

Photoelectrochemical Behavior of Iron Oxide Thin Film Electrodes Prepared by Sol-Gel Method

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Iron oxide films were prepared on the silica glass substrates by sol-gel method combined with dip-coating technique. The crystallization behavior and optical properties of these films were investigated as a function of post-heating time and temperature. Photoelectrochemical and a.c. impedance measurements were made on these post-heated iron oxide film electrodes. The maximum photocurrent was obtained for the sample heated at 700°C for 2 h. An obvious break was observed for the Mott-Schottky plot of the present film electrode, indicating the presence of deep and shallow donors as in the case of the sintered body. The presence of two kinds of optical transitions with different band gap energies was also confirmed from the action spectrum. The smaller and larger ones were assigned to an indirect Fe^{3+} (3d non-bonding)—conduction band (CB) transition with $E_g=2.06$ eV and a direct O^{2-} (2p bonding)—CB transition with $E_g=2.64$ eV, respectively.

KEY WORDS: Photoelectrochemistry/ Iron Oxide/ Thin Film/ Sol-Gel Method/

1. INTRODUCTION

Utilization of solar energy is absolutely necessitated to meet future energy demands. The conversion of solar energy into electricity and/or chemical substances, for example hydrogen, using semiconductors as a photoelectrochemical electrode is also considered to be one of the most promising means. A quite number of researches have been made on this subject since Fujishima and Honda¹⁾ succeeded in decomposing water into H_2 and O_2 using a photoilluminated TiO_2 anode without any degradation of the electrode.

The main requirements for photoelectrochemical electrodes are (1) chemical and photoelectrochemical stability and (2) high conversion efficiency²⁾. TiO_2 has high chemical and photoelectrochemical stability, but low solar energy conversion efficiency only less than 4% due to its large band gap (3.0 eV). Semiconductors with small band gap, in general, lack chemical and photoelectrochemical stability. Among them, $\alpha\text{-Fe}_2\text{O}_3$ with a band gap of about 2eV is an exceptional semiconductor which almost satisfies the above requirements.

Hardee and Bard³⁾ were the first who made photoelectrochemical studies on Fe_2O_3 films prepared by CVD from $\text{Fe}(\text{C}_5\text{H}_7\text{O}_2)_3$. Since then, several works³⁻¹⁵⁾

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have been done using different kinds of Fe_2O_3 electrodes prepared by flux growth⁴⁾, thermal oxidation^{5,9,10)}, r.f. sputtering^{10,14,15)} and sintering^{6,7,11,12-14)} in addition to CVD. It has been also found here that both n- and p-type Fe_2O_3 can be prepared by adding divalent and tetravalent metal oxides, respectively, as dopants^{4,6,9-11)}. All of them, however, show a rather low quantum efficiency and a decline in onset potential.

On the other hand, the authors have reported the preparation of semiconducting TiO_2 thin films by sol-gel method and their photoelectrochemical properties¹⁶⁾. The sol-gel derived TiO_2 film electrode was found to give a large photocurrent due to the porous surface structure inherent in a gel. In the present study, sol-gel method is applied to the preparation of $\alpha\text{-Fe}_2\text{O}_3$ thin films for photoelectrodes and their photoelectrochemical properties are investigated in details.

2. EXPERIMENTAL

2.1 Substrates

Synthetic silica glasses were coated with SnO_2 doped with 1 mol% Sb_2O_3 and used for substrates. SnO_2 coating films were made by a fume pyrolysis: coating solution containing 50 ml ethyl acetate, 20 ml conc. HCl , 10 g SnCl_2 and 0.1256 g SbCl_3 was sprayed onto silica glass heated at 750°C . The electrical resistance was around 50–60 $\Omega/\square$.

2.2 Coating and heat treatment

Coating solutions for Fe_2O_3 films were prepared as follows. 17.7 g of iron acetylacetonate, $\text{Fe}(\text{acac})_3$ and 60 ml of Hacac were put into 200 ml meyer flask and stirred. Then, 8.5 ml of HNO_3 (13.8N) was dropped in the solution using a pipette under stirring. The resultant solution was kept on stirring for 2–3 days prior to use.

A glass substrate obtained in section 2.1 was immersed in the solution, pulled up at a rate of 0.3 mm s^{-1} , dried for 3 min and then heated at 500°C for 10 min. Fe_2O_3 films of $0.4 \mu\text{m}$ thick were obtained by repeating the above operation ten times. Post-heat treatment was carried out at temperatures between 500 and 800°C for 1–120 min in order to investigate the crystallization behavior of the as-prepared Fe_2O_3 films. The whole process is summarized in Fig. 1.

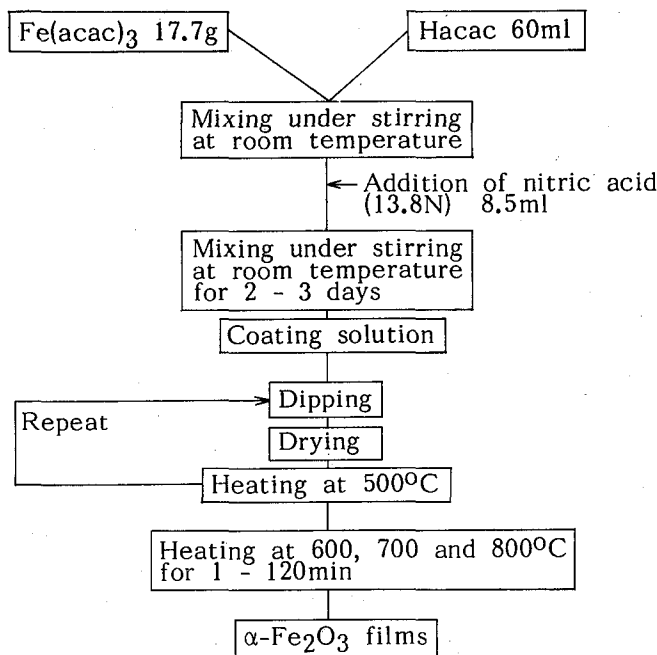
The precipitated crystalline phase was identified by an X-ray diffractometer using $\text{CoK}\alpha$ radiation. The crystallite size was determined from the FWHM of (104) line according to Scherrer's equation.

2.3 Absorption spectra

The absorption spectra of Fe_2O_3 films heated at various temperatures for different times were measured using a Cary Model 14 spectrometer (Varian, U.S.A.).

2.4 Photoelectrochemical measurements

Photocurrent-potential curves were recorded using a potentiostat/galvanostat model 2000 (TOHO Giken, Japan) with three electrodes system: Fe_2O_3 film working,

Fig. 1. Flow chart for preparing Fe_2O_3 film electrode.

platinized Pt counter and saturated calomel electrodes (SCE). Illumination was with a Xenon-arc lamp (500W). Monochromatized light in the wavenumber range from 200 to 700 nm was obtained by a monochromator model CT10 (JASCO, Japan). Impedance analysis for obtaining the Mott-Schottky plot was performed using a frequency response analyzer model S-5720B (NF, Japan) operated at 1010 Hz in conjunction with the potentiostat. Measurements and data accumulation were made with the help of a personal computer PC-9801VM (NEC, Japan) via GP-IB.

Two kinds of electrolytic solutions were used: (1) $0.2\text{M Na}_2\text{B}_4\text{O}_7 + 0.1\text{M H}_2\text{SO}_4 + 0.3\text{M Na}_2\text{SO}_4$ (pH 7) and (2) $0.1\text{M NaOH} + 0.3\text{M Na}_2\text{SO}_4$ (pH 13).

3. RESULTS

3.1 Optical properties

The absorption spectra of Fe_2O_3 films heated at 700°C for different times are shown in Fig. 2. The spectra have two mountains and troughs in the measured wavelength region. Since these positions varied with heating time, in other words, with film thickness, they do not arise from absorption, but from the interference of a light.

Fe^{3+} and Fe^{2+} in octahedral coordination are known to show absorption bands around 800 nm and 1100 nm, respectively¹⁷⁾. Both peaks, however, were not visible probably due to small absorbance compared with the interference spectrum. For all samples, irrespective of heating time and temperature, the steep rise of absorb-

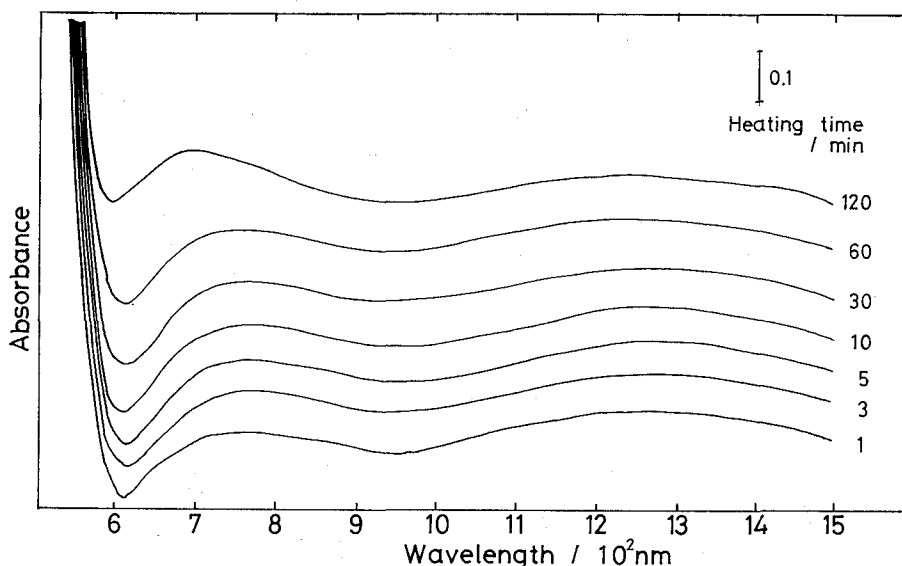


Fig. 2. Absorption spectra of Fe_2O_3 films heated at 700°C for different time.

ance was observed below 580 nm probably due to the charge transfer. The band gap energy of Fe_2O_3 films prepared in the present study was estimated from the absorption edge as about 2.1 eV.

3.2 Crystallization behavior

$\alpha\text{-Fe}_2\text{O}_3$ (hematite) crystals were found to precipitate in the as-prepared Fe_2O_3 films which were heated at 500°C . Fig. 3 shows the X-ray diffraction patterns of Fe_2O_3 films forming on the SnO_2 -coated silica glass which were heated at 800°C for 1 and 120 min. With increasing heating time, (110) line appeared in addition to (104) line indicating that the crystallinity was improved.

The variations of crystallite size in the $\alpha\text{-Fe}_2\text{O}_3$ films heated at various temperatures with time are shown in Fig. 4. The crystallite size increased sharply at the early stage of heating up to 10–20 min and then became constant; 33 nm at 500°C and 45 nm above 600°C .

3.3 Photoelectrochemistry

Polarization curves in solutions of pH 7 and 13 for Fe_2O_3 film electrodes which were heated at 600, 700 and 800°C for various times are shown in Figs. 5a, b, 6a, b, and 7a, b, respectively. There are noticeable differences in the photocurrent and the shape of polarization curves taken in solutions of pH 7 and 13. That is, the photocurrents in neutral solution are smaller than in pH 13 solution and the polarization curves in pH 7 solution have a plateau in the potential region between 0.5 and 1V (vs. SCE). The smaller photocurrents observed in solution of pH 7 than pH 13 is clearly due to the oxygen overpotential. All the samples studied did not show a saturated photocurrent.

Figs. 8a, b and c show the time dependence of the photocurrent at several bias

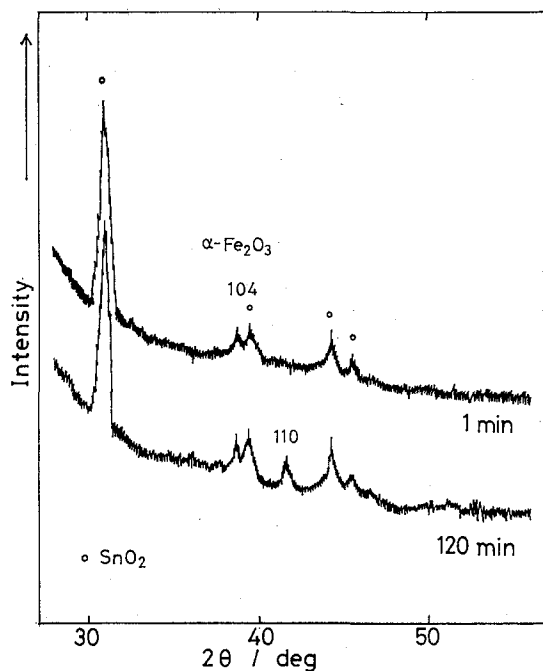


Fig. 3. X-ray diffraction patterns of Fe_2O_3 films forming on the SnO_2 -coated SiO glass heated at 800°C for 1 and 120 min.

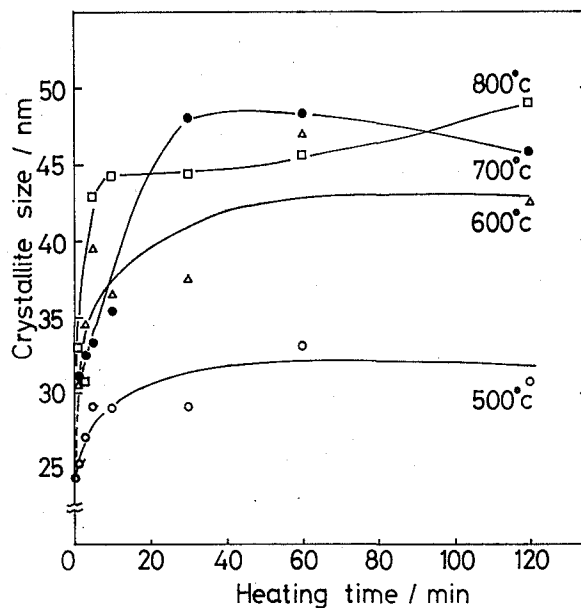


Fig. 4. Variations of crystallite size in the $\alpha\text{-Fe}_2\text{O}_3$ films heated at different temperatures with time.

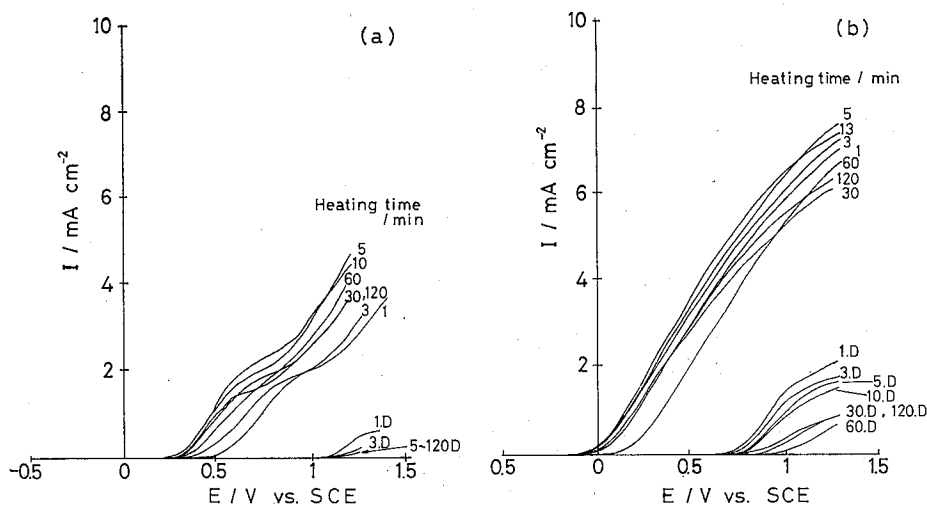


Fig. 5. Polarization curves of Fe_2O_3 film electrodes heated at 600°C ; (a) pH 7 and (b) pH 13.

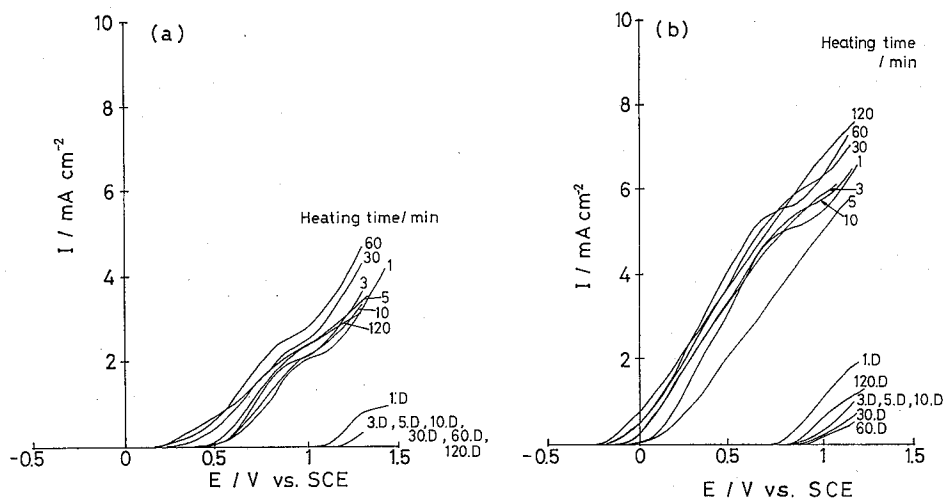


Fig. 6. Polarization curves of Fe_2O_3 film electrodes heated at 700°C ; (a) pH 7 and (b) pH 13.

potentials for samples heated at 600, 700 and 800°C , respectively. At 600°C , the photocurrents first increase with heating time up to 5–10 min, decrease slightly and then attain constant values. At 700°C they gradually increase with heating time and then become constant after 60 min. On the contrary, at 800°C they decrease rapidly with heating time up to 60 min and then become almost constant.

Fig. 9 shows the action spectra taken in solutions of pH 7 and 13 for the sample heated at 600°C for 5 min. The two spectra have basically the same features, showing a maximum at 360 nm (3.45 eV) and a small maximum around 475 nm (2.61 eV) and a long tail extending up to about 600 nm (2.07 eV).

Photoelectrochemistry of Fe_2O_3 Thin Film Electrodes Prepared by Sol-Gel Method

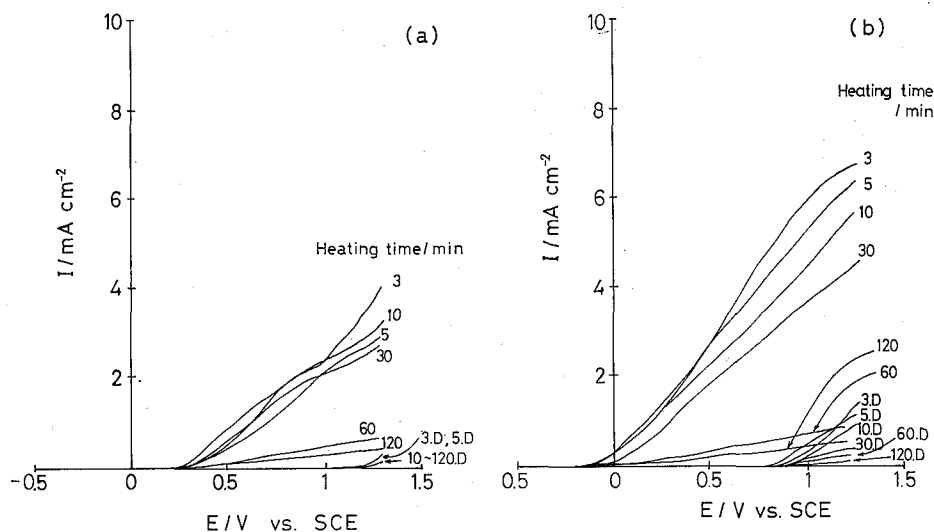


Fig. 7. Polarization curves of Fe_2O_3 film electrodes heated at 800°C ; (a) pH 7 and (b) pH 13.

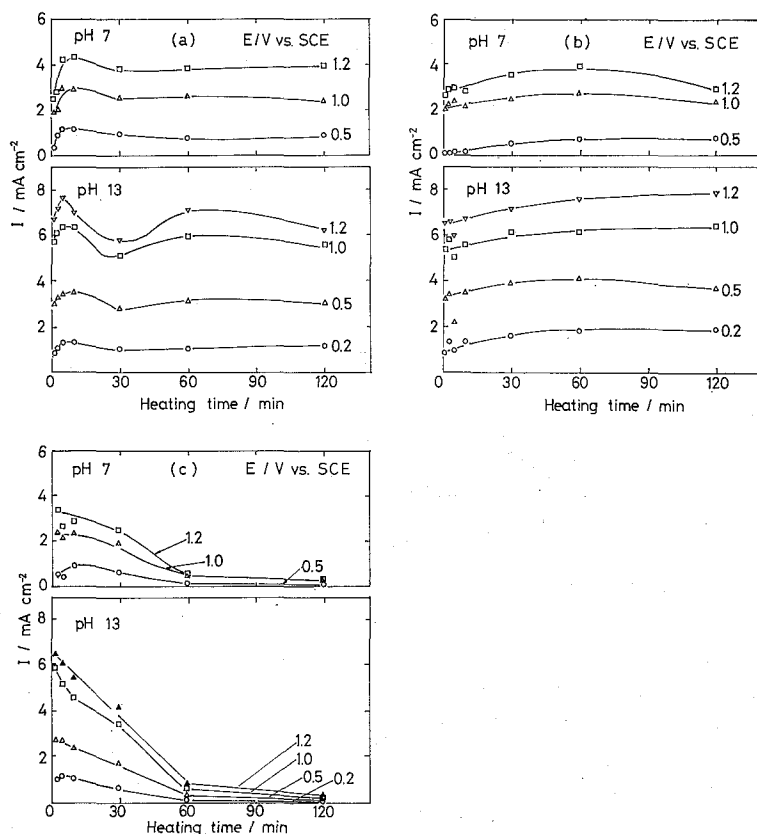


Fig. 8. Heating time dependence of the photo photocurrent in solutions of pH 7 and 13 at several bias potentials for Fe_2O_3 film electrodes heated at (a) 600°C , (b) 700°C and (c) 800°C .

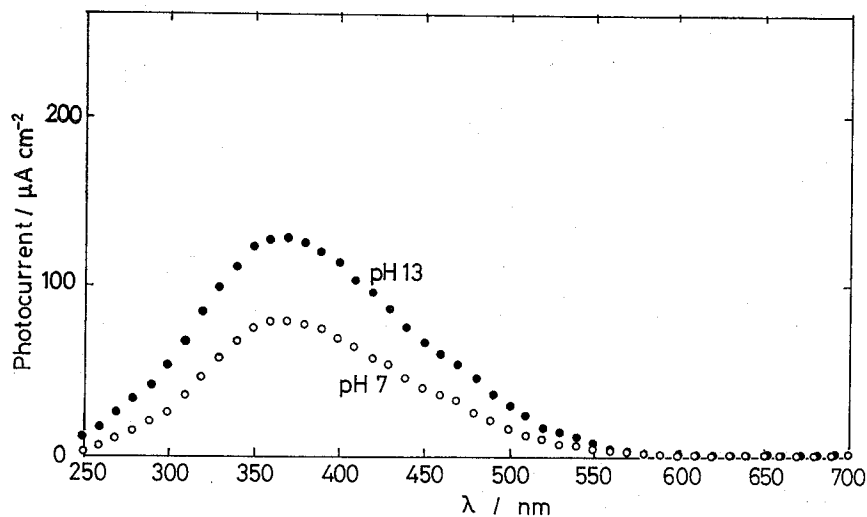


Fig. 9. Action spectra of Fe_2O_3 film electrode heated at 700°C for 5 min.

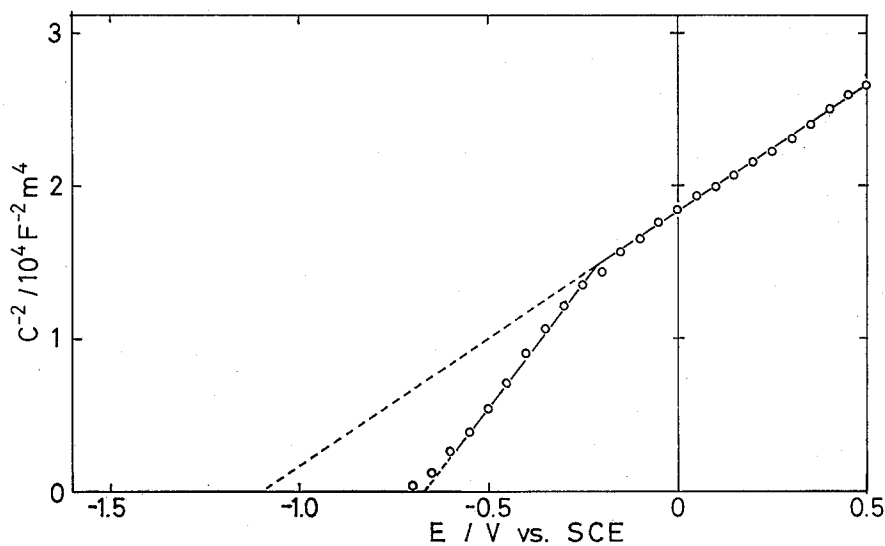


Fig. 10. Mott-Schottky plot of Fe_2O_3 film electrode heated at 700°C for 30 min.

In Fig. 10, the Mott-Schottky plot obtained by a.c. impedance analysis is shown for the sample heated at 700°C for 30 min. There is a sharp break around -0.3V (vs. SCE), giving rise to two apparent flat band potentials, -0.67 and -1.09V (vs. SCE).

DISCUSSION

It has been found that the post-heating treatment of the as-prepared Fe_2O_3 films influences markedly the photoelectrochemical properties, especially photocur-

rent as seen from Figs. 5-8. That is, the onset potentials shift towards cathodic direction and the dark currents decrease apparently with increasing heating time at any temperatures. This is considered to be primarily due to the improvement of crystallinity as expected from Fig. 4, although the crystallites cease to grow at a certain time at any heating temperatures.

The heating time dependence of the photocurrent does not seem simple, but basically can be explained by the improvement of crystallinity except heating at 800°C. A sharp decrease in the photocurrent of the samples heated at 800°C with time probably results from the high resistance layer forming between Fe_2O_3 and SnO_2 films, because a large increase in resistance was observed for these samples while there is no appreciable difference in donor density.

Fe_2O_3 electrodes have been known not to show a saturated photocurrent even at deep anodic bias potential, but to show a large dark current and a pronounced transient photocurrent. This is also the case for the present samples derived from sol-gel method. Therefore, this phenomena can be said to be inherent in Fe_2O_3 itself irrespective of the sample preparation processes. They reflect the strong recombination effects not only at the surface but also in the bulk of the materials. The surface recombination centers were found to be diminished to a considerable extent by adding chelating-type supporting electrolyte, resulting in the enhancement of efficiency^{7,9)}. However, as far as pure Fe_2O_3 is concerned, it may be very difficult to avoid the problems relating to the bulk recombination.

The photocurrent response was observed in the wavelength region below 600

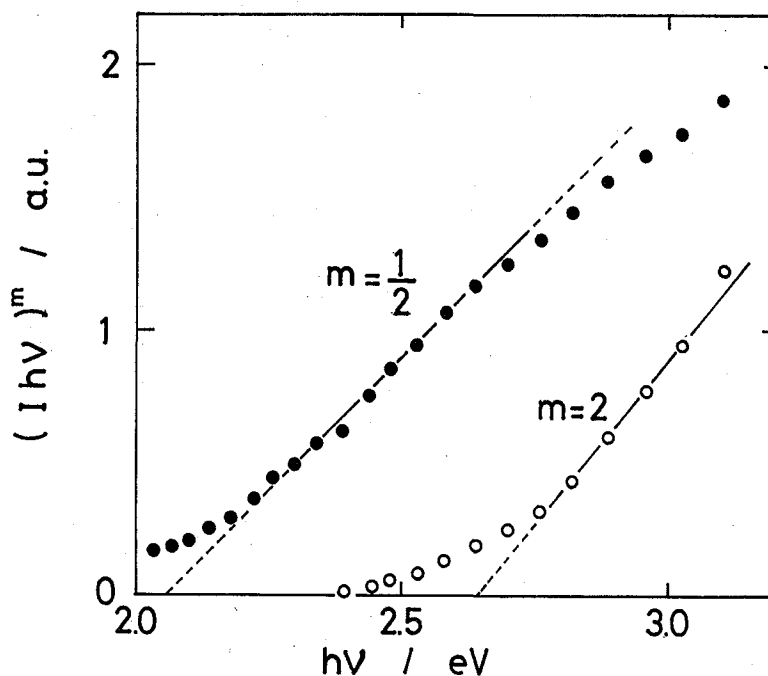


Fig. 11. Plots of $(Ih\nu)^m$ versus $h\nu$ for Fe_2O_3 film electrode heated at 700°C for 5 min.

nm as clearly seen from Fig. 9. It is interesting to note again that a smaller maximum appeared at 475 nm in the action spectra. This suggests that two different transitions are involved in the excitation process. The energy band gap E_g of the interband transition can be determined from the following relation¹⁸⁾,

$$(Ih\nu)^m \propto A(h\nu - E_g)$$

where I is the photocurrent, $h\nu$ the photon energy of an incident light and A the constant depending on the bias potential. For a direct band gap semiconductor, $m=2$ and for an indirect band gap one $m=1/2$.

Relations between $(Ih\nu)^m$ and $h\nu$ are shown in Fig. 11. Two straight lines are obtained for $m=1/2$ in the lower energy region and for $m=2$ in the higher energy region. From their intercepts to the abscissa, the energies are estimated as 2.06 and 2.64 eV for indirect and direct band gaps, respectively. The indirect band gap energy of 2.06 eV agrees very well with the value of 2.1 eV obtained from the absorption edge in Fig. 2. This result indicates that the smaller band gap is possibly assigned to the indirect Fe³⁺(3d⁵ non-bonding)-conduction band (CB) transition. However, as Schumacher *et al.* pointed out¹⁵⁾, the holes generated in the d band have a very low mobility due to its narrowness, leading to their poor transport, in other words, lower conversion efficiency. On the contrary, the larger band gap of 2.64 eV may be assigned to the direct charge transfer due to O (2p bonding)-CB transition. Taking into account that this transition is a major cause of the photocurrent, Fe₂O₃ should be taken as a semiconductor with a band gap energy of 2.64 eV.

Another interesting feature of the Fe₂O₃ film electrodes is to show a sharp break in the Mott-Schottky plot as shown in Fig. 10. Since it was also observed for different kinds of Fe₂O₃ electrodes prepared by sintering⁶⁾, and reactive sputtering and plasma oxidation¹⁵⁾, this phenomenon is an intrinsic property of Fe₂O₃. Kennedy

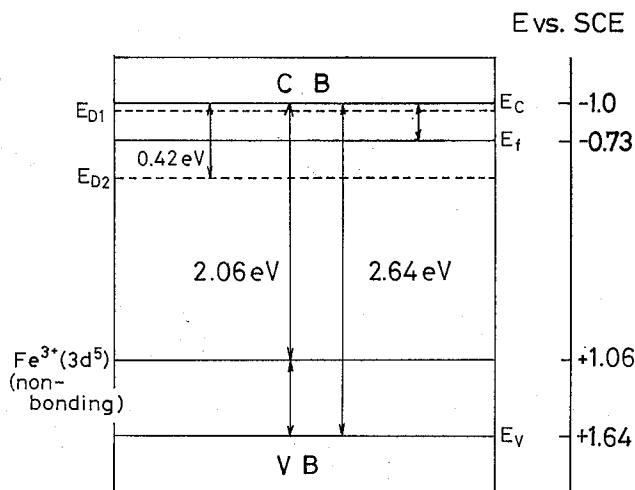


Fig. 12. Energy diagram for the present α -Fe₂O₃ film.

and Frese⁶⁾ explained this by assuming the presence of two kinds of donors, shallow and deep. In the present case (Fig. 10), the energy level of the deep donor E_{D2} is estimated as about 0.42 eV below the shallow one E_{D1} from the potential intercepts. The energy diagram for the present α - Fe_2O_3 films can be summarized as in Fig. 12, taking into account the two optical band gaps obtained here. The origin of the shallow donor is possibly assigned to the d electrons in the anti-bonding orbital⁶⁾. Although the deep donor was assigned to Fe^{2+} by Kennedy and Frese⁶⁾, the cause is not clear at present.

SUMMARY

Fe_2O_3 has an apparent optical band gap of 2.06 eV which is assigned to the Fe^{3+} (3d non-bonding)-CB transition. However, the photocurrent caused by this transition is very small compared with that due to the second transition from O^{2-} (2p bonding)-CB with a band gap of 2.64 eV. In this respect, Fe_2O_3 is a semiconductor with a band gap of 2.64 eV, rather 2.06 eV.

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REFERENCES

- (1) A. Fujishima, K. Honda and S. Kikuchi, *Kogyo-Kagaku Zasshi*, **72**, 108 (1969).
- (2) R. Memming, *Electrochim. Acta*, **25**, 78 (1980).
- (3) K.L. Hardee and A.J. Bard, *J. Electrochem. Soc.*, **123**, 1024 (1976).
- (4) R.K. Quinn, R.D. Nashby and J. Baughman, *Mat. Res. Bull.*, **11**, 1011 (1976).
- (5) Lun-Shu Ray Yeh and N. Hackerman, *J. Electrochem. Soc.*, **124**, 833 (1977).
- (6) J.H. Kennedy and K.W. Frese, Jr., *ibid.*, **125**, 723 (1978).
- (7) idem., *ibid.*, **125**, 709 (1978).
- (8) J.H. Kennedy, R. Shinar and J.P. Ziegler, *ibid.*, **127**, 2307 (1980).
- (9) P. Iwanski, J.S. Curran, W. Gissler and R. Memming, *ibid.*, **128**, 2128 (1981).
- (10) H. Ono, H. Morisaki and K. Yazawa, *Jap. J. Appl. Phys.*, **21**, 1075 (1982).
- (11) C. Leygraf, M. Henderwerk and G.A. Somorjai, *J. Catal.*, **78**, 341 (1982).
- (12) J.E. Turner, M. Hendewerk, J. Parmeter, D. Neiman and G.A. Somorjai, *J. Electrochem. Soc.*, **131**, 1777 (1984).
- (13) S. Shai and J.H. Kennedy, *ibid.*, **132**, 1116 (1985).
- (14) F.A. Benko, J. Longo and F.P. Koffyberg, *ibid.*, **132**, 609 (1985).
- (15) L.C. Schumacher, S. Mamiche-Afara, M.F. Weber and M.J. Dignam, *ibid.*, **132**, 2945 (1985).
- (16) T. Yoko, K. Kamiya and S. Sakka, *Yogyo-Kyokai-Shi*, **95**, 150 (1987).
- (17) T. Bates, "Modern Aspects of the Vitreous States", Vol.2, ed. by J.D. Mackenzie, Butterworths, London, (1962) pp. 195.
- (18) M.A. Butler, D.S. Ginley and M. Eibschitz, *J. Electrochem. Soc.*, **127**, 2307 (1980).

The Papers Published by the Staff Member of the Institute from July 1988 to June 1989

Nuclear Chemistry

Charge Distribution of the Daughter Atom in α DEcay of ^{210}Po , T. Mukoyama and S. Ito, *Physics Letters A*, **131**, 182, (1988).

Nuclear Excitation by Synchrotron Radiation —Background—, T. Mukoyama, H. Kaji, K. Yoshihara, and T. Nakajima, Photon Factory Activity Report 1988 #6 (National Laboratory for High Energy Physics, Tsukuba, 1989) p. 184.

Chemical Effects on X-Ray Intensity Ratios of Nuclei Excited by Synchrotron Orbital Radiation, K. Yoshihara, H. Kaji, T. Sekine, T. Mukoyama, and T. Nakajima, Photon Factory Activity Report 1988 #6 (National Laboratory for High Energy Physics, Tsukuba, 1989), p. 192.

Charge Distribution of Xe Ions Produced by Multiple-Photoionization, T. Mukoyama, A. Yagishita, T. Tonuma, T. Koizumi, T. Matsuo, H. Shibata, K. Shima, and H. Tawara, Photon Factory Activity Report 1988 #6 (National Laboratory for High Energy Physics, Tsukuba, 1989), p. 230.

Simple Correlation in Atomic Collisions, J. H. McGuire, N.C. Deb, O.L. Weaver, T. Ishihara, L. Kocbach, and T. Mukoyama, *Nucl. Instr. and Meth.*, **B40/41**, 340, (1989).

M-Shell X-Ray Emission Rates for Dy in Dirac-Fock Approximation, T. Mukoyama, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 624, (1989).

K X-Ray Emission Rates in Superheavy Elements, T. Mukoyama and H. Adachi, *Bull. Inst. Chem. Res., Kyoto Univ.*, **67**, 15, (1989).

Study of L _{γ} X-Ray Emission from α Decay of ^{210}Po , T. Mukoyama and S. Ito, *Bull. Inst. Chem. Res., Kyoto Univ.*, **67**, 23, (1989).

Calculations of Cross-Sections for Excitation and Ionization of Inner Shells of Atoms by Heavy Ions in Distortion Approximation, T. Mukoyama and C.D. Lin, *Chinese J. Phys.*, **27**, 117, (1989).

Inverse and Higher-Order Processes of Internal Conversion, T. Mukoyama, INS-T-488 [Accelerator-9] (Institute for Nuclear Study, Tokyo University, Tanashi, 1989), p. 85, In Japanese.

Photonuclear Excitation of ^{103}Rh by Synchrotron Radiation, K. Yoshihara, H. Kaji, T. Sekine, T. Nakajima, and T. Mukoyama, *Appl. Radiat. Isot.*, **40**, 491, (1989).

Cems Study of Corrosion on Iron Foil at Low Temperatures, T. Kobayashi, K. Fukumura, Y. Isozumi and R. Katano, *Hyperfine Interactions*, **39**, 419, (1988).

A Simple Cristal Spectrometer for Low-Energy X-Rays Emitted from Radiocative Sources, S. Kishimoto, Y. Isozumi, S. Ito, R. Katano and H. Takekoshi, *Appl. Radiat. Isot.* **40**, 299, (1989).

Cryogenic Resonance-Electron Mossbauer Spectroscopy with Helium-Filled Proportional Counter, R. Katano, T. Fujii, T. Kobayashi, K. Fukumura and Y. Isozumi, *Nucl. Instr., Methods in Physics Research*, **A20**, 285, (1989).

Spectral function of the $p_{3/2}$ nucleons in ${}^6\text{Li}$, R. E. Warner, A. Okihana, M. Fujiwara, N. Matsuoka, K. Tamura, M. Tosaki, T. Ohsawa, K. Fukunaga, P.A. Kimoto, and N. Koori, *Phys. Rev. C*, **38**, 2945, (1988).

PIXE measurement of the movement of elements in urine of Pb-treated rats, E. Matsugi, M. Tanaka, M. Goto, K. Miyasaki, T. Yamagata, M. Inoue, and H. Ogata, *Nucl. Instr. Methods in Physics Research B*, **35**, 167, (1988).

Analyzing Power and Continuous Energy Spectrum for Three Body Breakup Reaction in the DD Collision at 60 MeV, K. Fukunaga, S. Kakigi, T. Ohsawa, A. Okihana, T. Sekioka, H. Nakamura-Yokota, T. Murayama, T. Hayashi, *Bull. Inst. Chem. Res., Kyoto Univ.*, **67**, 1, (1989).

4-Rod RFQ Proton Acceleration Tests, H. Fujisawa, Y. Iwashita, H. Takekoshi, *Bull. Inst. Chem. Res. Kyoto Univ.*, **67**, 7, (1989).

Study on a Volume-Production H^- Ion Sourec, S. Takama, *Bull. Inst. Chem. Res., Kyoto Univ.*, **67**, 27, (1989).

General Eigenvalue Solver for Large Sparse Symmetric Matrix with Zero Filtering, Y. Iwashita, *Bull. Inst. Chem. Res., Kyoto Univ.*, **67**, 32, (1989).

Elastic scattering of the unstable nucleus ${}^7\text{Be}$ on ${}^{12}\text{C}$ at 140 MeV, T. Yamagata, K. Yuasa, N. Inabe, M. Nakamura, M. Tanaka, S. Nakayama, K. Katori, M. Inoue, S. Kubono, T. Itahashi, H. Ogata, Y. Sakuragi, *Phys. Rev. C*, **39**, 873, (1989).

An application of 80386/387 in native mode, Y. Iwashita, *Interface*, 16-June, 241, (1989). in Japanese.

Physical Chemistry

Fourier Transform Infrared-Attenuated Total Reflection Spectroscopy of Hydration of Dimyristoylphosphatidylcholine multibilayers, L. Ter-Minassian-Saraga, E. Okamura, J. Umemura, and T. Takenaka, *Biochim. Biophys. Acta*, **946**, 417, (1988).

Resonance Raman and Absorption Spectra of an Azobenzene-Containing Ammonium Amphiphile in Aqueous Solution and Adsorbed Monolayers at the Interface with Carbon Tetrachloride, T. Takenaka, Seventh International Symposium on Surfactants in Solution, 94, (1988).

FT-IR Study on Phase Transition in an Amid-Group-Incorporated Phospholipid-Water System, J. Umemura, T. Kawai, and T. Takenaka, Seventh International Symposium on Surfactants in Solution, 145, (1988).

Memory of Infrared Spectroscopy and its Application to Study of Langmuir Blodgett Films, T. Takenaka, Shimazu Scientific Instrument News, **29**(2), 1 (1988), in Japanese.

Surface Enhanced Resonance Raman Scattering of Cetyl Orange LB Monolayers, T. Takenaka, J. Umemura, and T. Nakagawa, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 590, (1989).

Functionality and Evaluation of Molecular Solids—Fourier-Transform Infrared Spectroscopy, T. Takenaka, Molecular Engineering, Ed. by M. Okada et al., p. 172, Science Forum (1989), in Japanese.

Surface Enhanced Raman Scattering from Langmuir-Blodgett Films, T. Takenaka, *Journal of the Society of Photographic Science and Technology of Japan*, **52**, 62, (1989), in Japanese.

New Evaluation Method of Molecular Orientation in Thin Organic Films, T. Takenaka, *Oyo Buturi*, **58**, 1109, (1989), in Japanese.

Ionic Dynamics in Computer Simulated Molten LiNO_3 . I. Translational and Rotational Motion, T. Kato, K. Machida, M. Oobatake, and S. Hayashi, *J. Chem. Phys.*, **89**, 3211 (1988).

Ionic Dynamics in Computer Simulated Molten LiNO_3 . II. Tumbling and Spinning Motions of Nitrate Ions, T. Kato, K. Machida, M. Oobatake, and S. Hayashi, *J. Chem. Phys.*, **89**, 7471 (1988).

Characterization of Surface Thin Films (Mainly LB Films) by FT-IR Spectroscopy, J. Umemura, *J. Shimadzu Sci. Instr.*, **1**, 133, (1989), in Japanese.

Dark Field Electron Microscope and Electron Diffraction Studies on Langmuir-Blodgett Films of a TCNQ Derivative, Mutsuo Matsumoto and Natsu Uyeda *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 554, (1989).

Studies on Lattice Defects in Organic Crystals by Direct Imaging of Molecules, T. Kobayashi, *Denshi Kenbikyo*, **23**, 229, (1989), in Japanese.

Structure of Metal-Phthalocyanine Polymer Studies by High Resolution Electron Microscopy and Electron Energy Loss Spectroscopy, T. Kobayashi, H. Kurata, T. Meada and N. Kawase, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 605, (1989).

Electron Energy Loss Spectroscopy and Its Application, T. Kobayashi, H. Kurata, *Kinzoku*, 21, (1989), in Japanese.

High Resolution Electron Microscopic Study of Silver Sulfide Microcrystals

Formed on Silver Bromide Emulsion Grains, T. Shiozawa and T. Kobayashi, *Phys. Stat. Sol. (a)*, **110**, 375, (1988).

Structure of Tobacco Mosaic Virus A-Protein in Low Ion Concentration at Alkaline PH, Y. Sano, H. Inoue, K. Kajiwara, Y. Hiragi, E.K. Kim and S. Isoda, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 481, (1989).

Microtwin Structure in (SN)x, S. Isoda, A. Uemura, S. Moriguchi, M. Ohara and K. Katayama, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 530, (1989).

Crystallization of Polyethylene from Its Vapor Phase on Cycloparaffin Single Crystals, K. J. Ihn, M. Tsuji, S. Isoda, A. Kawaguchi, K. Katayama, T. Tanaka and H. Sato, *Makromol. Chem.*, **10**, 185, (1989).

Direct Imaging of Molecular Arrangement in a Radiation-Sensitive Polymer Single Crystal, M. Tsuji, M. Ohara, S. Isoda, A. Kawaguchi and K. Katayama, *Phil. Mag. B*, **59**, 393, (1989).

Morphology of Cycloparaffins Crystallized Epitaxially on NaCl, K.J. Ihn, M. Tsuji, S. Isoda, A. Kawaguchi, K. Katayama, Y. Tanaka and H. Sato, *Makromol. Chem., Rapid Commun.*, **190**, 837, (1989).

Structural Changes of Poly (p-phenylene sulfide) on Doping, A. Uemura, S. Isoda, A. Kawaguchi, A. Ishizawa and K. Katayama, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 263, (1988).

Phase Transition in Polymer Crystals, T. Itoh and S. Isoda, *Denshi Kenbikyo*, **23**, 77, (1988) in Japanese.

On the Dynamical Extinction Due to a Horizontal Diamond Glide Plane, K. Ishizuka, *Ultramicroscopy*, **27**, 335, (1989).

On Detection Limit by Parallel Electron Energy Loss Spectrometer, K. Ishizuka, H. Kurata and T. Kobayashi, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 580, (1989).

Near Edge Structure in Electron Energy Loss Spectra of Chromium Trioxide Intercalated into Graphite and Some Chromium Oxides, H. Kurata, K. Ishizuka and T. Kobayashi, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 572, (1989).

Intermolecular Interactions of Fluorine Atoms in the Crystal of 1,3-Dimethyl-5-Fluorouracil and Its Mixed Crystal with 1,3-Dimethyluracil, T. Taga, N. Yamamoto and K. Machida, *Bull. Chem. Soc. Japan*, **62**, 354, (1989).

Structure of Mixed Crystals of Benzoic Acid and p-Fluorobenzoic Acid, and Their Energy Evaluation by Empirical Potential Functions, N. Yamamoto, T. Taga and K. Machida, *Acta Crystallographica B*, **45**, 162, (1989).

The Number of Interfaces and the Associated Dielectric Relaxations in Heterogeneous Systems, T. Hanai, H.Z. Zhang, K. Sekine, K. Asaka and K. Asami, *Ferroelectrics*, **86**, 191, (1988).

Dielectric Relaxations due to the Interfacial Polarization in Bilamellar Structure, K.S. Zhao, K. Asaka, K. Sekine and T. Hanai, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 540, (1988).

Some Characteristics of Heterogeneous Structure in Membrane Systems as Viewed from Dielectric Behavior, T. Hanai, *Membrane*, **14**, 101, (1989), in Japanese.

Frequency domain studies of impedance characteristics of biological cells using micropipet technique. I. Erythrocyte, S. Takashima, K. Asami, and Y. Takahashi, *Biophys. J.*, **54**, 995, (1988).

Dielectric properties of mouse lymphocytes and erythrocytes, K. Asami, Y. Takahashi, and S. Takashima, *Biochim. Biophys.*, **1010**, 49, (1989).

Dielectric Properties of Cellulose Acetate Membranes in Aqueous Salt Solutions, K. Asaka, *Membrane*, **14**, 54, (1989).

Dielectric Studies on Phase Transition of $\text{Ca}_2\text{Sr}(\text{CH}_3\text{CH}_2\text{COO})_6$ Crystals Doped with $\text{HCF}_2\text{CF}_2\text{COO}/\text{HCF}_2\text{COO}$ Ion, S. Yano, M. Sahara and K. Iwauchi, *J. Phys. Soc. Jpn.*, **58**, 577, (1989).

Absolute Oscillator Strengths for Photoabsorption and the Molecular and Dissociative Photoionization of Acetylene, G. Cooper, T. Ibuki, and C.E. Brion, *Chem. Phys.*, **125**, 307, (1988).

Photochemistry of CCl_3F and CCl_2F_2 in the 106–200 nm Region, T. Ibuki, A. Hiraya, and K. Shobatake, *J. Chem. Phys.*, **90**, 6290, (1989).

Absolute Dipole Oscillator Strengths for Photoabsorption and the Molecular and Dissociative Photoionization of Ethylene, T. Ibuki, G. Cooper, and C.E. Brion, *Chem. Phys.*, **129**, 295, (1989).

Photoabsorption Spectrum and CCl_2 ($\dot{\text{A}}^1\text{B}_1$) Radical Formation in the VUV Excitation of C_2Cl_6 , T. Ibuki, A. Hiraya, and K. Shobatake, *Chem. Phys. Lett.*, **157**, 521, (1989).

Absorption and Fluorescence Cross Sections of Hexachloroethane, T. Ibuki, A. Hiraya, and K. Shobatake, *UVSOR*, **16**, 25, (1989).

VUV Photoabsorption and Fluorescence Excitation Spectra of Group IIb Organometallics, T. Ibuki, A. Hiraya, and K. Shobatake, *UVSOR*, **16**, 28, (1989).

Rydberg Excitation of $\text{M}(\text{CH}_3)_3$ in the 106–270 nm Region, T. Ibuki, A. Hiraya, K. Shobatake, Y. Matsumi, and M. Kawasaki, *UVSOR*, **16**, 30, (1989).

Analytical and Inorganic Chemistry

The Transfer of Carboxylate and Sulphonate Anions at the Aqueous/Organic Solution Interface Studied by Polarography with the Electrolyte Solution Dropping

Electrode, S. Kihara, M. Suzuki, M. Sugiyama and M. Matsui, *J. Electroanal. Chem.*, **249**, 109, (1988).

Electrodeposition of Polonium and Interaction between the Deposited Polonium and Based-Electrode Materials, S. Kihara, Z. Yoshida and M. Matsui, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 49, (1988).

Bistability and Oscillations in the Bromate-Bromide-Cerium (III) System in Continuous-Flow Stirred Tank Reactor. A Simulation Using a New Set of Rate Constants of the FKN Scheme, Y. Sasaki, *Bull. Chem. Soc. Jpn.*, **61**, 4071, (1988).

Are the oceanographic distributions of germanium species governed by the biochemical processes?, Y. Sohrin and K. Isshiki, *Kaiyo*, **21**, 127, (1989), in Japanese.

Determination of Uranium in Phosphate Minerals by Inductively Coupled Plasma Atomic Emission Spectrometry, O. Fujino, H. Shoda, K. Hiraki, Y. Nakaguchi and M. Matsui, *Research Institute for Science and Technology, Kinki Univ.* **1**, 21, (1989), in Japanese.

Determination of Thorium in Phosphate Minerals by Solvent Extraction-ICP Atomic Emission Spectrometry, O. Fujino, M. Matsui, S. Umetani and K. Hiraki, *J. the Chem. Soc. Jpn.* **1**, 39, (1989), in Japanese.

Simultaneous Determination of Tungsten and Molybdenum in Sea Water by Catalytic Current Polarography after Preconcentration on a Resin Column, Y. Sohrin, K. Isshiki, E. Nakayama, S. Kihara and M. Matsui, *Anal. Chim. Acta*, **218**, 25, (1989).

Coprecipitation of Manganese with Calcite and Aragonite between 15°C to 50°C, T. Kumagai and M. Matsui, *Radioisotopes*, **38**, 1, (1989).

Synergic Liquid/Liquid Extraction of Lithium and Sodium with 4-Acyl-5-Pyrazolones with Bulky Substituents and Tri-n-Octylphosphine Oxide, H. Mukai, S. Miyazaki, S. Umetani, S. Kihara and M. Matsui, *Anal. Chim. Acta*, **220**, 111, (1989).

Synergic Extraction of Metals with α -Acyl-d-Camphor and Optically Active Lewis Bases, H. Mukai, S. Miyazaki, S. Umetani, S. Kihara and M. Matsui, *Anal. Chim. Acta*, **221**, 179, (1989).

State Analysis of Ions in Solutions, Z. Yoshida, H. Aoyagi and S. Kihara, Proceedings of International Symposium on Advanced Nuclear Energy Research —Near-Future Chemistry in Nuclear Energy Field—, 398, (1989).

Voltammetry for the Charge Transfer at two Immiscible Electrolyte Solutions Interface —A New Branch of Electroanalytical Chemistry—, S. Kihara, M. Suzuki, K. Maeda, K. Ogura, M. Matsui and Z. Yoshida, Proceedings of International Symposium of Advanced Nuclear Energy Research —Near-Future Chemistry in Nuclear Energy Field—, 428, (1989).

Microstructural Changes in Sol-Gel Derived Silica Gel Monolith with Heating as Revealed by the Crack Formation on Immersion in Water, T. Adachi and S. Sakka, *J. Ceram. Soc. Japan*, **97**[3], 203-07, (1989).

Stability of Solutions, Gels and Glasses in the Sol-Gel Glass Synthesis, S. Sakka, H. Kozuka and T. Adachi, *J. Non-Crystal. Solids*, **102**, 263-268, (1988).

Preparation of Silica Glass Fibers from Tetraethylorthosilicate and Hexamethyldisiloxane, H. Unuma, Y. Suzuki and S. Sakka, *J. Ceram. Soc. Japan*, **97**[3], 208-212, (1988).

Crystallization of Li-Si-O-N Oxynitride Glasses, H. Unuma, T. Kokubo and S. Sakka, *J. Mater. Sci.*, **23**, 4399-4405 (1988).

X-ray Diffraction Study of Glasses in the $\text{ZrF}_4\text{-AlF}_3\text{-BaF}_2\text{-LiF}$ System, S. Sakka and X. Zhao, *Materials Science Forum*, **32-33**, 409-414, (1988).

Surface Modification of Fluorozirconate Glasses, X. Zhao and S. Sakka, *Materials Science Forum*, **32-33**, 267-272, (1988).

Properties of Glasses in the $\text{ZrF}_4\text{-AlF}_3\text{-BaF}_2\text{-RF}$ ($\text{R}=\text{Li, Na or K}$) System, X. Zhao and S. Sakka, *J. Mater. Sci.*, **23**, 3455-3458, (1988).

X-ray Diffraction Study on the Structure of $\text{Cs}_2\text{O-Nb}_2\text{O}_5\text{-Ga}_2\text{O}_3$ Glass, K. Fukumi and S. Sakka, *J. Mater. Sci. Lett.*, **7**, 239-240, (1988).

Raman Spectroscopic Study on the $\text{RO-Nb}_2\text{O}_5\text{-Ga}_2\text{O}_3$ Glasses Containing >50 mol% RO ($\text{R}=\text{Ca, Sr and Ba}$), K. Fukumi and S. Sakka, *J. Mater. Sci. Lett.*, **7**, 631-632, (1988).

Coordination State of Nb^{5+} ions in Silicate and Gallate Glasses as Studied by Raman Spectroscopy, K. Fukumi and S. Sakka, *J. Mater. Sci.*, **23**, 2819-2823, (1988).

Study of the Structure of $\text{K}_2\text{O-2TiO}_2$ Glass by X-ray Radial Distribution Analysis, S. Sakka, F. Miyaji and K. Fukumi, *J. Non-Crystal. Solids*, **107**, 171-177, (1989).

Structure of $\text{R}_2\text{O-Ga}_2\text{O}_3\text{-TiO}_2$ ($\text{R}=\text{Na, K, Cs}$) Glasses Studied by Raman Spectroscopy, F. Miyaji and S. Sakka, *J. Ceram. Soc. Japan*, **97**[3], 267-273, (1989), in Japanese.

Properties and Sintering of Gels Derived from Metal Alkoxide, S. Sakka and H. Kozuka, *Sintering '87*, ed. by S. Somiya, M. Shimada, M. Yoshimura and R. Watanabe, Elsevier Applied Science, New York, 145-150, (1987).

Fabrication of $\text{Yb}_{0.2}\text{Cu}_{0.8}\text{O}_{7-8}$ Superconducting Fibers by the Sol-Gel Method, T. Umeda, H. Kozuka and S. Sakka, *Adv. Ceram. Mater.*, **3**[5], 520-522, (1988).

Crystallization of $\text{BaO-YO}_{1.5}\text{-SiO}_2$ Glasses, H. Kozuka, Y. Li and S. Sakka, *Zairyo*, **37**[42], 86-92, (1988), in Japanese.

Preparation of $\text{YBa}_2\text{Cu}_3\text{O}_{7-8}$ Superconductor by Sol-Gel Method and Fiber Drawing, H. Kozuka, T. Umeda, J.S. Jin and S. Sakka, *Mat. Res. Soc. Symp. Proc.*, **121**, 639-642, (1988).

Effect of Solution Composition, Aging and Exposure to Water Vapor on the Structure and Properties of Highly Porous Silica Gels, H. Kozuka, J. Yamaguchi and S. Sakka, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**[2], 68-79, (1988).

Silicate Species with Cagelike Structure in Solutions and Rapid Solidification with Organic Quaternary Ammonium Ions, I. Hasegawa and S. Sakka, *ACS Symposium Series*, **398**, 140-151, (1989).

Transesterification Research of Tetraethoxysilane and Butyl Alcohols, I. Hasegawa and S. Sakka, *Bull. Chem. Soc. Japan*, **61**, 4087-4092, (1988).

Sinterability of Sol-Gel Derived Monolithic Oxide Precursor Gels, K. Kamiya, S. Mabe and T. Yoko, *Sintering '87*, ed. by S. Somiya, M. Shimada, M. Yoshimura and R. Watanabe, Elsevier Applied Science, New York, 134-138, (1988).

ZrO_2 Fibers Prepared by Sol-Gel Method —Preparation Process of Gel Fibers and Their Microstructure Change on Heating—, K. Kamiya, T. Yoko, K. Tanaka, H. Itoh and M. Iwai, *Rep. Asahi Glass Found. Inf. Technol.*, **52**, 255-265, (1988), in Japanese.

Conversion Process of Gel Fibers Prepared from $\text{Zr}(\text{O}\cdot\text{nC}_3\text{H}_7)_4$ by Sol-Gel Method to ZrO_2 Fibers, T. Yoko, K. Kamiya, K. Tanaka and H. Itoh, *Sintering '87*, ed. by S. Somiya, M. Shimada, M. Yoshimura and R. Watanabe, Elsevier Applied Science, New York, 96-101, (1988).

Structure and Ionic Conductivity of $\text{KCl-Li}_2\text{O}_2\text{-TeO}_2$ Glasses, K. Tanaka, T. Yoko, H. Yamada and K. Kamiya, *J. Non-Crystal. Solids*, **103**, 250-256, (1988).

Preparation of Fe_3O_4 thin Film by the Sol-Gel Method and its Magnetic Properties, K. Tanaka, T. Yoko, M. Atarashi and K. Kamiya, *J. Mater. Sci. Lett.*, **8**, 83-85, (1989).

Growth of Fibrous Hydroxyapatite in the Gel System, K. Kamiya, T. Yoko, K. Tanaka and Y. Yujiyama, *J. Mater. Sci.*, **24**, 927-932, (1989).

Preparation of Porous $\text{ZrO}_2\text{-SiO}_2$ Glasses by the Sol-Gel Method, K. Kamiya, S. Mabe, T. Yoko and K. Tanaka, *J. Ceram. Soc. Japan*, **97**[3], 229-234, (1989).

Glass-Forming Region and Structure of Oxyhalide Tellurite Glasses Containing LiX ($\text{X}=\text{F}$ and Br) and Li_2O , T. Yoko, K. Kamiya, K. Tanaka, H. Yamada and S. Sakka, *J. Ceram. Soc. Japan*, **97**[3], 289-294, (1989).

Surface Modification of a TiO_2 Film Electrode Prepared by the Sol-Gel Method and its Effect on Photoelectrochemical Behavior, T. Yoko, K. Kamiya, A. Yuasa, K. Tanaka and S. Sakka, *J. Non-Crystal. Solids*, **100**, 483-489, (1988).

Science of Sol-Gel Method —Low Temperature Synthesis of Functional Glasses and Ceramics—, S. Sakka, Agne-Shofu-Sha, July, (1988), in Japanese.

SiO₂ Coating Films Via Sol-Gel Method, S. Sakka, *Koubunshi*, **37**, 472 (1988), in Japanese.

Material Synthesis and Coathing Films through Sol-Gel Method, S. Sakka, *Tosokogaku*, **24**[4], 165–173, (1989), in Japanese.

Sol-Gel Synthesis Using Metal Alkoxides, S. Sakka, *Kagaku*, **44**[2], 130–131, (1989), in Japanese.

Oxynitride Glasses, S. Sakka, *Kinozairyou*, **1**, 42–50, (1989), in Japanese.

Functional New Glasses, S. Sakka, *Erekutoroniku Seramikusu*, **1**, 9–14, (1989), in Japanese.

Development of Functional Glasses and Periodic Table —Oxide and Halide Glasses—, S. Sakka, *Kinzoku*, **9**, 46–51, (1988), in Japanese.

Synthesis of Functional Ceramics by the Sol-Gel Method, S. Sakka, Proceedings of the Thirtysecond Japan Congress on Materials Research, 1–5, (1989).

Promising Solar Energy Conversion by a Semiconductor Electrode, T. Yoko, *Bull. Japan Inst. Metals*, **28**[3], 171–175, (1989), in Japanese.

Preparation of Functional Materials by the Sol-Gel Method, T. Yoko, K. Kamiya and S. Sakka, *Bull. Japan Inst. Metals*, **27**[10], 775–783, (1988), in Japanese.

Photoelectrochemical Properties of Thin Film Semiconductor prepared by the Sol-Gel Method, T. Yoko, K. Kamiya and S. Sakka, *Bull. Japan Inst. Metals*, **28**[3], 176–183, (1989), in Japanese.

Application of Sol-Gel Processing to Preparation of High Temperature Superconducting Materials, H. Kozuka, T. Umeda, J. Jin, T. Monde and S. Sakka, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**[2], 80–92, (1988).

Preparation of Y-Ba-Cu-O Superconductor by Sol-Gel Method, H. Kozuka and S. Sakka, *Bull. Japan Inst. Metals*, **27**[10], 784–788, (1988), in Japanese.

Preparation of ZrO₂ Fibers by Sol-Gel Method, T. Yoko and K. Kamiya, *Fine Ceramics*, **9**, 163–175, (1988), in Japanese.

Improvement of Workability of Alkali-Resistant BaO-SiO₂-TiO₂ Glass, H. Takagi, S. Shingaki, and T. Kokubo, *J. Ceram. Soc. Jpn.*, **96**, 789, (1988), in Japanese.

Mechanical Properties of Alkali-Resistant BaO-SiO₂-TiO₂ Glass Fiber, H. Takagi, and T. Kokubo, *J. Ceram. Soc. Jpn.*, **96**, 1012, (1988), in Japanese.

Preparation of Glass-Ceramic Containing Crystalline Apatite and Magnesium Titanate for Dental Crowns, T. Kokubo, S. Sakka, M. Sako, and S. Ikejiri, *J. Ceram. Soc. Jpn.*, **97**, 239, (1989), in Japanese.

Apatite-wollastonite containing glass ceramic-fibrin mixture as a bone defect filler, K. Ono, T. Yamamuro, T. Nakamura, Y. Kakutani, T. Kitsugi, K. Hyakuna, T. Kokubo, M. Oka, and Y. Kotoura, *J. Biomed. Mater. Res.*, **22**, 869, (1988).

Bonding Behavior of a Glass-Ceramic Containing Apatite and Wollastonite in Segmental Replacement of the Rabbit Tibia under Load-Bearing Conditions, T. Kitsugi, T. Yamamuro, and T. Kokubo, *J. Bone and Joint Surg.*, **71-A**, 264, (1989).

Apatite Formation on Bioactive Ceramics in Body Environment, T. Kokubo, H. Kushitani, Y. Ebisawa, T. Kitsugi, S. Kotani, K. Oura, and T. Yamamuro, *Bioceramics*, **1**, 157, (1989).

Effects of Varying Amount of Al_2O_3 on the Bond between A-W-Glass Ceramics and Bone, T. Kitsugi, T. Yamamuro, T. Nakamura, S. Kotani, and T. Kokubo, *Bioceramics*, **1**, 169, (1989).

Bone bonding behavior of $\text{MgO-CaO-SiO}_2\text{-P}_2\text{O}_5\text{-CaF}_2$ glass (mother glass of A W-glass-ceramics), T. Kitsugi, T. Yamamuro, T. Nakamura, and T. Kokubo, *J. Biomed. Mater. Res.*, **23**, 631, (1989).

Bioactivity of Glass-Ceramics, T. Kokubo, H. Kushitani, C. Ohtsuki, Y. Ebisawa, T. Kitsugi, K. Oura, S. Kotani, and T. Yamamuro, *Proceedings of XV International Congress on Glass*, **3a**, 114, (1989).

Biomedical Applications of Ceramics, T. Kokubo, *Fine Cera*, **17**, 21, (1989), in Japanese.

Formation of Fine-Grained Crystalline Particles in Amorphous Phase, T. Kokubo, *J. Soc. Powder Tech.*, **26**, 189, (1989), in Japanese.

Artificial Bone, T. Kokubo, *Chemistry*, **43**, 436, (1989), in Japanese.

Glass Biomaterials, T. Kokubo, *NEW GLASS*, **4**, 27, (1989), in Japanese.

Z_2 Vortex-Induced Broadening of the EPR Linewidth in the Two-Dimensional Triangular Lattice Antiferromagnets, HCrO_2 and LiCrO_2 , Y. Ajiro, H. Kikuchi, S. Sugiyama, T. Nakashima, S. Shamoto, N. Nakayama, M. Kiyama, N. Yamamoto and Y. Oka, *J. Phys. Soc. Jpn.*, **57**, 2268, (1989).

Modified London Penetration Depth in Oxide Superconductors, J. Takada, H. Mazaki, and Y. Bando, *Bull. Inst. Chem. Res., Kyoto Univ.*, **36**, 45, (1988).

Structure of PbSe-SnSe Artificial Superlattices, Z. Hiroi, N. Nakayama, and Y. Bando, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 56, (1988).

New Hexavalent Iron Compound, $K_2Sr(FeO_4)_2$, S. Ogasawara, M. Takano, and Y. Bando, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 64, (1988).

London Penetration Depth of Superconductors Having Lifetime Broadened Density of States, J. Takada, Y. Bando, and M. Mazaki, *Appl. Phys. Lett.*, **53**, 332, (1988).

Epitaxial Growth of $YBa_2Cu_3O_{7-x}$ Thin Films on (110) $SrTiO_3$ Single Crystals by Activated Reactive Evaporation, T. Terashima, Y. Bando, K. Iijima, K. Yamamoto, and K. Hirata, *Appl. Phys. Lett.*, **53**, 2232, (1988).

Tunnel Junctions Using Oxides Superconducting Thin Films Epitaxially Grown on $SrTiO_3$, J. Takada, T. Terashima, Y. Bando, H. Mazaki, K. Iijima, K. Yamamoto, and K. Hirata, *Appl. Phys. Lett.*, **53**, 2689, (1988).

Low Temperature Growth of High T_c Oxide Superconductors, Y. Bando, T. Terashima, K. Iijima, K. Yamamoto, J. Takada, K. Hirata, and H. Mazaki, Extended Abstracts of the 20th (1988 International) Conference on Solid State Devices and Materials, Aug. 24-26, Tokyo, 419, (1988).

Tunnel Junctions Using Single Crystal Films of $YBa_2Cu_3O_{7-x}$ Superconductor, J. Takada, H. Mazaki, T. Terashima, K. Iijima, K. Yamamoto, K. Hirata, and Y. Bando, Extended Abstracts of the 20th (1988 International) Conference on Solid State Devices and Materials, Aug. 24-26, Tokyo, 455, (1988).

Complex Susceptibility of Bi, Pb-Sr-Ca-Cu-O Superconductors, H. Mazaki, M. Takano, J. Takada, K. Oda, H. Kitaguchi, Y. Miura, Y. Ikeda, Y. Tomii, T. Kubozoe, *Jpn. J. Appl. Phys.*, **27**, L1639, (1988).

X-ray Diffractions Study on $YBa_2Cu_3O_{7-8}$ Epitaxial Thin Film Grown by an Activated Reactive Evaporation Method, K. Kamigaki, H. Terauchi, T. Terashima, K. Iijima, K. Yamamoto, K. Hirata, and Y. Bando, *Jpn. J. Appl. Phys.*, **27**, L1899, (1988).

The High- T_c Phase with a New Modulation Mode in the Bi,Pb-Sr-Ca-Cu-O System, Y. Ikeda, M. Takano, Z. Hiroi, K. Oda, H. Kitaguchi, J. Takada, Y. Miura, Y. Takeda, O. Yamamoto, H. Mazaki, *Jpn. J. Appl. Phys.*, **27**, L2067, (1988).

An Electrochemical Evidence for the Participation of Iron(IV) Porphyrin Species in the C-C Bond Cleavage of 1,2-Diaryl-1,2-Ethanediol, T. Okamoto, K. Sasaki, M. Takano, and S. Oka, *Chem. Lett.*, 415, (1988).

High T_c Superconducting Oxide Thin Films by Reactive Evaporation, Y. Bando, *J. Mag. Soc. Jap.*, **12**, 581, (1988), in Japanese.

Preparation of YBCO Single-Crystal Thin Films by Activated Reactive Evaporation, Y. Bando, *J. Jpn. Soc. Powder & Powder Met.*, **35**, 305, (1988), in Japanese.

Phase Equilibrium in the $\text{YO}_{1.5}\text{-BaO-SrO-CuO}$ System, Y. Ikeda, Y. Oue, K. Inaba, M. Takano, Y. Bando, Y. Tadeka, R. Kanno, H. Kigaguchi, and J. Takada, *J. Jpn. Soc. Powder & Powder Met.*, **35**, 329, (1988), in Japanese.

Single Crystal Thin Film Tunnel Junctions $\text{Pt/AlO}_y/\text{YBa}_2\text{Cu}_3\text{O}_{7-x}\text{SrTiO}_3$, J. Takada, K. Yamamoto, K. Iijima, H. Mazaki, T. Terashima, and Y. Bando, *J. Jpn. Soc. Powder & Powder Met.*, **35**, 397, (1988), in Japanese.

Preparation of Bi-Pb-Sr-Ca-Cu-O High- T_c Superconductor from Coprecipitated Oxalate, K. Oda, H. Kitaguchi, J. Takada, A. Osaka, Y. Miura, Y. Ikeda, M. Takano, Y. Bando, N. Yamamoto, Y. Oka, Y. Tomii, T. Unesaki, Y. Takeda, and H. Mazaki, *Jpn. J. Soc. Powder & Powder Met.*, **35**, 424, (1988), in Japanese.

Microscopic Coexistence of the Orthorhombic and Tetragonal Phases in $\text{YBa}_2\text{Cu}_3\text{O}_y$ Observed by Electron Microscopy, Z. Hiroi, M. Takano, Y. Bando, and Y. Takeda, *Jpn. J. Soc. Powder & Powder Met.*, **35**, 915, (1988), in Japanese.

A Study on Oxide Superconductor Bi-Pb-Sr-Ca-Cu-O System Synthesized under High Oxygen Pressure, Y. Takeda, R. Kanno, F. Tanigawa, O. Yamamoto, M. Takano, Y. Ikeda, Y. Bando, J. Takada, K. Oda, and H. Kitaguchi, *Jpn. J. Soc. Powder & Powder Met.*, **35**, 923, (1988), in Japanese.

Study on Suspension Effect of High- T_c Oxide Superconductor, H. Kitaguchi, J. Takada, K. Oda, A. Osaka, Y. Miura, Y. Tomii, and M. Takano, *J. Jpn. Soc. Powder & Powder Met.*, **35**, 945, (1988), in Japanese.

Equilibrium Phase Diagrams for the Systems $\text{Bi}_2\text{O}_3\text{-PbO-CaO}$ and $\text{Bi}_2\text{O}_3\text{-PbO-SrO}$ at 873K and 1073K in Air, J. Takada, M. Ohno, H. Kitaguchi, K. Oda, A. Osaka, Y. Miura, Y. Ikeda, M. Takano, and Y. Bando, *J. Jpn. Soc. Powder & Powder Met.*, **35**, 952, (1988), in Japanese.

The Preparation and Characterization of Pb-Bi-Sr-Ca-Cu-O High- T_c Phase, Y. Ikeda, H. Ito, Z. Hiroi, M. Takano, H. Kitaguchi, J. Takada, K. Oda, Y. Miura, Y. Takeda and H. Mazaki, *J. Jpn. Soc. Powder & Powder Met.*, **35**, 965, (1988), in Japanese.

Effect of Ba Addition on the Formation of the High- T_c Phase in the Bi,Pb-Sr-Ca-Cu-O System, J. Takada, H. Kitaguchi, K. Oda, A. Osaka, Y. Miura, Y. Ikeda, M. Takano, Y. Oka, N. Yamamoto, Y. Tomii, and Y. Takeda, *J. Jpn. Soc. Powder Powder Met.*, **35**, 1003, (1988), in Japanese.

Energy Gap Measurement Made on Cryogenically Cleaved Y-Ba-Cu-O and Bi-Sr-Ca-Cu-O Surfaces, J.S. Tsai, I. Takeuni, J. Fujita, T. Yoshitake, S. Miura, S. Tanaka, T. Terashima, Y. Bando, K. Iijima, and K. Yamamoto, Springer Sries in Mater. Sci., Mecha. High Temp. Superconduct. (eds H. Kamimura, A. Oshiyam), springer-Verlag, 11, 229, (1988).

Thin Film Synthesis by Reactive Evaporation, Y. Bando, *Oyo Buturi*, **57**, 1223, (1988), in Japanese.

Properties of Single Crystalline $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ Films, Y. Bando, *Parity*, **3**, 38, (1988), in Japanese.

Research on Single Crystal Thin Films, Y. Bando, *ISTEC J.*, **1**, 16, (1988).

Low Temperature Growth and Properties of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Single-Crystal Films, Y. Bando, *Sci. Superconduct. & New Mater.* (ed. S. Nakajima) Progress High Temp. Superconduct., World Scientific, **18**, 31, (1988).

Deposition of Metal Oxide Films by Reactive Evaporation, Y. Bando, and T. Takada, *Fine Ceramics* (ed. S. Saito), Elsevier, Ohmsha (Tokyo), **71**, (1988).

Grain Boundary Structure of Mn-Zn Ferrite, Y. Bando, and T. Akashi, *Fine Ceramics*, (ed. S. Satio) Elsevier, Ohmsha (Tokyo), **122**, (1988).

Angle-Resolved Photoemission from Epitaxial $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ (001) Films, Y. Sakisaka, T. Komeda, T. Maruyama, M. Onchi, H. Kato, Y. Aiura, H. Yanashima, T. Terashima, Y. Bando, K. Iijima, K. Yamamoto, and K. Hirata, *Phys. Rev. B*, **39**, 2304, (1989).

Angle-Resolved Photoemission Investigation of the Electronic Band Properties of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ (001), Y. Sakisaka, T. Komeda, T. Maruyama, M. Onchi, H. Kato, Y. Aiura, H. Yanashima, T. Terashima, Y. Bando, K. Iijima, K. Yamamoto, and K. Hirata, *Phys. Rev. B*, **39**, 9080, (1989).

Microstructure and Electronic Properties of $\text{RBa}_2\text{Cu}_3(1-x)\text{M}_{3x}\text{O}_y$ (R: Y, Gd; M: Fe, Co, Ni, Zn), M. Takano, Z. Hiroi, H. Mazaki, Y. Bando, Y. Takeda, R. Kanno, O. Yamamoto, Y. Shimakawa, and M. Shimada, *Proc. MRS Int. Meet. Adv. Mat.*, Tokyo, May 30-June 3, 1988 (MRS, Pittsburg, 1989), **6**, 433, (1989).

Properties of Single-Crystal $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Thin Films prepared by Activated Reactive Evaporation, Y. Bando, T. Terashima, K. Iijima, K. Yamamoto, K. Hirata, and H. Mazaki, *Proc. MRS Int. Meet. Adv. Mat.*, Tokyo, May 30-June 3, 1988 (MRS, Pittsburg, 1989), **6**, 731, (1989).

Phase Relation and Substitution Effects in the Bi-Sr-Ca-Cu-O System, M. Takano, Y. Ikeda, J. Takada, K. Oda, H. Kitaguchi, Y. Miura, Y. Tomii, and H. Mazaki, *Proc. MRS Int. Meet. Adv. Mat.*, Tokyo, May 30-June 3, 1988 (MRS, Pittsburg, 1989), **6**, 981, (1989).

Formation and Structure of Artificial Superlattices of Oxides and Selenides by Evaporation Techniques, Y. Bando, M. Takano, T. Terashima, and Z. Hiroi, *Proc. MRS Int. Meet. Adv. Mat.*, Tokyo, May 30-June 3, 1988 (MRS, Pittsburg, 1989), **10**, 83, (1989).

Behavior of Iron-Nickel Catalysts during the Hydrogenation of CO, T. Shigematsu, M. Ohtsuki, K. Watanabe, Y. Bando, and N. Nakanishi, *J. Jpn. Soc. Powder & Powder Met.*, **36**, 56, (1989), in Japanese.

Oxygen Ordering Model Describing the Two-Phase Microstructures in $\text{YBa}_2\text{Cu}_3\text{O}_{6+\text{c}}$, Z. Hiroi, M. Takano, and Y. Bando, *Solid State Commun.*, **69**, 223, (1989).

Formation and Structures of NiO-ZnO Artificial Superlattices, K. Iijima, T. Terashima, K. Yamamoto, and Y. Bando, *J. Crystal Growth*, **95**, 505, (1989).

Formation and Properties of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Single-Crystal Thin Films by Activated Reactive Evaporation, T. Terashima, K. Iijima, K. Yamamoto, J. Takada, K. Hirata, H. Mazaki, and Y. Bando, *J. Crystal Growth*, **95**, 617, (1989).

Cluster Model Investigation of the Electronic State and Chemical Bond in Cuprous and Cupric Oxide, H. Adachi, and M. Takano, *Physica C*, **157**, 169, (1989).

Magnetic Suspension of a Bi, Pb-Sr-Ca-Cu-O Superconductor due to the Meissner Effect, H. Kitaguchi, J. Takada, K. Oda, A. Msaka, Y. Miura, Y. Tomii, H. Mazaki, and M. Takano, *Physica C*, **157**, 267, (1989).

Structure and Properties of $\text{YBaSrCu}_3\text{O}_y$ ($y=6.2-7.3$), Y. Takeda, R. Kanno, O. Yamamoto, M. Takano, Z. Hiroi, Y. Bando, M. Shimada, H. Akinaga, and K. Takita, *Physica C*, **157**, 358, (1989).

Two-Phase Microstructures in $\text{YBa}_2\text{Cu}_3\text{O}_y$ Observed by Transmission Electron Microscopy, Z. Hiroi, M. Takano, Y. Bando, Y. Takeda, and R. Kanno, *Physica C*, **158**, 269, (1989).

Phases and Their Relations in the Bi-Sr-Cu-O System, Y. Ideda, H. Ito, S. Shimomura, Y. Oue, K. Inaba, Z. Hiroi, and M. Takano, *Physica C*, **159**, 93, (1989).

In Situ Reflection High Energy Electron Diffraction Observation During Growth of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Thin Films by Activated Reactive Evaporation, T. Terashima, K. Iijima, K. Yamamoto, K. Hirata, Y. Bando, and T. Takada, *Jpn. J. Appl. Phys.*, **28**, L987, (1989).

Chemical and Structural Aspects of The Bi, Pb-Sr-Ca-Cu-O System, M. Takano, Japan-China Oxide High T_c Superconduct. Symp., Apr. 9-12, 1989, Tsukuba, Japan, 76, (1989).

Hole Concentration Dependence of T_c and T_N in $\text{Nd}_{1+x}\text{Ba}_{2-x}\text{Cu}_3\text{O}_{7+\delta}$ ($\delta \gtrsim 0$), M. Takita, H. Akinaga, K. Masuda, H. Asano, Y. Takeda, M. Takano, K. Ni-shiyama, and K. Naganime, Proc. Tsukuba Seminar on High T_c Superconduct., May 31-June 2, 1989, Tsukuba, Japan, 11, (1989).

Low-Frequency Raman Spectra in the Single Crystal $\text{YBa}_2\text{Cu}_3\text{O}_{7-\delta}$ and the Thin Film $\text{GdBa}_2\text{Cu}_3\text{O}_{7-\delta}$, T. Sekine, M. Jouanne, M. Balkanski, R. Suryanarayanan, O. Gorochoy, Y. Ochiai, F. Nakamura, T. Terashima, K. Iijima, K. Yamamoto, K. Hirata, Y. Bando, and Y. Narahara, Proc. Tsukuba Seminar on High T/ Superconduct., May 31-June 2, 1989, 121, (1989).

Crystal Growth and Some Properties of $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ Single-Crystal Thin Film, Y. Bando, Proc. Tsukuba Seminar on High T_c Superconduct., May 31-June 2, 1989, Tsukuba, Japan, 133, (1989).

Epitaxial Growth of Metal Oxides by Reactive Evaporation - Artificial Superlattice and Superconducting Oxide- Y. Bando, *Surface*, **27**, 103, (1989), in Japanese.

Preparation of Superconducting $Mxide$ Single-Crystal Thin Film by Reactive Evaporation and its Characterization, Y. Bando, *J. Soc. Non-Tradition. Technol.*, **230**, 9, (1989), in Japanese.

Demand for Single-Crystal Thin Films of High- T_c Superconductors and Their Problems, Y. Bando, *J. Surface Soc. Japan*, **10**, 224, (1989), in Japanese.

Superlattice Construction and its Control, M. Takano, Year Book of High Technol. & Sci. '89, Gijutsu Syuppan, 289, (1989), in Japanese.

^{57}Fe Mössbauer Study of High- T_c Superconductor Y-Ba-Cu Oxides, S. Nasu, H. Kitagawa, T. Kohara, Y. Oda, T. Shinjo, K. Asayama and F.E. Fujita, Proceedings of JIMIS-5: Non-Equilibrium Solid Phases of Metals and Alloys Supplement to Trans. JIM, **29**, 543, (1988).

Magnetic Properties of Metals-Thin Film Sandwiches, Y. Endoh, T. Shinjo and N. Hosoiito, Landolt-Bornstein New Series Group III, **19**, 228, 1988.

Possibility of Structural Fabrication on an Atomic Scale, T. Shinjo, *Zairyo-Kagaku*, **25**, 1, (1988), in Japanese.

Magnetic Properties of Fe/Dy Artificial Superstructured Films, K. Yoden, N. Hosoiito, K. Kawaguchi, K. Mibu and T. Shinjo, *Jpn. J. Appl. Phys.*, **27**, 1680, (1988).

Magnetic Properties of $\text{BiFeO}_3\text{-BaTiO}_3$ and $\text{BiFeO}_3\text{-PbTi (Zr)O}_3$ glassy sputtered films, T. Fujii, S. Jinzenji, Y. Asahara, A. Kajima and T. Shinjo, *J. Appl. Phys.*, **64**, 5434, (1988).

Ferromagnetic Resonance of Mn/Sb Multilayered Films with Artificial Superstructure, H. Yamazaki, Y. Ajiro, I. Moritani, N. Nakayama and T. Shinjo, *J. Phys. Soc. Japan*, **57**, 4343, (1988).

Iron Spin Reorientation in Multilayered Fe/Rare Earth Metal Films, N. Hosoiito, K. Yoden, K. Mibu and T. Shinjo, *J. Phys.*, **49**, C8-1777, (1988).

Magnetization and Magnetoresistance Measurements on Monoatomic Scale in MnSb/Sb Sandwiches and Multilayers, P. Beaurillain, P. Bruno, C. Chappert, C. Dupas, J. P. Renard, F. Trigui, P. Veillet, E. Velu, I. Moritani, N. Nakayama, T. Shinjo and D. Renard, *J. Phys.*, **49**, C8-1801, (1988).

Mössbauer Spectroscopic Study of Fe-Doped Superconducting Cu-Oxides, T. Shinjo, S. Nasu, T. Kohara, T. Takabatake and M. Ishikawa *J. Phys.* **49**, C8-2207, (1988).

Structural and Magnetic Properties of Cr/Sb Multilayered Films, N. Nakayama, H. Dounomae and T. Shinjo, *J. Phys.*, **49**, C8-1775, (1988).

Electron microscopy study of Mn/Sb multilayered films with an artificial superstructure, N. Nakayama, I. Moritani, T. Shinjo, A. Ishzaki and K. Hajimoto, *Philos. Mag. A*, **59**, 547, (1989).

Magnetic and Magentoresistive Properties of Au/Co Superlattices, S. Araki, T. Takahata, T. Shinjo, *Nihon-ouyou-jikigaku-kaishi*, **13**, 339, (1989), in Japanese.

Mössbauer Studies of High- T_c Oxides, T. Shinjo and S. Nasu, Springer Series in Materials Science, **11**, 166, (1989).

Structural Characterization of Metallic Superlattice Films by X-Ray Diffraction, N. Nakayama, T. Shinjo and Y. Fujii, *MRS Int'l. Mtg. on Adv. Mats.*, **10**, 521, (1989).

Synchrotron X-Ray Diffraction Study of Supermodulus Effect in Ni/Mo Superlattices under High pressure, Y. Ohishi, Y. Fujii, N. Nakayama, T. Shinjo T. Matsushita and J. Fujita, *MRS Int'l. Mtg. on. Adv. Mats.*, **10**, 569, (1989).

Neutron Diffraction Studies on Magnetic Properties of Fe/Dy Artificial Superstructured Films, N. Hosoito, K. Yoden, K. Mibu T. Shinjo and Y. Endoh, *J. Phys. Soc. Jpn.*, **58**, 1775, (1989).

Organic Chemistry

Stereochemical Control in Microbial Reduction. 8. Stereo-chemical Control in Microbial Reduction of β -Keto Esters, K. Nakamura, Y. Kawai, S. Oka, and A. Ohno, *Bull. Chem. Soc. Jpn.*, **62**, 875, (1989).

Stereochemical Control in Microbial Reduction. 9. Diastereoselective Reduction of 2-Alkyl-3-oxobutanoate with Bakers' Yeast, K. Nakamura, T. Miyai, A. Nagar, S. Oka, and A. Ohno, *Bull. Chem. Soc. Jpn.*, **62**, 1178, (1989).

A New Method for Stereochemical Control of Microbial Reduction. Reduction of β Keto Esters with Bakers' Yeast Immobilized by Magnesium Alginate, K. Nakamura, Y. Kawai, S. Oka, and A. Ohno, *Tetrahedron Lett.*, **30**, 2245, (1989).

New Synthetic Reactions using Tellurium, S. Uemura, *Kagaku Zokan (Kagaku Dojin Co. Ltd.)*, **115**, 89–101, (1988), in Japanese.

A New Route to Seleno and Telluro Esters by $\text{Co}_2(\text{CO})_8$ -mediated and -catalyzed Carbonylation of Diaryl Diselenides and Ditellurides with Carbon Monoxide, S. Uemura, H. Takahashi, K. Ohe, and N. Sugita, *J. Organometal. Chem.*, **361**, 63–72, (1989).

Sodium Arenetelluroate Catalyzed Selective Conversion of Nitroaromatics to Aromatic Azoxy or Azo Compounds and Its Application for Facile Preparation of 3,3'-and 4,4'-Bis- $[\beta$ -(argtelluro)vinyl] azobenzenes from (3- and 4- Nitrophenyl)-acetylenes, K. Ohe, S. Uemura, N. Sugita, H. Masuda, and T. Taga, *J. Org. Chem.*, **54**, 4169–4174, (1989).

New Synthesis of α -Nitroso Esters and Oximes of α -Keto Esters, S.M. Ali, Y. Matsuda, and S. Tanimoto, *Synthesis*, 805, (1988).

Reaction of 2-Hydroxyacetophenones with Thionyl Chloride in the Presence of a Catalytic Amount of Pyridine, S.M. Ali, M. Ilyas, and S. Tanimoto, *Bull. Chem. Soc. Jpn.*, **61**, 3289, (1988).

Improved Synthesis of α -Formylcarboxylic Esters, Y. Matsuda, S.M. Ali, and S. Tanimoto, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 374, (1989).

Conversion of the Double Bonds of Dialkyl Maleates and Their Diels-Alder Adducts into γ -Butyrolactone Rings by Acetic Acid in Combination with Manganese (III) Acetate, S. Tanimoto and A. Ohnishi, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 369, (1989).

Preparation of α -(*N*-Trimethylsilyl)imino Esters and Their Use in the Synthesis of α -Amino Esters and 2-Alkoxy-carbonylimidazol-4(2*H*)-ones, Y. Matsuda, S. Tanimoto, T. Okamoto, and S.M. Ali, *J. Chem. Soc., Perkin Trans. I*, 279, (1989).

A High-Yield Regiospecific Synthesis of Keto Oximes from Aryl-Conjugated Ethylenes and Ethyl Nitrite in the Presence of Cobalt Complex and BH_4^- Ion, T. Okamoto, K. Kobayashi, S. Oka, and S. Tanimoto, *J. Org. Chem.*, **53**, 4897, (1988).

The Stereochemistry of a Substitution Reaction via an Episelenonium Ion: Retention by a 2-Pyridylseleno Group versus Scrambling by a Phenylseleno Group, A. Toshimitsu, M. Ito, and S. Uemura *J. Chem. Soc., Chem. Commun.*, 530, (1989).

Role of Cysteine Residues in Glutathione Synthetase from *Escherichia coli* B. Chemical Modification and Oligonucleotide Site-Directed Mutagenesis, H. Kato, T. Tanaka, T. Nishioka, A. Kimura, and J. Oda, *J. Biol. Chem.*, **263**, 11646, (1988).

Irreversible and Highly Enantioselective Acylation of 2-Halo-1-arylethanol in Organic Solvents Catalyzed by a Lipase from *Pseudomonas fluorescens*, J. Hiratake, M. Inagaki, T. Nishioka, and J. Oda, *J. Org. Chem.*, **53**, 6130, (1988).

Enzymatic Resolution of Racemic Hydroperoxides in Organic Solvent, N. Baba, M. Mimura, J. Hiratake, K. Uchida, and J. Oda, *Agric. Biol. Chem.*, **52**, 2685, (1988).

Asymmetric Synthesis of Optically Active Lactones from Cyclic Acid Anhydrides Using Lipase in Organic Solvents, Y. Yamamoto, K. Yamamoto, T. Nishioka, and J. Oda, *Agric. Biol. Chem.*, **52**, 3087, (1988).

Isolation and Structure of the Novel Dihydroxamate Siderophore Alcaligin, T. Nishio, N. Tanaka, J. Hiratake, Y. Katsube, Y. Ishida, and J. Oda, *J. Am. Chem. Soc.*, **110**, 8733, (1988).

Catalytic Antibody, J. Hiratake, and J. Oda, *Kagaku*, **43**, 525, (1988), in Japanese.

Highly Regioselective Ring-Opening of α -Substituted Cyclic Acid Anhydrides Catalyzed by Lipase, J. Hiratake, K. Yamamoto, Y. Yamanoto, and J. Oda, *Tetrahedron. Lett.*, **30**, 1555, (1989).

Intramolecular Asymmetric Lactonization Using Optically Active 1,2-Diphenylethylenediamine as a Chiral Auxiliary, N. Baba, A. Sakamoto, M. Mimura, Y. Yamamoto, K. Uchida, and J. Oda, *Chem. Lett.*, 889, (1989).

Design of Catalytic Function in Glutathione Synthetase, T. Nishioka, and J. Oda, *Tanpakushitsu Kakusan Koso*, **33**, 1592, (1988), in Japanese.

Nucleotide specificity of DNA cleavage by esperamycin/calicheamicin antitumor antibiotics, Y. Sugiura, Y. Takahashi, Y. Uesawa, and J. Kuwahara, *Nucleic Acids Research*, 63-64, (1988).

Significant Interaction Between Low-Spon Iron(III) Site and Pyrroloquinoline Quinone in Active Center of Nitrile Hydratase, Y. Sugiura, J. Kuwahara, T. Nagasawa, and H. Yamada, *Biochem. Biophys. Res. Commun.*, **154**, 522-528, (1988).

Man-designed bleomycins. Iron complexation and nucleotide sequence cleavage by synthetic models of bleomycin, M. Ohno, M. Otsuka, A. Kittaka, Y. Sugano, Y. Sugiura, T. Suzuki, J. Kuwahara, K. Umezawa, and H. Umezawa, *International Journal of Experimental and Clinical Chemotherapy*, **1**, 12-22, (1988).

Stereospecific Iron Uptake Mediated by Phytosiderophore in Gramineous Plants, F. Oida, N. Ota, Y. Mino, K. Nomoto, and Y. Sugiura, *J. Am. Chem. Soc.*, **111**, 3436-3437 (1989).

DNA Degradation by Bleomycin, Y. Sugiura, *Tanpakushitu Kakusan Kouso*, **33**, 3102-3108, (1988), in Japanese.

Spectroscopic Identification of 3-Substituted 4-Methoxycarbonyl-1,3-thiazolidine(or -oxazolidine)-2-thiones and 2-Substituted Thio-4-methoxycarbonyl- Δ^2 -1,3-thiazolines(or -oxazolines), Y. Nagao, K. Inoue, M. Yamaki, M. Shiro, S. Takagi, and E. Fujita, *Chem. Pharm. Bull.*, **36**, 4293, (1988).

Synthesis and Structural Analysis of a Vinylodonium Salt with an α -Silyl Substituent, and Generation of an Iodonium Ylide from It, M. Ochiai, M. Kunishima, K. Fuji, M. Shiro, and Y. Nagao, *J. Chem. Soc., Chem. Commun.*, 1076, (1988).

Effect of Silica Gel on the Benzenesulfinic Acid Catalyzed Isomerization of Vinylsilanes. Formation of Silyl Benzenesulfinate, M. Ochiai, Y. Takaoka, T. Ukita, Y. Nagao, and E. Fujita, *J. Org. Chem.*, **54**, 2346, (1989).

Conjugate Addition of Acyloxy Groups to Alkynylphenyliodonium Tetrafluoroborates under Both Basic and Acidic Conditions. Synthesis of α -Acyloxy Ketones, M. Ochiai, M. Kunishima, K. Fuji, and Y. Nagao, *J. Org. Chem.*, **54**, 4038, (1989).

Efficient Preparation of New Chiral Synthons Useful for (+)-Carbacyclin Synthesis by Utilizing Enzymatic Hydrolysis of Prochiral σ -Symmetric Diesters, Y. Nagao, M. Kume, R.C. Wakabayashi, T. Nakamura, and M. Ochiai, *Chem. Lett.*, 239, (1989).

Stabilizing 1,3-Diaxial Interaction between a Metal (Group 14) and a Heteroatom. Fixation of Six-membered Carbacycles to the 1,3-Diaxial Conformer, M. Ochiai, S. Iwaki, Y. Takaoka, and Y. Nagao, *Organometallics*, **8**, 1751, 1989.

Oxidative Decarboxylation of Cyclic Amino Acids and Dehydrogenation of Cyclic Secondary Amines with Iodosobenzene, M. Ochiai, M. Inenaga, Y. Nagao, R.M. Moriarty, R.K. Vaid, and M.P. Duncan, *Tetrahedron Lett.*, **29**, 6917, (1988).

Hypervalent Alkenyliodonium Tetrafluoroborates. Evidence for Generation of Alkylidenecarbenes via Base-Induced α -Elimination, M. Ochiai, Y. Takaoka, and Y. Nagao, *J. Am. Chem. Soc.*, **110**, 6565, (1988).

Alkynyliodonium Tetrafluoroborates as a Good Michael Acceptor for an Azido Group. A Stereoselective Synthesis of (Z)-(β -Azidovinyl)iodonium Salts, M. Ochiai, M. Kunishima, K. Fuji, and Y. Nagao, *J. Org. Chem.*, **53**, 6144, (1988).

Hypervalent Iodine Oxidation of Amines Using Iodosobenzene: Synthesis of Nitriles, Ketones and Lactams, R.M. Moriarty, R.K. Vaid, M.P. Duncan, M. Ochiai, M. Inenaga, and Y. Nagao, *Tetrahedron Lett.*, **29**, 6913, (1988).

New Chiral Recognition of Chiral Tin(II) Enolates toward Cyclic Acyl Iminium Species: Asymmetric Total Synthesis of (–)-Supinidine, Y. Nagao, W.-M. Dai, and M. Ochiai, *Tetrahedron Lett.*, **29**, 6133, (1988).

Highly Enantioselective Claisen-Type Acylation and Dieckmann Annulation, Y. Nagao, Y. Hagiwara, T. Tohjo, Y. Hasegawa, M. Ochiai, and M. Shiro, *J. Org. Chem.*, **53**, 5983, (1988).

Synthesis, Structure, and Self-Oxidation of Alkynyl(phenyl)iodonium Periodates, M. Ochiai, M. Kunishima, K. Fuji, Y. Nagao, and M. Shiro, *Chem. Pharm. Bull.*, **37**, 1948, (1989).

Radiosensitizing Hypoxic Cells with New 3-Nitro-1,2,4-triazole Derivatives *in Vitro* and *in Vivo*, Y. Nagao, S. Sano, M. Ochiai, K. Fuji, S. Nishimoto, T. Kagiya, C. Murayama, T. Mori, Y. Shibamoto, K. Sasai, and M. Abe, *Chem. Pharm. Bull.*, **37**, 1951, (1989).

Asymmetric Total Synthesis of New Non-natural 1 β -Methoxycarbapenem, Y. Nagao, T. Abe, H. Shimizu, T. Kumagai, and Y. Inoue, *J. Chem. Soc., Chem. Commun.*, 821, (1989).

Chiral Induction Using Heterocycles, E. Fujita and Y. Nagao, *Advances in Heterocyclic Chem.*, **45**, 1, (1989).

Binaphthol as a Chiral Auxiliary. Asymmetric Alkylation of Arylacetic Acid, K. Fuji, M. Node, F. Tanaka, and S. Hosoi, *Tetrahedron Lett.*, **30**, 2825, (1989).

Terpenoids. LII. Structures of Antitumor Diterpenoids, Trichorabdals A—E, Isolated from *Rabdosia trichocarpa*, K. Fuji, M. Node, M. Sai, E. Fujita, T. Shingu, W.H. Watson, D.A. Grossie, and .V. Zabel, *Chem. Pharm. Bull.*, **37**, 1465, (1989).

Terpenoids. LIII. The Structures of Trichorabdal F, Trichorabdal G Acetate, and Trichorabdal H. A Comment on the Structure of Shikodonin, M. Node, M. Sai, E. Fujita, and K. Fuji, *Chem. Pharm. Bull.*, **37**, 1470, (1989).

Terpenoids. LIII. Antitumor Activity of Trichorabdals and Related Compounds, K. Fuji, M. Node, M. Sai, E. Fujita, S. Takeda, and N. Unemi, *Chem. Pharm. Bull.*, **37**, 1472, (1989).

Polymer Chemistry

Self Diffusion of Block Copolymers in Solution, T. Inoue, N. Nemoto, and M. Kurata, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 194, (1988).

Viscoelasticity of a Solution of Star-Branched Polystyrene, K. Osaki, E. Takatori, M. Kurata, H. Watanabe, H. Yoshida, and T. Kotaka, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 205, (1988).

Comparison of the Self Diffusion Coefficient of Polystyrene in Solution Estimated by Forced Rayleigh Scattering and Fluorescence Recovery after Photobleaching, T. Inoue, N. Nemoto, T. Kojima, and M. Kurata, *Polym. J.*, **20**, 869, (1988).

Self Diffusion of Polymers in the Concentrated Regime I. Temperature Dependence of the Self Diffusion Coefficient and the Steady Viscosity of Polystyrene in Dibutyl Phthalate, N. Nemoto, T. Kojima, T. Inoue, and M. Kurata, *Polym. J.*, **20**, 875, (1988).

Self-Diffusion of Polymers in Block Copolymer Solution, T. Inoue, M. Kishine, N. Nemoto, and M. Kurata, *Macromolecules*, **22**, 494, (1989).

Birefringence of a Block Copolymer Solution in the Stress-Relaxation Process, K. Osaki, E. Takatori, M. Ueda, M. Kurata, T. Kotaka, and H. Ohnuma, *Macromolecules*, **22**, 2457, (1989).

Viscoelasticity of Polymer Blends. Solutions of Mixture of Polystyrene and Poly(vinyl methylether) in Dibutyl Phthalate, E. Takatori, S. Sibasaki, K. Osaki, and M. Kurata, *Nihon Reoriji Gakkaishi*, **16**, 171, (1988), in Japanese.

Structure of Polyelectrolyte Solutions, K. Kaji, T. Kanaya, H. Urakawa, K. Nishida, R. Kitamaru, J.S. Higgins and B. Gabryś, *Bull. Inst. Chem., Res., Kyoto Univ.*, **66**, 352-367, (1988).

Low Energy Excitations in Polyethylene: Comparison between Amorphous and Crystalline Phase, T. Kanaya, K. Kaji, S. Ikeda and K. Inoue, *Chem. Phys. Lett.*, **150**, 334-338, (1988).

Quasielastic Neutron Scattering from Amorphous Polymers above Glass Transition Temperature, K. Inoue, T. Kanaya, K. Kaji, Y. Kiyanagi and K. Shibata, *J. Phys. Soc. Japan*, **57**, 2862-2863, (1988).

Local Motions of Counter-ions in Polyelectrolyte Solutions without Added Salts, T. Kanaya, K. Kaji, R. Kitamaru, B. Gabryś and J.S. Higgins, *J. Chem. Soc., Faraday Trans. 1*, **84**, 3487-3500, (1988).

Amorphous State of Polymers, K. Kaji, *Zairyo Kagaku*, **25**, 43-51, (1988), in Japanese.

Gelation Process of PVA, K. Kaji, T. Kanaya and M. Ohkura, *Kohbunshi Kako*, **38**, 2-7, (1989), in Japanese.

Structure of Polyelectrolyte Solutions, K. Kaji, *KEK Report*, **88**, 36-40, (1988).

Dynamics of Polyelectrolyte Solutions by Neutron Spin Echo: Molecular Weight Dependence, T. Kanaya, K. Kaji, R. Kitamaru, J.S. Higgins and B. Farago, *Macromolecules*, **22**, 1356-1359, (1989).

Permeation of Gases and a Gas Mixture through a Polymer Membrane in the Glass Transition Region, T. Uyeda, H. Odani, and M. Kurata, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 344, (1988).

Studies on Permeation of Gases through Polymer Membranes in the Temperature Region Encompassing the Glass Transition —Permeation of Gas/Vapor Mixtures through a Disubstituted Polyacetylene and Poly(vinyl Acetate) Membranes—, H. Shimomura, T. Uyeda, K. Nakanishi, H. Odani, and M. Kurata, *Rep. Asahi Glass Found. Ind. Technol.*, **53**, 293, (1988), in Japanese.

NMR Measurement of Identical Polymer Samples by Round Robin Method II. Reliability of Spin-Lattice Relaxation Time and Nuclear Overhauser Enhancement Factor, R. Chujo, K. Hatada, R. Kitamaru, T. Kitayama, H. Sato, Y. Tanaka,

T. Horii and Y. Terawaki, *Polym. J.*, **20**, 627, (1988).

^{13}C NMR Analysis of the α -Methyl Group Rotation of Solid Poly(methyl methacrylate)s with Different Tacticities, F. Horii, Y. Chen, M. Nakagawa, B. Gabry's and R. Kitamaru, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 317, (1988).

The Structure of Cellulose as Studied by CP/MAS ^{13}C NMR Spectroscopy, F. Horii, "Nuclear Magnetic Resonance in Agriculture", CRC Press, Chapter 10, 311, (1989).

Structural Study of Ultradrawn Polyethylene Films by High-Resolution Solid-State ^{13}C NMR Spectroscopy, Q. Zhu, F. Horii, M. Tsuji and R. Kitamaru, *J. Soc. Rheology, Japan*, **17**, 35, (1989), in Japanese.

The Reliability of ^1H and ^{13}C NMR Measurements. Spin-Lattice Relaxation Times and Nuclear Overhauser Enhancement, F. Horii, *Koubunshi*, **38**, 292, (1989), in Japanese.

Solid Structure I. Analyses by High-Resolution Solid-State ^{13}C NMR Spectroscopy, F. Horii, *Koubunshi*, **38**, 370, (1989), in Japanese.

Properties of Particle Scattering Functions for Two Types of Spherical Micelles Composed of Hard Core and Shell of Symmetrically Arranged Rods or Shell of Gaussian Subchains, Y. Tsunashima, M. Hiarta, and M. Kurata, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 184, (1988).

Micelles Constructed from the Hard Core and the Shell of Symmetrically Arranged Rods. Particle Scattering Function and Mean-Square Radius of Gyration, M. Hirata and Y. Tsunashima, *Macromolecules*, **22**, 249, (1989).

Tissue Biocompatibility of Cellulose and Its Derivatives, T. Miyamoto, S. Takahashi, H. Ito and H. Inagaki, *J. Biomed. Mater. Res.*, **23**, 125-133, (1989).

Garfing of Polypeptide on Cellulose Derivatives, O. Hasegawa, S. Takahashi, H. Suzuki and T. Miyamoto, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 93-102, (1988).

Functional Cellulose Derivatives I. Thermotropic Liquid Crystals, T. Miyamoto and T. Yamagishi, *Polymer Applications*, **38**, 168-174, (1989), in Japanese.

Functional Cellulose Derivatives II. LB Films, T. Miyamoto and T. Yamagishi, *Polymer Applications*, **38**, 225-232, (1989), in Japanese.

Functional Cellulose Derivatives III. Biomedical Materials, T. Miyamoto and T. Yamagishi, *Polymer Applications*, **38**, 269-274, (1989), in Japanese.

Characterization of Linear Polymers Induced by Thermal Denaturation of Ovalbumin, T. Koseki, T. Fukuda, N. Kitabatake and E. Doi, *Food Hydrocolloids*, **3**, 135-148, (1989).

Thermotropic Cellulose Derivatives with Flexible Substituents. I. Preparation of Tri-O-(β -methoxyethoxy)ethyl Cellulose and Its Cholesteric Mesophase Properties, T. Yamagishi, T. Fukuda and T. Miyamoto, *Mol. Cryst. Liq. Cryst.*, **172**, 17-25, (1989).

Grafting of Living Polystyrene onto Poly(methyl methacrylate) and Its Copolymer, S. Nishihara, T. Fukuda and H. Inagaki, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 103-114, (1988).

Thermotropic Cellulose Derivatives with Flexible Substituents II. Effect of Substituents on Thermal Properties, T. Yamagishi, T. Fukuda, T. Miyamoto and J. Watanabe, *Polymer Bulletin* **20**, 373-377, (1988).

A Comparative Study on Barton's and Johnston's Equations for Copolymer Glass Transition Temperature, H. Suzuki, and T. Miyamoto, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 297-311, (1988).

An Insight into the Barton Equation for Copolymer Glass Transition, H. Suzuki and V.B.F. Mathot, *Macromolecules*, **22**, 1380, (1989).

Lyotropic Mesophase Formation of Imogolite, K. Kajiwara, H. Urakawa, N. Donkai, Y. Hiragi, H. Inagaki and M. Schmidt, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 165, 1988.

Lattice Disorders in the Stereocomplex of Poly(L-lactide) and Poly(D-lactide), T. Okihara, A. Kawaguchi, H. Tsuji, S.-H. Hyon, Y. Ikada and K. Katayama, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 271, (1988).

Microtwin Structure in (SN)_x, S. Isoda, A. Uemura, S. Moriguchi, M. Ohara and K. Katayama, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 530, (1988).

Electron-Microscopic Observation of Crystal Structure of Polymers, A. Uemura, S. Isoda, M. Tsuji, A. Kawaguchi and K. Katayama, Abstract IUPAC 32-nd Int. Symp. Macromol., Kyoto, 726, (1988).

Improvement of Resolution Limit by Cryo-Protection in High-Resolution Electron Microscopy of Polymer Crystals, M. Tosaka, M. Tsuji, A. Kawaguchi, K. Katayama and M. Iwatsuki, Abstract IUPAC 32-nd Int. Symp. Macromol., Kyoto, 727, (1988).

Oriented Crystallization of Polymers, K. Katayama and S. Murakami, *Ann. Report Res. Inst. Chem. Fiber Japan*, **45**, 9, (1988), in Japanese.

Structural Changes of Poly(p-phenylene sulphide) on Doping, A. Uemura, S. Isoda, A. Kawaguchi, A. Ishizawa and K. Katayama, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 263, (1988).

Epitaxial crystallization of polyoctenamer on uniaxially oriented polypropylene films, Y. Xu, T. Asano, A. Kawaguchi, U. Rieck, J. Petermann, *Journal of Materials Science Letters*, **8**, 675, (1989).

Substrate-Induced Crystallization of n-paraffins on Oriented Polyolefins, A. Kawaguchi, T. Okihara, M. Ohara, M. Tsuji, K. Katayama and J. Petermann, *Journal of Crystal Growth*, **94**, 857, (1989).

Electron Microscopy, M. Tsuji, "Comprehensive Polymer Science", Ed. by Sir G. Allen and J.C. Bevington, Vol. 1 (Polymer Characterization), vol. ed. by C. Booth and C. Price, Pergamon Press, Chapt. 34, 785, (1989).

Direct imaging of the molecular arrangement in a radiation-sensitive polymer single crystal: poly(tetramethyl-p-silphenylene siloxane), M. Tsuji, M. Ohara, S. Isoda, A. Kawaguchi and K. Katayama, *Philos. Mag.-B*, **59**, 393, (1989).

Microstructural study of as-polymerized and isomerized fibrils of trans-polyacetylene, K. Shimamura, Y. Yamashita, F. Yokoyama, K. Monobe, T. Ikawa, M. Tsuji, A. Uemura and K. Katayama, *Polymer*, **30**, 425, (1989).

Morphology of cycloparaffins crystallized epitaxially on NaCl, K.J. Ihn, M. Tsuji, S. Isoda, A. Kawaguchi, K. Katayama, Y. Tanaka and H. Sato, *Makromol. Chem.*, **190**, 837, (1989).

Crystallization of polyethylene from its vapour phase on cycloparaffin single crystals, K.J. Ihn, M. Tsuji, S. Isoda, A. Kawaguchi, K. Katayama, Y. Tanaka and H. Sato, *Makromol. Chem. Rapid Commun.*, **10**, 185, (1989).

Biochemistry

Repeat Sequences of Amino Acids Suggest the Origin of Protein, Y. Seto and M. Kanehisa, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 461, (1988).

The Future of Computational Molecular Biology, M. Kanehisa, In "Computational Molecular Biology" (A.M. Lesk, ed.) Oxford Univ. Press, 223, (1989).

Databases: What's There and What's Needed, M. Kanehisa, In "Biomolecular Data: A Resource in Transition" (R.R. Colwell, ed.) Oxford Univ. Press, 91, (1989).

Protein Three-Dimensional Structure and Data Processing, A. Ogiwara and M. Kanehisa, *Kagaku to Kogyo*, **41**, 1094, (1988), in Japanese.

Current Status and Usage of DNA and Protein Data Banks, M. Kanehisa, In "Protein Engineering" (S. Ono, ed.) Maruzen Advanced Technology, 25, (1989), in Japanese.

Utilization of Databases, M. Kanehisa, In "Experimental Manual for Nucleic Acid Signals" (M. Takanami, ed.) Kodansha Scientific, 8, (1989), in Japanese.

Database and Computational Methods in the Human Genome Project, M. Kanehisa, *Byoutai Seiri*, **8**, 930, (1989), in Japanese.

Characteristic roles of hydrated water for 20 amino acid residues in stabilization of globular proteins, M. Oobatake and T. Ooi, *Bull. of the Inst. for Chem. Res., Kyoto Univ.*, **66**, 433-445, (1989).

Role of hydrated water in protein denaturation, T. Ooi and M. Oobatake, *Comments Mol. Cell. Biophys.*, **5**, 233-251, (1988).

Ionic dynamics in computer simulated molten LiNO_3 II. Tumbling and spinning motions of nitrate ions, T. Kato, K. Machida, M. Oobatake, and S. Hayashi, *J. Chemical Physics*, **89**, 7471-7477, (1988).

Comparison of α -helix stability in peptides having a negatively or positively charged residue block attached either to the N- or C-terminus of an α -helix: The electrostatic contribution and anisotropic stability of the α -helix, S. Takahashi, E.-H. Kim, T. Hibino, and T. Ooi, *Biopolymers*, **28**, 995, (1989).

Syntheseis of hexapeptides having cysteines at N- and C-terminals, S. Takahashi, *Bull. Inst. Chem. Res. Kyoto University*, **66**, 492, (1989).

A Temperature-Jump Apparatus and Measuring System for Synchrotron Solution Scattering Experiments, Y. Hiragi, H. Nakatani, K. Kajiwara, H. Inoue, Y. Sano and M. Kataoka, *Rev. Sci. Instr.*, **59**, 64, (1988).

Micellar Structure of β -Casein Observed by Small-Angle X-ray Scattering, K. Kajiwara, R. Niki, H. Urakawa, Y. Hiragi, N. Donkai and M. Nagura, *Biochim. Biophys. Acta*, **955**, 128, (1988).

Temperature Dependence of the Structure of Aggregates of Tobacco Mosaic Virus Protein at pH 7.2. Static Synchrotron Small-Angle X-Ray Scattering, Y. Hiragi, H. Inoue, Y. Sano, K. Kajiwara, T. Ueki, M. Kataoka, H. Tagawa, Y. Izumi, Y. Muroga and Y. Amemiya, *J. Mol. Biol.*, **204**, 129, (1988).

Conformation Analysis of Broken Rodlike Chains: II. Conformational Analysis of Poly(D-Glutamic Acid) in Aqueous Solution by Small-Angle X-ray Scattering, Y. Muroga, H. Tagawa, Y. Hiragi, T. Ueki, M. Kataoka, Y. Izumi and Y. Amemiya, *Macromolecules*, **21**, 2756, (1988).

EXAFS Study of Selenometallothionein Structure, N. Esaki, H. Maeda, T. Oikawa, H. Sakurai, Y. Hiragi, T. Murata, H. Tanaka and K. Soda, *Photon Factory Activity Report*, **6**, 23, (1988).

X-Ray Solution Scattering Studies on Solubilized Bacteriorhodopsin III, M. Kataoka, M. Nakasako, F. Tokunaga, T. Ueki, Y. Hiragi and K. Kobayashi, *Photon Factory Activity Report*, **6**, 107, (1988).

Quarternary Structure Change of Tryptophanase Observed by Small-Angle X-Ray Scattering, E.H. Kim, Y. Hiragi, T. Oda, M. Tokushige, K. Kajiwara, H. Urakawa, Y. Sano, T. Ueki, M. Kataoka and K. Kobayashi, *Photon Factory Activity*

Report, **6**, 108, (1988).

Conformational Analysis of Broken Rodlike Chains: II. Conformational Analysis of Poly(D-Glutamic Acid) in Aqueous Solution by Small-Angle X-Ray Scattering, Y. Muroga, H. Tagawa, Y. Hiragi, T. Ueki, M. Kataoka, Y. Izumi and Y. Aem-miya, *Photon Factory Activity Report*, **6**, 109, (1988).

Time Resolved Small-Angle X-Ray Scattering Study of Aggregation Process of Cucumber Green Mottle Mosaic Virus Protein, Y. Sano, H. Inoue, Y. Hiragi, K. Kajiwara, H. Urakawa, S. Isoda, E. Kim, S. Moriguchi and T. Ueki, *Photon Factory Activity Report*, **6**, 135, (1988).

Crystallization of Poly(Vinyl Alcohol) on Heterogeneous Nuclei, S. Isoda, S. Moriguchi, A. Kawaguchi, Y. Hiragi, E. Kim, K. Kajiwara and H. Urakawa, *Photon Factory Activity Report*, **6**, 182, (1988).

Lyotropic Mesophase Formation of Imogolite, K. Kajiwara, H. Urakawa, N. Donkai, Y. Hiragi, H. Inagaki, M. Schmidt, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 165, (1988).

Structure of Tobacco Mosaic Virus A-Protein in Low Ion Concentration at Alkaline pH, Y. Sano, H. Inoue, K. Kajiwara, Y. Hiragi, E. Kim and S. Isoda, *Bull. Inst. Chem. Res., Kyoto Univ.*, **66**, 481, (1989).

Selenium, N. Esaki, H. Tanaka, and K. Soda, *Tanpakushitu Kakusan Kouso*, **33**, 3017-3023, (1988), in Japanese.

Selenium-containing Enzymes and Selenium Amino Acids, N. Esaki, H. Tanaka, and K. Soda, "Kagaku Zoukan 115" (N. Inamoto, T. Ohishi, N. Sonoda, and S. Tomoda Eds., Kagakudoujin, Kyouto), 205-208, (1988), in Japanese.

Enantioselective Synthesis of Various D-Amino Acids by a Multi-enzyme System, N. Esaki, K. Tanizawa, H. Tanaka, and K. Soda, *J. Bacteriol.*, **8**, 243-248, (1988).

Gene Cloning and Sequence Determination of Leucine Dehydrogenase from *Bacillus stearothermophilus* and Structural Comparison with Other NAD(P)⁺-dependent Dehydrogenases, S. Nagata, K. Tanizawa, E. Esaki, Y. Sakamoto, T. Ohshima, H. Tanaka, and K. Soda, *Biochemistry*, **27**, 9056-9062, (1988).

Selenium: Micronutrient with Various Functions, K. Soda, *Nippon Nogeikagaku Kaishi*, **62**, 1081-1083, (1988), in Japanese.

Enzymology of Selenium, H. Tanaka and N. Esaki, *Nippon Nogeikagaku Kaishi*, **62**, 1087-1089, (1988), in Japanese.

Stereochemistry and molecular mechanism of pyridoxal enzyme reactions, K. Tanizawa, *Seikagaku*, **60**, 499-516, (1988), in Japanese.

Synthesis of Biologically Active Selenium-Containing Amino Acids and Peptides,

H. Tanaka, N. Esaki, M. Sugimoto, T. Oikawa, P. Chocat, and K. Soda, "Phosphorus and Sulfur" R.A. Zingaro and G.W. Kabalska Eds., Godon and Breach, Science Publishers, Inc., United Kingdom, **38**, 19-24, (1988).

D-Selenocystine α, β -Lyase: A Novel Pyridoxal 5'-Phosphate Enzyme, K. Soda, N. Esaki, V. Seraneeprakarn, and H. Tanaka, "Phosphorus and Sulfur" R.A. Zingaro and G.W. Kabalka Eds., Godon and Breach, Science Publishers, Inc., United Kingdom, **38**, 25-33, (1988).

Selenium, N. Esaki and K. Soda, "Metalloproteins" (S. Otsuka and T. Yamanaoka Eds.), Kodansha Ltd. & Elsevier, Tokyo, **8**, 429-439, (1988).

The C₃-N Bond Cleavage of 2-Amino-3-(N-substituted-amino)-propionic Acids Catalyzed by L-Methionine γ -Lyase, H. Takada, N. Esaki, H. Tanaka, and K. Soda, *Agric. Biol. Chem.*, **52**, 2897-2901, (1988).

Glutamine Synthetase from a Cyanobacterium, *Phormidium lapideum*: Purification, Characterization, and Comparison with Other Cyanobacterial Enzymes, Y. Sawa, H. Ochiai, K. Tonaha, K. Tanizawa, H. Tanaka, and K. Soda, *J. Biochem.*, **104**, 917-923, (1988).

Chemical Synthesis and Expression of Copper Metallothionein Gene of *Neurospora crassa*, M. Sugimoto, T. Oikawa, N. Esaki, H. Tanaka, and K. Soda, *J. Biochem.*, **104**, 924-926, (1988).

Deamination and γ -Addition Reactions of Vinylglycine Catalyzed by Yeast Kynurenine Aminotransferase, and Suicidal Inactivation of the Enzyme during Its Processing, Y. Sada, K. Tanizawa, K. Yonaha, and K. Soda, *Agric. Biol. Chem.*, **52**, 2873-2878, (1988).

Biotransformation of Oleic Acid to Ricinoleic Acid, K. Soda, "World Conference on Biotechnology" (T.H. Applewhite Ed.), American Oil Chemists' Society, U.S.A., 178-179, (1988).

Production and Application of Superoxide Dismutase, K. Soda, *Bioscience to Indasutori*, **46**, 9-16, (1988), in Japanese.

Distribution of Glutamate Racemase in Lactic Acid Bacteria and Further Characterization of the Enzyme from *Pediococcus pentosaceus*, N. Nakajima, K. Tanizawa, H. Tanaka, and K. Soda, *Agric. Biol. Chem.*, **52**, 3099-3104, (1988).

Synthesis of a Selenium Analogue of Metallothionein from *Neurospora crassa* and Its Properties, N. Oikawa, M. Sugimoto, N. Esaki, H. Tanaka, and K. Soda, *Biryouseiyousokenkyu*, **5**, 75-79, (1988), in Japanese.

Thermostable Enzymes: Their Potentialities and Application, K. Soda, H. Tanaka, K. Tanizawa, and N. Esaki, "8th International Biotechnology Symposium. Paris" (G. Durand, L. Bobichon, J. Florent Eds.), **1**, 361-370, (1988).

Thermostable Alanine Racemase and Its Application to D-Amino Acid Synthesis, K. Soda, H. Tanaka, and K. Tanizawa, *Enz. Engineering*, **542**, 375-382, (1988).

Selective Enzymatic Determination of L-Phenylalanine and Phenylpyruvate, T. Oshhima, H. Sugimoto and K. Soda, *Anal. Lett.*, **21**, 2205-2215, (1988).

Site-Directed Mutagenesis of the CysteinyI Residues and the Active-Site Serine Residue of Bacterial D-Amino Acid Transaminase, M. Merola, A. Martinez del Pozo, H. Ueno, P. Recei, A. Di Donato, J.M. Manning, K. Tanizawa, Y. Masu, S. Asano, H. Tanaka, and K. Soda, *Biochemistry*, **28**, 505-509, (1989).

Activity and Spectroscopic Properties of Bacterial D-Amino Acid Transaminase after Multiple Site-Directed Mutagenesis of a Single Tryptophan Residue, A. Martinez del Pozo, M. Merola, H. Ueno, J.M. Manning, K. Tanizawa, K. Nishimura, S. Asano, H. Tanaka, K. Soda, *Biochemistry*, **28**, 510-516, (1989).

Mechanism-Based Inactivation of L-Methionine γ -Lyase by L-2-Amino-4-chloro-4-pentenoate, N. Esaki, H. Takada, M. Moriguchi, S. Hatanaka, H. Tanaka, and K. Soda, *Biochemistry*, **28**, 2111-2116, (1989).

The Primary Structure of Thermostable D-Amino Acid Aminotransferase from a Thermophilic *Bacillus* Species and Its Correlation with L-Amino Acid Aminotransferases, K. Tanizawa, S. Asano, Y. Masu, S. Kuramitsu, H. Kagamiyama, H. Tanaka, and K. Soda, *J. Biol. Chem.*, **264**, 2450-2454, (1989).

Thermostable D-Amino Acid Aminotransferase from a Thermophilic *Bacillus* Species, K. Tanizawa, Y. Masu, S. Asano, H. Tanaka, and K. Soda, *J. Biol. Chem.*, **264**, 2445-2449, (1989).

Other Functions of Metallothionein, T. Oikawa and K. Soda, *Kagaku*, **44**, 66-67, (1989), in Japanese.

Cloning and sequencing of a ligninase gene from a lignin-degrading basidiomycete, *Phanerochaete chrysosporium*, Y. Asada, Y. Kimura, M. Kuwahara, A. Tsukamoto, K. Koide, A. Oka and M. Takanami, *Applied Microbial and Biotechnology*, **29**, 469-473, (1988).

Sequence determination and characterization of the replicator region in the tumor-inducing plasmid pTiB6S3, S. Tabata, P.J.J. Hooykaas and A. Oka, *J. of Bacteriol.*, **171**, 1665-1672, (1989).

Putative start codon TTG for the regulatory protein VirG of the hairy-root-inducing plasmid pRiA4, T. Aoyama, T. Hirayama, S. Tamamoto and A. Oka, *Gene*, **78**, 173-178, (1989).

Construction of an ordered cosmid collection of the *Escherichia coli* K-12 W3110 chromosome, S. Tabata, A. Higashitani, M. Takanami, K. Akiyama, Y. Kohara, Y. Nishimura, A. Nishimura, S. Yasuda and Y. Hirota, *J. of Bacteriol.*, **171**, 1214-1218, (1989).

Reconstitution of nucleosomes in vitro with a plasmid carrying the long terminal repeat of Moloney murine leukemia virus, T. Kimura, T. Takeya and M. Takanami, *Biochim. Biophys. Acta*, **1007**, 318-324, (1989).

The *FokI* restriction-modification system I. Organization and nucleotide sequences of the restriction and modification genes, K. Kita, H. Kotani, H. Sugisaki and M. Takanami, *J. of Biol. Chem.*, **264**, 5751-5756, (1989).

The *FokI* restriction-modification system II. Presence of two domains in *FokI* methylase responsible for modification of different DNA strands, H. Sugisaki, K. Kita and M. Takanami, *J. of Biol. Chem.*, **264**, 5757-5761, (1989).

Characterization of partially activated p 60^{c-src} in chicken embryo fibroblasts, M. Sato, J. Kato and T. Takeya, *J. of Virol.*, **63**, 683-688, (1989).

Reconstitution of nucleosomes in vitro with a plasmid carrying the long terminal repeat of Moloney murine leukemia virus, T. Kimura, T. Takeya and M. Takanami, *Biochim. Biophys. Acta*, **1007**, 318-324, (1989).

Pospho amino acid analysis and peptide mapping, T. Takeya, Experiments in conformation of nucleic acids and its recognition, 149-155, (1989), in Japanese.