

# The Catalysis Society of Japan (CATSJ): History and Activities\*\*

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## 50th Anniversary of the Foundation of the CATSJ

The Catalysis Society of Japan has entered into the 50th anniversary of the foundation in 2008. In celebration of the Golden Jubilee year of the Society, we organized an International Symposium on Creation and Control of Advanced Selective Catalysis in Kyoto. The Symposium was also organized as a Pre-Symposium of the 14th International Congress on Catalysis in Seoul. The Symposium was the greatest event among several programs for the celebration that the Society has planned. We are very much grateful to so many scientists and engineers for their attendance at the Symposium in Kyoto.

The five topics included in the Symposium, namely fundamentals and theory for selective catalysis, in situ characterization of selective catalysis, new

selective catalysis for green processes, new catalytic materials for selective catalysis, and innovative processes by selective catalysis, are the key issues and materials to solve the increasing scientific and technological demands in the fields related to the Symposium title, which are believed to be at the frontiers and cutting edge of catalytic science and technology. The excellent class of the invited speakers and the large number of first-class contributed presentations, including highlighted achievements of worldwide young scientists, made up a scientific program that we were truly proud of, and excellent peer-reviewed works are published in this Special Issue of *Angewandte Chemie* and also in a Special Issue of *Topics in Catalysis*.

Catalysis can play a pivotal role as a central science and technology in ensuring sustainable human life. The theme of the present Symposium is most appropriate, and we found great achievements and new horizons in the papers presented, which will give rise to further developments of the science and technology and will also provide a strong influence to the promotion of the welfare of mankind.

We are deeply grateful for financial aid made by the Ministry of Education, Culture, Sports, Science, and Technology (MEXT), Japan Society for the Promotion of Science (JSPS), Commemorative Organization for the Japan World Exposition (1970), and several enterprises. We also wish to express our

**Table 1:** The history of the Catalysis Society of Japan.

Year	Event
1958	Started as the Catalysis Club of Japan, „Shokubai Kondankai“. Published the first volume of <i>Catalysts &amp; Catalysis</i> , „Shokubai“
1964	Renamed the Catalysis Society of Japan (CATSJ). The CATSJ Meeting („Shokubai Touronkai“) held twice a year (spring and fall). Became a constituent member of the International Catalyst Conference Council.
1966	The Catalyst Research Symposium („Shokubai Kenkyu Happyoukai“) started in the CATSJ Meeting.
1967	Specified as the Academic Society by the Japanese Patent Office.
1970	Joined the Conference of Cooperation Union of Japanese Chemistry-Related Academic Institutions.
1971	The First Japan–Soviet Catalyst Seminar (USSR).
1979	Reference catalyst committee started as the first research division. The First Japan–France Catalysis Symposium (Lyon).
1980	The Seventh Congress on Catalysis (ICC7) (Tokyo).
1982	The First Japan–China–US Catalysis Symposium (Dalian).
1984	Registered as an Academic Research Organization by the Science Council of Japan.
1987	The First Japan–Korea Catalysis Symposium (Seoul)
1990	TOCAT-1 (Tokyo).
1991	The First Japan–UK Catalysis Symposium (Tokyo). Joined Japan Federation of Engineering Societies
1994	The Japan–FUS Catalysis Seminar (Tsukuba).
2007	The 100th-Anniversary CATSJ Meeting (Sapporo).
2008	The 50th Anniversary of the founding of the CATSJ. Pre-symposium of ICC14 (Kyoto).

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## History of the CATSJ

The Catalysis Society of Japan (CATSJ) was founded in 1958 to promote and encourage the growth and development of the catalytic science and technology (Table 1). The first president was Prof. J. Horiuti of Hokkaido University. The society was launched as the Catalysis Club of Japan „Shokubai Kondankai“ in 1958 and renamed to the Catalysis Society of Japan (CATSJ) in 1964. Now, the CATSJ has a history encompassing 50 years and holds about 2500 individual members, including 400 students and 150 corporate members (Figure 1). Membership is fully open to qualified persons abroad as overseas members. The CATSJ is the only comprehensive organization on catalysis in Japan that unites academia and industry.<sup>[1]</sup>

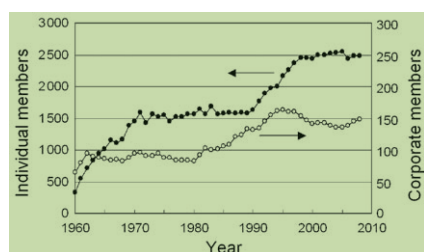


Figure 1. The number of the CATSJ members.

## Organization of the CATSJ

The Board of Directors of the CATSJ consists of 16 directors, including one president, two vice-presidents, and one executive director. There are 12 standing committees to accomplish major tasks in the objectives of the CATSJ. The committees are organized into the following: Editorial, CATSJ Meeting, Education, International Exchange, Publication, Basic Activity, Science and Technology, Steering, Award Nomination, Award Selection, Financial, and Information.

Table 2: Successive presidents of the Catalysis Society of Japan.



**J. Horiuti**  
(1st and 4th president,  
1959–60, 1965–66)



**K. Tamaru**  
(23rd president, 1987,  
IACS president, 1984–88)



**M. Imanari**  
(44th president,  
2008)

<b>J. Horiuti</b>	1959–1960	<b>M. Niwa</b>	1976	<b>K. Tamaru</b>	1987	<b>T. Onoda</b>	1998
	1965–1966	<b>A. Ozaki</b>	1977	<b>K. Tanabe</b>	1988	<b>S. Yoshida</b>	1999
<b>T. Shiba</b>	1961–1962	<b>T. Seiyama</b>	1978	<b>K. Ohnishi</b>	1989	<b>T. Yashima</b>	2000
<b>K. Hirota</b>	1963–1964	<b>T. Keii</b>	1979	<b>Y. Murakami</b>	1990	<b>H. Hattori</b>	2001
<b>K. Morikawa</b>	1967–1968	<b>S. Teranishi</b>	1980	<b>Y. Saito</b>	1991	<b>E. Kikuchi</b>	2002
<b>O. Toyama</b>	1969	<b>Y. Yoneda</b>	1981	<b>T. Imanaka</b>	1992	<b>T. Hattori</b>	2003
<b>G. Okamoto</b>	1970	<b>I. Yasumori</b>	1982	<b>Y. Izumi</b>	1993	<b>K. Segawa</b>	2004
<b>K. Uchida</b>	1971	<b>H. Kobayashi</b>	1983	<b>M. Misono</b>	1994	<b>Y. Iwasawa</b>	2005
<b>S. Tsutsumi</b>	1972–1973	<b>Y. Izumi</b>	1984	<b>Y. Ono</b>	1995	<b>Y. Takita</b>	2006
<b>T. Kwan</b>	1974	<b>Y. Kubokawa</b>	1985	<b>T. Inui</b>	1996	<b>M. Iwamoto</b>	2007
<b>M. Tarama</b>	1975	<b>E. Echigoya</b>	1986	<b>Y. Morooka</b>	1997	<b>M. Imanari</b>	2008

The Science and Technology Committee has 17 research divisions at the present covering various fields of catalytic science and technology as listed below. Each research divisions make various events actively and hold several symposia (sometimes international symposia) beside the CATSJ Meetings. Depending on the needs of ages, these research divisions have been restructured as shown in Figure 2.

Catalysis and fine chemicals, organometallics, photocatalysis, computational analysis, biocatalysts, precisely controlled surfaces, polymerization catalysis, catalysis for production and utilization of hydrogen, highly selective oxidation catalysts, ordered porous materials, catalysis for methane conversion, nanoparticles, catalysis for fuel cells, environmental catalysis, industrial catalysis, principles of catalytic functions, and catalytic biomass conversion.

Under the Basic Activity Committee, the Reference Catalyst Division runs as a stand-alone section. Its unique and valuable activity from its original foundation (former Reference Catalyst

Committee) in 1979 is to distribute reference catalysts, such as  $\text{Al}_2\text{O}_3$ ,  $\text{SiO}_2$ ,  $\text{MgO}$ ,  $\text{TiO}_2$ , zeolite and so on with the physicochemical database to the members who request to use these materials for their research.<sup>[2]</sup> This is also very important for the standardization for characterization and preparation of the catalysts.

The CATSJ has three local branches (Hokkaido, East Japan, and West Japan) based on members' residential location. Each branch is involved in a number of activities aimed at promoting catalytic science and technology, providing educational services to members and other interested individuals, and stimulating research interaction and collaborations between academia and industry.

## Activities of the CATSJ

### 1. Publications

The Catalysis Society of Japan publishes „Catalysts & Catalysis („Shokubai,“ in Japanese)“, which is the most

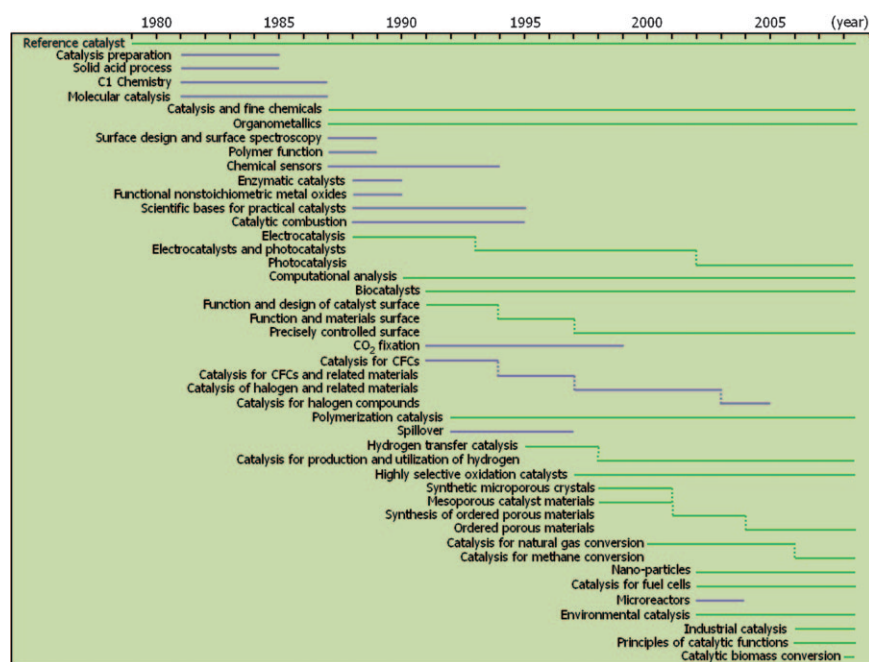


Figure 2. The list and history of the CATSJ research divisions.

widely read publication in the catalysis field in Japan. The membership magazine provides critical reviews of literature published in recent years, useful technical reports, and information about the activities of all members. Written by experts in the field, coverage is varied incorporating the importance of catalysis in our daily lives and to the economies of the world and helping to improve the understanding of this important area of work. Volume 1, No.1 was published in 1958. Since 1985 (Vol. 27), 8 issues per a year have been published. The first issue of 2008 (Vol. 50, No.1) was a special issue on the 50th anniversary of the CATSJ. Recently, the *Catalysts & Catalysis* portal site (called „Shokubai on the web“; Japanese language only) was opened to members at the web of the CATSJ.<sup>[3]</sup>

A report „Current & Prospect on Catalysis Technology“ has been published annually, which focuses on surveys of recent progress and activities in catalytic science and technology as well as related areas. Various activities of the CATSJ research divisions and local branches are also summarized. Several handbooks on catalysis have been also published frequently, and especially the

series of textbooks that have been published in 1964, 1985, and 2008.<sup>[4]</sup>

## 2. Annual Meetings

Since our first domestic meeting „Shokubai Touronkai“ was held in Sapporo in 1951, before the foundation of the CATSJ, we have normally had annual meetings twice a year, in spring and in fall. Figure 3 gives the statistics of the CATSJ Meetings.

Although the membership of our first meeting in 1951 did not exceed 60, the 100th meeting in 2007 brought together more than 1000 attendees. This has been accompanied by increasing number of presentations, from 14 (1951) to circa 800 (2007) in total annually. The CATSJ meeting consists of three categories, poster-A, oral-A, and oral-B. The oral-B session is especially highlighted because we have a longer time (15 min), which is enough for discussion. In the fall meeting, the research divisions offer more

than ten symposia on selected topics to provide a number of opportunities for its members to participate and pursue individual technical interests.

## 3. International Conferences

Soon after its foundation in 1958, the CATSJ has devoted itself to the exchange of scientific and technological knowledge with foreign catalysis societies in US, Europe, USSR, and Asian countries. In 1964, the CATSJ became a constituent member of the International Catalyst Conference Council. In 1980, the Seventh International Congress on Catalysis (ICC7) was held in Tokyo under the auspices of the International Association of Catalysis Societies (IACS) and the CATSJ. As our society has grown, an increasing number of international events relevant to catalysis have been held in many cities in Japan. In such a situation, the CATSJ has decided to organize its original event, named Tokyo Conference on Advanced Catalytic Science and Technology (TOCAT). Since the launch of TOCAT in 1990, this series of conferences has been held every four years, accompanied by growth in the size and number of participants. The CATSJ has organized TOCAT (1990), TOCAT2 (1994), TOCAT3 (1998), TOCAT4 (2002), and TOCAT5 (2006). The past five conferences have earned a good reputation as a new series of international conference on catalysis that have significantly filled the gap between research and technol-

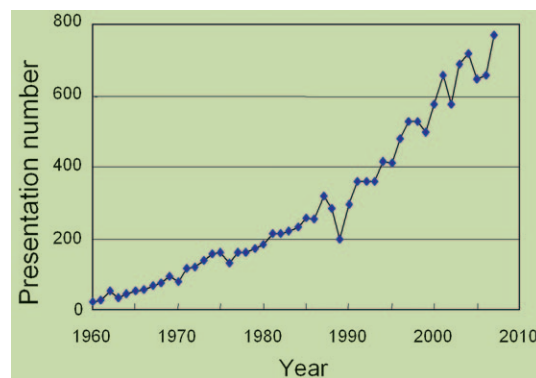


Figure 3. The number of presentations in the CATSJ Meetings.

ogy in catalysis. In the latest TOCAT5 in 2006, more than 800 researchers from 30 countries participated, and more than 500 extended abstracts were submitted. TOCAT6 will be held as a joint conference with the Fifth Asia Pacific Congress on Catalysis (APCAT5) in July of 2010 in Sapporo.

Other examples of International Conferences are as follows:

- **Japan–Soviet Catalysis Seminar:** The Japan–Soviet Catalyst Seminar started in the USSR in 1971. It is held every two years (until 1979; 5th Event) and each country has hosted alternately. The 6th, 7th, 8th, and 9th Seminars took place in 1981, 1983, 1986, and 1990, respectively. After the dissolution of the Soviet Union in 1991, a seminar was held in 1994 as the Japan–FUS Catalyst Seminar in Tsukuba.
- **Japan–China–US Catalysis Seminar:** This Seminar started in 1982. Since the 2nd Seminar was held in 1985, the Seminars have taken place every two years until the 7th Seminar was held in 1995. Afterwards it was taken over by the Asia–Pacific Congress on Catalysis (APCAT). It is held once every three years. The first four events were held in Korea (1997), Australia (2000), China (2003), and Singapore (2006). The themes of APCAT include progresses in all areas of catalysis, with emphasis on specific topics that have great impacts on the industrial sectors of the Asia–Pacific regions.
- **Japan–Korea Catalysis Symposium:** This symposium has been held every two years since 1987, with the aim of sharing the latest research results and ideas and boosting the cooperative relations among catalytic scientists and engineers between two countries. Each country hosts alternately.

Besides these symposia the Japan–France Catalysis Symposium was held in 1979, 1987, and 1988, and the Japan–UK Catalysis Symposium was held in 1991. The international symposia have been often held between Japan and other countries and areas, such as EU, Singapore, India, Taiwan, and Australia and

so on. The CATSJ has also coordinated a wide variety of International Conferences and Symposia related to the catalysis to be held in Japan.

#### 4. Educational Activities

The Education Committee carries out the various activities to promote the education of catalysis researchers and common people to understand the science and technology of catalysis with the corporation of three local branches of the CATSJ (Hokkaido, East Japan, and West Japan regions). „Catalysis School“ and „Catalysis Dojo“ for general researchers, „Freshman Seminar“, „Lectures on Catalyst Characterization“ and „Catalysis School of Northern Country“ for students, and „Cat-Chem Lab.“ for kids and general people have been opened.

Each local branch of the CATSJ has its own annual activity. The Hokkaido region hosts „Aurora Seminar“. It started in 1960 and the 48th event will be held in 2008. The East Japan region hosts a „Summer Seminar“ in Hakone every year. It started in 1970, and the 39th event will be held in 2008. The West Japan region hosts „Catalysis Research Club (Shokubai Kenkyu Kondankai)“. It started in 1960, and the 46th event will be held in 2008. Each local branch also carries out schooling and hosting a number of symposia.

The Financial Committee and the Science and Technology Committee also host the „Catalysis Salon“ and „Catalysis Forum“, respectively, to offer a platform to exchange information between the researchers mainly working in industries. Besides these regional activities, there is a Young Researcher's division, which hosts original seminars.

#### 5. Awards

Three awards are annually conferred to individuals and groups in recognition of their outstanding achievements in advancing catalytic science and technology: the Award of the CATSJ (Academic & Industrial Areas), The Award for



**Figure 4.** Professor Noyori presents his plenary lecture at the celebration of 50th Anniversary of the Catalysis Society of Japan.

Encouragement of Young Researchers, and the Awards for Contributions to Catalysis and Promotion of Society Activities.

#### Japan's Industrial Catalysis Technologies

Many catalytic technologies have been commercialized in Japan since the 1960's, coinciding with the growth of CATSJ. They cover not only the fields of refinery/energy and petrochemical industry but also the fields of fine chemicals and environmental protection. 175 of those technologies were summarized in *Shokubai* **2008**, 50, 84, and the ones awarded by the CATSJ and/or other organizations are listed below. Abbreviated names are used for following companies: Cosmo Oil (Cosmo), Idemitsu Kosan (Idemitsu), Nippon Oil (NOC), Asahi Kasei Chemicals (AKCC), Mitsubishi Chemical (MCC), Mitsubishi Gas Chemical (MGC), Mitsui Chemicals (MCI), Nippon Shokubai (NS), Showa Denko (SDK), Sumitomo Chemical (SCC), Ube Industries (Ube), Mazda Motor (Mazda), Nissan Motor (Nissan), and Toyota Motor (Toyota).

##### 1. Catalysts for Refineries

Upgrading of oil fractions: Residue hydrocracking (Idemitsu; 1982, Cosmo; 1983), mild hydrocracking of vacuum gas oil (Cosmo; 1987), hydrocracking (NOC; 1991, 1999), fluid catalytic crack-



ing of residual oil (Cosmo; 1991), isomerization of light naphtha (Cosmo, Mitsubishi Heavy Industries; 1996)

Hydrosulfurization: Deep hydrodesulfurization of gas oil (NOC; 1994, Idemitsu; 1995), direct residue desulfurization (Idemitsu; 1998), ultradeep hydrodesulfurization of diesel fractions (NOC; 2003, Cosmo; 2004) and of gasoline (NOC; 2004)

## 2. Catalysts for Polymer Production

Polyethylene: Ti–Mg catalyst (MCI; 1969) Ti–V catalyst (MCC; 1973), supported metallocene catalyst (MCI; 1995)

Polypropylene: Ti–Mg catalyst (MCI; 1976), Catalyst for non-solvent processes (SCC; 1983), metallocene catalysts supported on clay minerals (Japan Polychem, MCC; 2000)

Miscellaneous: Polymerization of oxiranes (Daiso; 1979), SBS, SBR hydrogenation (AKCC; 1987), syndiospecific polymerization of styrene (Idemitsu; 1997), ring-opening polymerization of tetrahydrofuran (MCC; 2000), melt polymerization for polycarbonate production (MCC; 2000), phosgene-free, dichloromethane-free polycarbonate production using CO<sub>2</sub> as a raw material (AKCC; 2002), poly(oxyalkylene)polyol synthesis by a phosphazene catalyst (MCI; 2002)

## 3. Catalysts for Monomer Production

Acrylic derivatives: Ammoxidation of propene (AKCC; 1967), partial oxidation of isobutylene (*tert*-butyl alcohol) for methacrylic acid production (NS; 1982; Mitsubishi Rayon; 1982), direct oxidative esterification of methacrolein for MMA production (AKCC; 1998), acrylonitrile hydration to acrylamide by a copper catalyst (MCI; 1972) and by nitrile hydratase (Dia-Nitrix; 1985)

Vinyl monomers: Oxychlorination of ethene (Tosoh; 1966), dehydrogenation of ethylbenzene (Süd-Chemie Catalysts; 1983), highly selective H<sub>2</sub> oxidation for ethylbenzene dehydrogenation (MCC; 2003), vapor-phase dehydration



**Figure 5.** Ammonium sulfate-free  $\epsilon$ -caprolactam plant based on ammoxidation and vapor-phase Beckmann rearrangement (2003, Sumitomo Chemical Co., Ltd).

of *N*-(2-hydroxyethyl)-2-pyrrolidone to *N*-vinyl-2-pyrrolidone (NS; 2001)

Monomers for nylon and engineering plastics: Oxidative acetoxylation of butadiene to 1,4-butanediol and THF (MCC; 1982), oxidative coupling of phthalate for BPDA production (Ube; 1982), hydroformylation of allyl alcohol for 1,4-butanediol production (Kuraray; 1987), cyclohexanol production via partial hydrogenation of benzene to cyclohexene followed by hydration of cyclohexene (AKCC; 1990), reductive amination of 1,9-nonanedial to 1,9-nonanediamine (Kuraray; 1998), diphenyl carbonate synthesis from phenol and phosgene by an ammonium salt recycling system (MCC; 2000), vapor-phase Beckmann rearrangement for  $\epsilon$ -caprolactam production (SCC; 2003)

Recycling of recovered HCl: HCl oxidation to Cl<sub>2</sub> by a chromium oxide catalyst (MCI; 1988) and by a supported ruthenium oxide catalyst (SCC; 2003)

## 4. Catalysts for Other Organic Syntheses

C<sub>1</sub>-Related reaction: Methane steam reforming (MGC, JGC, Nikki Chemical; 1956), hydroformylation of propene

by a rhodium catalyst (MCC; 1978), dibutyl oxalate synthesis via oxidative CO coupling (Ube; 1978), methanol carbonylation for acetic acid production (Daicel Chemical Industries; 1980), hydroformylation of octenes to isononyl alcohol (MCC; 1987), hydroformylation of 3-methyl-3-butene-1-ol to 3-methyl-1,5-pentanediol (Kuraray; 1987), dehydrogenation of methanol to methyl formate (MGC; 1988), methylal oxidation for formaldehyde production (AKCC; 1988), steam reforming of light hydrocarbon (Toyo Engineering; 1992), dimethyl carbonate synthesis by oxidative carbonylation (Ube; 1993).

Oxidation products: Phthalic acid anhydride production by partial oxidation of a naphthalene/*o*-xylene mixed material (Nippon Steel Chemical; 1983), oxidative acetoxylation of propene for allyl alcohol production (SDK; 1994), direct acetic acid synthesis by ethene oxidation (SDK; 1997), vapor-phase oxidation of *p*-methoxytoluene to anisaldehyde (NS; 1997), propene oxide synthesis with no byproducts using cumene as an oxygen carrier (SCC; 2003)

Hydrogenation products: Vapor-phase hydrogenation of carboxylic acids

to aldehydes (MCC; 1988), hydrogenation of maleic anhydride to  $\gamma$ -butyrolactone (MCC; 1997)

Hydration and related reactions: Propene hydration to isopropyl alcohol by a heteropolyacid catalyst (Tokuyama; 1972), hydrodimerization of butadiene to  $C_8$  alcohol (Kuraray; 1991), vapor-phase acetic acid addition to ethene for direct synthesis of ethyl acetate (SDK; 1999), hydration of *n*-butene to *sec*-butyl alcohol (Idemitsu; 2003)

Hydrocarbon transformation: Dimerization of propene to dimethylbutenes (SCC; 1983), MTBE decomposition for isobutylene production (SCC; 1984), isomerization of 5-vinyl-2-norbornene to vinylidene norbornene by a solid superbase (SCC; 1986), ethene oligomerization to  $\alpha$ -olefins (Idemitsu; 1989), BTX production by catalytic aromatization of olefinic light hydrocarbons (AKCC; 1993)

N- or Cl-containing intermediates: Isomerization of chlorinated aromatics (Toray; 1980's), methyamine synthesis from methanol and ammonia by zeolite catalyst (Mitsubishi Rayon; 1984), ammoxidation of 2-methylpyridine to 2-cyanopyridine (Koei Chemical; 1986), dehydration of monoethanolamine to ethylenimine (NS; 1990), selective synthesis of pyridine bases (Koei Chemical; 1990), selective diethanolamine synthesis from EO and ammonia (NS; 2003)

Optically active chemicals: Asymmetric isomerization (Takasago International; 1983), asymmetric carbenoid reaction (SCC; 1984), asymmetric hydrogenation (Takasago International; 1992, 2006), hydrolytic kinetic resolution of epoxides (Daiso; 2000)

## 5. Catalysts for Environmental Protection

Purification of automobile exhaust gas: Catalyst mounting to automobiles (Toyota; 1975), monolithic oxidation catalyst (Nissan; 1980), monolithic three-way catalyst (Nissan; 1984), promoter materials for automobile catalysts (Daiichi Kigenso Kagaku Kogyo; 1986), monolithic mixed cerium series composite oxide and two-coat layer-type three-way catalyst (Nissan; 1989), monolithic palladium three-way catalyst (Nissan; 1992, Toyota; 1993), NO<sub>x</sub> reduction catalyst for lean combustion engines (Toyota; 1994, Mazda; 1994, ICT; 1996), palladium-loaded three-way catalyst for Miller cycle engine (Mazda; 1994), high-capacity oxygen-storage-release type three-way catalyst (Toyota; 1997), monolithic HC adsorption-type three-way catalyst (Nissan; 1998), NO<sub>x</sub> storage-type reduction catalyst for direct injection gasoline engines (Toyota; 1999), self-regenerative intelligent catalyst (Daihatsu Motor, Japan Atomic Energy Agency, Cataler, Hokko Chemical Industry; 2002, 2005)

Purification of diesel engine exhaust gas: Diesel particulate and NO<sub>x</sub> reduction system (Toyota; 2001)

## Prospects of the CATSJ

As introduced in the above sessions, the Catalysis Society of Japan presently has many roles in various fields, from basic to applied catalyses, and is firmly committed to the promotion of exchange of ideas among the government, universities, and industries. As we enter the next 50 years, the Society is increas-

ingly required to encourage the cooperation among the three groups for further advancement of globalization and a contribution to both world and regional society. There are many objectives to be studied; green sustainable chemistry, the biomass refinery including reducing carbon dioxide emission, and so on. To fulfill these objectives, it is necessary to carry out the following action plans in a strong spirit of cooperation:

- To organize the annual meetings and the international meeting TOCAT. The latter will be occasionally expanded to or joined with APCAT
- To enhance the division system to adapt the Society to progress in the research fields and to promote effective exchange of ideas
- To encourage the young people through awards, short stays/studies at different laboratories, catalysis schools, and helping him/her with overseas travel expenses
- To publish the journal „*Shokubai (Catalysts & Catalysis)*“

[1] <http://www.shokubai.org/>.

[2] <http://www.shokubai.org/com/sansyo/>.

[3] <http://www.shokubai.org/jnl/cgi-bin/ccotw.cgi>.

[4] CATSJ Ed., *Lectures on Catalysis Engineering*, „*Shokubai Kagaku Koza*“, Chijin Publ., Tokyo (1964); CATSJ Ed., *Lectures on Catalysis*, „*Shokubai Koza*“, Kodansha Publ., Tokyo (1985); CATSJ Ed., *Handbook on Catalysis*, „*Shokubai Binkan*“, Kodansha Publ., Tokyo (2008).