microbiol. 67:597–608. 2008.
19	Production of isopropanol by metabolically engineered *Escherichia coli*.	T. Jojima, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 77:1219-1224. 2008.
20	Expression of *Clostridium acetobutylicum* butanol synthetic genes in *Escherichia coli*.	M. Inui, M. Suda, S. Kimura, K. Yasuda, H. Suzuki, H. Toda, S. Yamamoto, S. Okino, N. Suzuki and H. Yukawa.	Appl. Microbiol. Biotechnol. 77:1305-1316. 2008.
21	Technological options for biological fuel ethanol.	A.A. Vertès, M. Inui and H. Yukawa.	J. Mol. Microbiol. Biotechnol. (in press)
22	Transcription of *Corynebacterium glutamicum* genes involved in tricarboxylic acid cycle and glyoxylate cycle.	S.O. Han, M. Inui and H. Yukawa.	J. Mol. Microbiol. Biotechnol. (in press)

	Title	Researchers	Journal
23	Regulation of expression of general components of the phosphoenolpyruvate:carbohydrate phosphotransferase system (PTS) by the global regulator SugR in *Corynebacterium glutamicum*	Y. Tanaka, H. Teramoto, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 78:309-318. 2008
24	Production of D-lactic acid by *Corynebacterium glutamicum* under oxygen deprivation.	S. Okino, M. Suda, K. Fujikura, M. Inui and H. Yukawa.	Appl. Microbiol. Biotechnol. 78:449-454. 2008

■2007 International Oral Presentation

	Title	Researchers	Forum
1	Ethanol Producing using RITE Bioprocess.	H. Yukawa	The 4th World Congress on Industrial Biotechnology and Bioprocessing, 22 March 2007.
2	Ethanol production from mixed sugars by genetically engineered *Coyrnebacterium glutamicum*.	S. Okino, S. Sakai, H. Kawaguchi, M. Sasaki, M. Suda, M. Inui and H. Yukawa.	The 4th World Congress on Industrial Biotechnology and Bioprocessing, 21-24 March 2007.
3	Ethanol production from mixed sugars derived from lignocellulosic biomass by the RITE bioprocess.	H. Yukawa	AIChE Spring National Meeting, 24 April 2007.
4	Improved ethanologenic *Corynebacterium glutamicum* strains for fuel ethanol production from lignocellulosic biomass.	H. Teramoto, H. Kawaguchi, S. Okino, M. Inui and H. Yukawa.	The 29th Symposium on Biotechnology for Fuels and Chemicals, 29 April-2 May 2007.
5	Ethanol production from lignocellulosic biomass by the RITE bioprocess.	H. Yukawa	BIO 2007 International Convention, 7 May, 2007.
6	Regulation of the expression of phosphoenolpyruvate: Carbohydrate phosphotransferase system (PTS) genes in *Corynebacterium glutamicum* R.	Y. Tanaka, N. Okai, H. Teramoto, M. Inui and H. Yukawa.	American Society for Microbiology 107th General Meeting, 21-25 May 2007.
7	Identification of a novel SOS inducible cell-division inhibitor in *Corynebacterium glutamicum*.	H. Ogino, H. Teramoto, M. Inui and H. Yukawa.	American Society for Microbiology 107th General Meeting, 21-25 May 2007.
8	Anaerobic growth of *Corynebacterium glutamicum* using nitrate as a terminal electron acceptor.	T. Nishimura, A.A. Vertès, Y. Shinoda, M. Inui and H. Yukawa.	American Society for Microbiology 107th General Meeting, 21-25 May 2007.
9	Enhanced biohydrogen production from biomass-derived substrates.	A. Yoshida, M. Inui, and H. Yukawa.	SIM Annual Meeting, 31 July 2007.
10	Efficient ethanol production from glucose and xylose mixture using growth-arrested Corynebacteria.	S. Sakai, M. Sasaki, M. Suda, S. Okino, T. Jyojima, Y. Tsuchida, M. Inui and H. Yukawa.	234th ACS National Meeting, 19-23 August 2007.
11	Production of D-lactic acid by the RITE bioprocess using genetically engineered *Corynebacterium glutamicum*.	S. Okino, M. Suda, M. Inui and H. Yukawa.	234th ACS National Meeting, 19-23 August 2007.
12	Engineering of an L-arabinose metabolic pathway in *Corynebacterium glutamicum*.	M. Sasaki, H. Kawaguchi, S. Okino, T. Jyojima, M. Inui and H. Yukawa.	234th ACS National Meeting, 19-23 August 2007.
13	Transcriptional profiling of *Corynebacterium glutamicum* metabolism during organic acid production under oxygen deprivation conditions.	M. Suda, S. Okino, H. Nonaka, L.G. Puskás, A.A. Vertès, M. Inui and H. Yukawa.	2007 AIChE Annual Meeting, 4-9 November 2007.
14	Analyses and suppression of acetate formation for development of efficient biorefining process by growth-arrested corynebacteria.	K. Yasuda, T. Jojima, M. Suda, S. Okino, M. Inui and H. Yukawa.	2007 AIChE Annual Meeting, 4-9 November 2007.
15	Ethanol production from mixed sugars derived from lignocellulosic biomass by the "RITE-bioprocess" using corynebacteria	H. Yukawa	2007 Pacific Rim Summit on Industrial Biotechnology and Bioenergy, 14 November 2007.
16	Production of biofuels from soft biomass by the RITE Bioprocess	H. Yukawa	Asia Biofuels Conference & EXPO V, 13 December 2007.

◆2007 International Publication etc.

	Title	Researchers	Journal
1	Genomes and Genome-Level Engineering of Amino Acid-Producing Bacteria.	H. Yukawa, M. Inui and A.A. Vertès.	Amino Acid Biosynthesis – Pathways, Regulation and Metabolic Engineering

Plant Research Group

■2007 Paper

	Title	Researchers	Journal
1	Histidine kinases plays important roles in the perception and signal transduction of H_2O_2 in the cyanobacterium, *Synechocystis*.	Y. Kanesaki, H. Yamamoto, K. Paithoonrangsarid, M. Shoumskaya, I. Suzuki, H. Hayashi, N. Murata	The Plant Journal 49(2): 313-324
2	Overexpression of Ferredoxin in Tobacco Chloroplasts stimulates Cyclic Electron Flow around Photosystem I (CEF-PSI) and enhances Non-Photochemical Quenching (NPQ) of Chl Fluorescence	H. Yamamoto, C. Miyake	Photosynthesis 2007 Proceedings "Photosynthesis: Energy from the Sun"
3	Relationship between mesophyll conductance to CO2 diffusion and contents of aquaporin localized at plasma membrane in tobacco plants grown under drought conditions.	Shin-Ichi Miyazawa, Satomi Yoshimura, Yuki Shinzaki, Masayoshi Maeshima, Chikahiro Miyake	In "Photosynthesis: Energy from the Sun". pp. 809-812. Springer (Dordrecht). 2008.

■2007 Meeting

	Title	Researchers	Meeting
1	Stimulation of Cyclic Electron Flow around Photosystem I (CEF-PSI) by Overexpression of Ferredoxin in Transplastomic Tobacco enhances Non-Photochemical Quenching (NPQ) of Chlorophyll Fluorescence	H. Yamamoto, C. Miyake	Plant Biology & Botany 2007 Joint Congress (Chicago, USA)
2	Overexpression of Ferredoxin in Tobacco Chloroplasts stimulates Cyclic Electron Flow around Photosystem I (CEF-PSI) and enhances Non-Photochemical Quenching (NPQ) of Chl Fluorescence.	H. Yamamoto, C. Miyake	Photosynthesis 2007 (Glasgow, Scotland)
3	Internal resistance to CO2 diffusion in the leaves and its relationship with water-use efficiency under drought	Shin-Ichi Miyazawa, Satomi Yoshimura, Yuki Shinzaki, Masayoshi Maeshima, Chikahiro Miyake	Phenotypic plasticity in response to environmental change:from the molecular to ecosystem level. Oct 23-26 2007. Tochigi, Japan.

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